

WI-D.1 Abdulkadrirov, S; Mercatus Center, George Mason University; sabdukadrirov@mercatus.gmu.edu

Protecting Patients from "Innocuous Drugs": Medical Marketplace vs. FDA

Since 1962, the FDA required all new drugs to demonstrate efficacy in order to receive approval for marketing. The agency justified its precautionary approach by claiming that patients did not have the necessary expertise to evaluate the effectiveness of new drugs and would likely become victims of snake oil peddlers without FDA regulations. Yet, the last few decades saw the rise of alternative sources of medical expertise capable of filtering out ineffective drugs from the market. Thus, the competing sources of medical expertise provide us with two competing regimes for efficacy testing. The centralized precautionary approach relies entirely on FDA regulators to remove ineffective drugs from the market. In contrast, the decentralized market-based approach relies on the distributed expertise and local knowledge of patients, physicians and insurance companies to achieve the same result. This paper examines the costs and benefits of each approach.

P.75 Abualfaraj, N*; Gurian, P; Olson, M; Drexel University; nafaraj@gmail.com

Review of potential risk from various exposure pathways to Marcellus shale flowback water

Concern over natural gas extraction across the U.S. and particularly from the Marcellus Shale formation, which underlies approximately two-thirds of the state of Pennsylvania, has been growing in recent years as natural gas drilling activity has increased. Identifying sources of concern and risk from shale gas development, particularly from the hydraulic fracturing process, is an important step in better understanding sources of uncertainty within the industry. Scenarios of concern are modeled in order to estimate occupational and residential risk from exposure to flowback water based on the most likely exposure pathways for on-site workers and the general public. Examining health risks to workers due to inhalation of volatilized contaminants from on-site holding ponds using mean, 2.5 percentile, and 97.5 percentile concentrations of 12 VOCs found in flowback water revealed that these risks were minimal under typical exposure conditions. An occupational risk assessment for worker exposure to flowback water through accidental spills at hydraulic fracturing sites was carried out for contaminants of concern found in flowback water. The occupational cancer risk estimate for median concentrations did not exceed the target lifetime cancer risk of 10⁻⁶ except for benzo(a)pyrene, which exceeds the target risk level even at the 2.5 percentile value. A risk assessment for residential exposure of the general public in shale gas development areas to a list of carcinogenic and non-carcinogenic chemicals of concern to human health found in flowback water through ingestion, inhalation, and dermal exposure pathways revealed that several carcinogenic compounds found in flowback water exceed target limits and significantly increase the risk of an individual developing cancer following chronic exposure. In general, exposure from the dermal pathway posed the greatest risk to human health. Exposure to radionuclides in flowback water, particularly through the inhalation pathway, poses a greater threat to human health than other contaminants examined.

P.28 Abdulla, A*; Vaishnav, P; UC San Diego and Carnegie Mellon University; ayabdulla@ucsd.edu

Public perceptions of clean energy technologies

In order to deeply decarbonize the world's energy system by the end of this century, it is likely that all available low-carbon technologies will have to be deployed to some extent. Each of these must contend with different technical, economic, and institutional challenges. Moreover, each has a different risk profile and therefore a different level of social acceptability. There is a substantial literature that examines public attitudes to technologies that are considered particularly controversial. Of these findings, perhaps the most replicated and undisputed is nuclear power's unique status as a technology that engenders "dread." In this paper, we recruit respondents and randomly assign them to one of two groups. The first of these groups is given information about the risk profile of each of the clean technology options available for mass deployment. We focus on the following five risk categories: economic cost, service reliability, health impacts, environmental emissions, and land use implications. The second group is given the same risk profile information, though the names of the options are withheld. In each case, we ask respondents to rank the technologies in order of preference. We then task them with creating a clean energy portfolio to meet U.S. electricity demand in 2030 under an emissions constraint. Upon completion of the protocol, the names associated with each technology are revealed to the second group, and they are offered the option of adjusting their preferences. The results of this investigation will allow policymakers to strike the right balance between allocating resources to reducing the actuarial risk associated with different energy technologies, versus addressing perceptions.

P.115 Ahumada, W*; Gutiérrez, VV; Toledo, MI; Universidad Diego Portales; waldo.ahumada@mail.udp.cl

Risk factors of cyberbullying in 5th grade Chilean students

Currently, the use of Internet, mobile technologies and web pages allow us to use information and communicate easily. But with the use of technology and the internet can appear a new phenomenon: cyberbullying. Cyberbullying can be defined as a harm that one person or a group can do inflict against other(s) through hostile, deliberated and repeated behaviors, using a variety of electronic media. The effects on cybervictims are too diverse: depression, low academic performance, self-esteem decrease and even suicidal thoughts. The objective of this research is to determine risks factors associated with cybervictims. We hypothesized that those factors could be gender, self-esteem, popularity on social networks and presence of preliminary history of bullying. The sample was applied to student from elementary school from the city of Santiago, Chile. 841 students answered the survey. The results indicate that the presence of cyberbullying is related to the studied risk factors. The results are discussed in terms of public policy.

W4-D.3 Aiken, DV; U.S. Department of Transportation;
deborah.aiken@dot.gov

Challenges in Risk-Informed Rulemaking at the U.S. Department of Transportation

Traditionally, U.S. Department of Transportation (DOT) agencies have relied on data from prior accidents to analyze benefits for Regulatory Impact Analyses (RIAs). The calculation examines the historical accident record to identify underlying causes. That information is used to determine the degree to which a rule would have prevented previous accidents, often expressed as reductions in the probability that each accident would have occurred if the rule had been in place. This serves as an effectiveness rating, which is then applied against the number of fatalities (or other safety outcome measure) for a given accident to estimate expected benefits. In aviation, for example, identifying specific activities where regulations could improve safety historically involved identifying defects or practices that had already caused fatal accidents. Between 1994 and 2002, 45 commercial aviation accidents resulted in 1,309 fatalities. Gradually, regulations were introduced to require safety alerting systems, revised aircraft designs, training and other requirements. Consequently, only 6 accidents occurred from 2010 to 2015 resulting in 17 fatalities, and in 2011 and 2012, there were no fatal accidents. Regulations designed to anticipate and address risks posed by future events cannot be evaluated using methods that rely solely on historical accidents. Evaluations of regulations in an environment with reduced baseline levels of safety incidents may require that DOT more fully develop the concepts of prospective, predictive, and forward-looking risk analysis as a basis for assessing benefits. The purpose of this paper is to explore practical alternatives to the current practice of defining and measuring risk by relying exclusively on the frequency of historical events. It surveys analytic methods applied at agencies besides the DOT as well as how these methods have been applied in conducting RIAs. It also considers how these methods could be applied to DOT regulatory issues.

W4-A.1 Alderson, DL*; Brendecke, J; Lin, KY; Naval Postgraduate School; dlalders@nps.edu

Repair, Rebuild, or Replace? Protecting Aging Infrastructure From Hazards and Threats

We consider an infrastructure system whose function depends on a number of components that fail randomly according to known rates. Components that are “new” have a small failure rate and components that are “old” have a larger failure rate. When a component fails it can be replaced to “new” status or repaired to “old” status. An “old” component can also be proactively replaced to “new” status. We formulate and solve a Markov decision process to identify the optimal replace/repair policies for given system operating costs and discuss implications for real infrastructure systems.

P.192 Akai, K*; Makino, R; Takeshita, J; Kudo, T; Aoki, K; Shimane University; akaikenju@gmail.com

An economic lab experiment to compare the risk and productivity between parallel and series production systems

This study compare the risk and productivity between parallel and series production systems proposed by Husken (2002) in Risk Analysis, Vol. 22, No. 1. We employ Japanese university students including undergraduate and graduate students and pay money relative to their achievements in the laboratory. The experimental software is constructed by z-Tree which is connected by the internet among subjects. They play as labors each other and pay their efforts (cost) into their works. Then, each system decides the probability of accidents. We control two types of treatments; a death game treatment in which labors do not continue to the game once accident happens vs. continuous game treatment in which labors can keep working after the accident occurs. The laboratory result shows that the parallel system achieves more efficiency in the aspect of risk reducing and productivity in each treatment. In the death game treatment, in each system, the session finishes within first five or six periods. This result implies that learning effect among subjects are important to achieve the high performance in production sites. Especially, in the series production system, how to educate labors about accident probability and importance of risk reducing.

W4-C.1 Alexeev, A*; Henshel, DS; Cains, MG; Sun, Q; Indiana University; aalexeev@indiana.edu

Stochastic Epidemiological Model of the Risk of Malware Propagation in Heterogeneous Networks

Security is a crucially important component of sustainable operation of cyber networks. Malware proliferation represents one of the main risk threats to the network security. Malware propagation in computer networks has attributes similar to those of disease transmission among human or animal populations. Although there is a vast literature on modeling of malware spread using epidemiological frameworks, most models are deterministic in their nature, do not account for heterogeneity of the network components: devices, software, and users, and, finally, do not account for behavioral and chance effects. Stochastic behavior is particularly important in small networks or when the number of initially compromised computers is small. This paper presents results of a study of malware spreading in heterogeneous networks using epidemiological modeling framework, namely, a stochastic-SIR-model (Suspected-Infected-Recovered). We describe different paths of malware propagation in a computer network with heterogeneous components using a system ordinary differential equations allowing to describe deterministic malware dynamics. The deterministic trajectories are compared to those with stochastic input to either network as a whole or to a single component of the network. Simulations are conducted for different ways of how stochasticity enters into the system: via variation in the parameters or variables. The paper concludes with discussion of the stochastic effects on risk of malware propagation in diverse computer networks.

W4-C.2 Alexeev, A; Krutilla, K*; Indiana University;
krutilla@indiana.edu

Modeling Cybersecurity as a Repeated Contest

Governmental cyber systems routinely face threats from criminal organizations and governmental entities of other states. We apply a contest game theoretic framework for modelling cyber security as a repeated game. In this model the attacker/defender allocate available resources and efforts to maximize gain/minimize loss from the attack. Employing a repeated game formulation allows for situations where the attack in a given period fails and so is repeated again. In this context, the model will show the rational resource commitment the defender nation should make period by period as a function of the parameters in the model, which include the relative valuation of economic damages, asymmetries in technology, and different discount rates. The purpose is to examine the system's response to parameter variation, and to assess the combination of parameter settings that would make existing cyber security resource commitments of the U.S government economically efficient.

P.136 Anderson, AA; Colorado State University;
ashley.a.anderson@colostate.edu

Extreme weather and climate change: The role of media use and interpersonal discussion in the formation of risk perceptions about climate change

Individuals' experiences with weather play an important role in how they perceive climate change (e.g., Brulle, Carmichael, & Jenkins, 2012; Joireman, Barnes Truelove, & Duell, 2010). In particular, extreme weather events are associated with perceptions that climate change is risky (Leiserowitz et al., 2014). And perceptions of weather experiences are connected to beliefs that climate change is occurring (Borick and Rabe, 2014). Few studies, however, have analyzed how communication around extreme weather events shapes attitudes about climate change, although some studies have shown that local television weathercasters can enhance climate change awareness (Anderson et al., 2013; Bloodhart, Maibach, Myers, Zhao, & Ebi, 2015; Zhao et al., 2013). In this study, I use a statewide survey of Coloradans (n = 863) following a state-wide flooding event in 2013 to analyze how communication of the extreme weather event shaped climate change risk perceptions. An ordinary least squares linear regression shows evidence that, after controlling for general beliefs about climate change, several sources of communication are related to increased risk perceptions of climate change. These communication sources are: 1) attention to news about extreme weather in general, 2) attention to flood-specific news, 3) face-to-face discussion about the flood, and 4) social media discussions about the flood. This study expands existing scholarship on the relationship between weather and climate change perceptions by pointing to the important role of media use and interpersonal discussion during weather events.

P.1 Alves, EN; Engine Engenharia Ltda; elizabeth@engine.eng.br
Risk mapping of technological disasters and its application in land use planning: the state of art

This review paper explores the articles published in journals during the past 16 years which dealing with risk mapping of accidents with hazardous materials and its application in Land Use Planning (LUP), in order to identify key issues and decision-making which have been highlighted and privileged at different times and places, thus delineating a state of the art on the topic, allowing to build a specific theoretical framework guiding further new discussions and paths that lead to the improvement of this theme, which is assuming an importance role in industrialized and urbanized countries, in its various scales, such as local, regional and national. The history of industrial accidents clearly demonstrates that its consequences can be severely amplified by the presence of dwellers living in areas at risk. The major articles tapped showed that risk mapping in LUP has been urged in many countries, particularly those in European Union driven by Seveso II, in order to adopt a policy for the vicinity of hazardous establishments as an essential element to mitigate accidents surrounding. The field of engineering has shown great domain of techniques and methodologies for prevention on loss of containment and for defining distances of risk, but it are constantly focused on the technological development inside industries, however, in order to achieve the targets for preparedness and response to major accidents within the perspective of social and environmental justice, it is necessary to dialogue with land use planners, whom in turn have always performed independently, and despite the great advances in theories and practices in LUP, there are still many unresolved problems, particularly those regarding to safety in urban and environmental areas

P.32 Anderson, R*; Norrman, J; Rosén, L; Volchko, Y; Chalmers
University of Technology; robert.anderson@chalmers.se

Is sustainable remediation of contaminated land more efficient?

It is estimated that there are 80,000 potentially contaminated sites in Sweden, where approximately 1300 are considered to pose substantial risk to human health and the environment. Soil remediation reduces negative impacts from contaminants on humans and ecosystems, however the process itself often results in other negative effects, such as large environmental footprints and high costs to society. Increased focus on implementing sustainable remediation solutions has been seen internationally in recent years. SCORE (Sustainable Choice of REmediation), developed at Chalmers University of Technology, is a multi-criteria decision analysis tool for assessing economic, environmental and social sustainability of remediation alternatives, incorporating social cost-benefit analysis and uncertainty analysis. In addition to sustainability, the Swedish EPA is also concerned with the efficiency of remediation, stemming from the slow-progress, low level of innovation, and high costs of state funded projects. The main objective of the SAFIRE research project is to evaluate if sustainability assessments can improve the efficiency and effectiveness of site remediation. Sustainability assessments were performed on four real case sites in Sweden using the SCORE method together with stakeholders. Alternatives from each site were then evaluated and compared using a number of efficiency and effectiveness indicators. In choosing the indicators, focus was given on risk-reduction and on reaching stakeholders' project specific goals. Results of the efficiency and effectiveness analysis on the case study sites are presented. The study aims to demonstrate how remediation sustainability and remediation efficiency can be related, an important question for national remediation programs worldwide.

T4-I.2 Annika, A*; Scheer, D; Sonnberger, M; University of Stuttgart; annika.arnold@zirus.uni-stuttgart.de

Risky transitions – how public perceptions of the energy transitions differ across countries and cultures

Climate change is one of the main drivers for a transformation of the energy system towards the use of sustainable energy sources. In Germany, this transition has become known as the “Energiewende”. However, such a large scale transformation cannot be achieved within national boundaries, but needs to be accompanied by European and even global measures, which in turn need the broad support of the public. Without people’s trust in the engineers and advocates for the energy transition, without the citizen’s willingness to accept sustainability as a normative driver itself, and without their willingness to support political decisions in favor of a sustainable energy system, this transition is at risk to fail. The proposed paper will look into the public perception of the energy transition across four European countries and will show, if and how these perceptions differ depending on cultural background and national policies. The large scale sustainability transformation is accompanied by a number of uncertainties, both factual and perceived. With this paper, we shed light on cultural differences and similarities of public assessments of the risks brought on by this transformation. The analysis of cross-national survey data reveals the perceived interrelations between the assessment of climate change and the evaluation of national and international energy policies in the four selected European nations (United Kingdom, France, Germany, and Norway). The public support of energy policies is not only a question of financial costs or energy security, but is also influenced by cultural patterns concerning risk perception towards e.g. nuclear energy or fracking as energy sources.

P.132 AOYAGI, M; National Institute for Environmental Studies; aoyagi@nies.go.jp

IPCC reports on Climate change and Media : comparing media coverage of IPCC AR4 and AR5

This paper compares and discusses two IPCC reports, AR4 in 2007 and AR5 in 2013~2014 with their media exposure and public perception on them in Japan. According to newspaper database, media coverage in 2007 and 2013~2014, though peaks were longer and higher in 2007, newspaper coverage for climate change increased in both periods in the world as a whole. But in Japan, the peak is none or very small in 2013~2014, while it is huge peak in 2007. We explore the reason why there were very few media coverage compared to 2007 media coverage on IPCC report in 2013~2014. Our hypothesis is its relationship of revising the Japanese Basic Energy Plan, which is deeply connected with Japanese economic situation at that time. Japan government submitted tentative 2020 Greenhouse gas reduction target (-3.8% compared to 2005) in November 29, 2013. The revised Basic Energy Plan was approved by the cabinet and released April 11, 2014, just after Japan government hosted IPCC WG2 general meeting on late March in Yokohama. This was followed by the Greenhouse gas reduction target for 2030 (-26% compared to 2013) in July 17, 2015. Interestingly, the Prime Minister Abe was governed both when AR4 and AR5 were released. During this period, so called gAbenomics h was implemented and it seemed to be worked well. Unemployment rate had been improved. We analyze this changes of target level, Japanese economic situation in those periods, energy policy, media coverage on climate change and public attitudes towards the climate change.

W4-F.5 Anyshchenko, A; University of Copenhagen; artem.anyshchenko@jur.ku.dk

Scientific criteria for the determination of endocrine-disrupting properties.

Endocrine disrupters, having potentially adverse effects on health, can interfere with human hormone system. However, there is no agreed scientific guidelines as to how to identify and evaluate endocrine disruption. EU legislation such as the Biocides Regulation, Plant Protection Product Regulation, REACH Regulation, and Cosmetics Regulation allows the marketing and use of chemical products if they do not bring on endocrine disruption in humans and non-target species. Biocidal products, for instance, cannot be marketed or used unless authorised in accordance with the Biocides Regulation. The use of biocides with highly hazardous properties is prohibited by law. In December 2015, the EU General Court in case T-521/14 Sweden v Commission declared that the European Commission breached EU law by failing to adopt measures concerning the specification of scientific criteria for the determination of endocrine-disrupting properties pursuant to the Biocides Regulation. Even after this judgement, it is unclear whether the Commission will take urgent actions to remedy the breach of law – it will be complicated to define clear rules in the light of scientific uncertainty. The Scientific Committee of EFSA, for example, notes the lack of scientific consensus with regard to the existence and relevance of certain aspects of effects and dose-response curves in ecotoxicology in connection with endocrine activity, endocrine disruption or other modes of actions. Apparently the EU has to act in conditions of scientific uncertainty. EU law requires that a high level of human health protection shall be ensured in the definition and implementation of all Union policies and activities. EU case law puts a special emphasis on the precedence of health and environmental protection over business interests and economic concerns. The question how to determine endocrine disruptors goes beyond the legal context, touching upon the relationship between science and law. Therefore, this issue deserves serious consideration.

T4-C.2 Aquino, GV; Sayes, CM; Lujan, H*; Baylor University; grace_aquino@baylor.edu

Understanding our exposure to emerging technologies: A screening level risk assessment of copper-containing micro- and nano-enabled products

The use of copper-containing, particle-enabled products in countless day-to-day activities, such as building/electrical materials, pesticides, transportation, paint, cosmetics, and clothing, is increasingly widespread. Reliable exposure information for copper intake is needed in order to conduct useful safety assessments. Essential information needed for these assessments includes the known health effects, the amount of product produced, the frequency of use, and the mechanisms of release from the product into the surrounding environment. A screening level risk assessment can be conducted to answer these fundamental questions with regard to copper nanoparticle-enabled products. To obtain current data, we used a 3-step experimental design: 1. assembled hazard data, 2. gathered production volume info, and 3. described product value chain stages. For each dominant copper species, market landscape data (an analyses of market size, penetration, and consumer needs) gave the yearly production values, distribution across the product value chain, and uses in products within five primary industries: building, electrical, transportation, consumer, and chemical. The available health hazard data was obtained from toxicological databases and the peer-reviewed literature; data gaps were filled using in vitro cell culture toxicity assays. Potential exposure was then determined using both data sets as well as literature describing intentionality. Results show that there are nine predominant copper species on the micro- to nanometer size scale whose effects on environmental and biological systems have been scarcely studied. In addition, our findings demonstrate that the potential exposure of these unique copper particle systems to environmental or human health systems is dependent on three factors: stage of the product life, production values at each stage, and complexity/composition of the nanoparticle product. Together, the specific hazard, exposure, and market data sets can provide better insight into product safety – applicable to workers, consumers, and the environment.

P.76 Arachy, H; Harvard University; *climateresearch@live.com*
Mercury Contamination in the Columbia River Basin: Health Risk Assessment of Tribal Exposure through Subsistence Lifeways
 Fish consumption is important to riverine tribal cultures & represents deeply held beliefs that have roots in spiritual practices, subsistence lifestyles and community. A principal exposure pathway of contaminants to riverine tribes is through fish consumption. A large Columbia River Basin database on concentrations of mercury in fish was used to evaluate trends for mercury contamination in fish from the waterways for a range of consumption rates. There were significant & important differences in mercury levels among species, but the locational differences were relatively small. The findings from this study demonstrated few fish are low enough in mercury to be safe for tribal members eating resident fish at traditional historic rates or at a moderate rate. The traditional methodology of a health risk assessment used is based on the use of exposure assumptions that represent the entire American population. To limit human risk to mercury residues in locally caught species, fish consumption advisories have been established to protect local populations from health risk. The state's fish advisories suggest reducing fish consumption with the goal of lowering risk; this shifts the burden of avoiding risk to the tribal members who now carry the burdens of contaminant exposure, socio-economic impacts and heritage and cultural loss. Tribal members are forced to choose between culture & health. These exposures represent potentially disproportionate risks for many tribes. These issues represent the potential inadequacy of health risk assessments to reflect important cultural differences in environmental justice communities. To rectify these risks federal and state agencies should take into consideration a subsistence traditional lifestyle when performing a risk assessment.

P.18 Arimoto, CW; Howard, PM*; ABSG Consulting Inc; *cameron.arimoto@gmail.com*
Establishing and Implementing Enterprise Risk Management in Government Agencies
 Government agencies face a variety of risks across their organization, from internal risks such as data breaches, human resources failures, and poor decision-making, to external risks such as a change in operating environments and mission-creep. A number of overseeing bodies, such as the Office of Management and Budget (OMB) and the Government Accountability Office (GAO) have been advocating for government agencies to implement an Enterprise Risk Management (ERM) program that identifies, assesses, evaluates, and prioritizes organizational-wide risks. These programs inform decision-making and enable effective mitigation of unacceptable risks. The first step in implementing an ERM program at a government agency is to determine what is the current state of risk management across the organization. The next step is determining which frameworks and guidelines are most applicable and appropriate for the particular agency. Finally, establish and execute the program to better inform strategic planning, performance management, and prevent catastrophic loss to an organization. This presentation will provide an overview of the process of establishing and implementing an ERM program in a government agency.

W2-D.5 Asfaw, A*; Centers for Disease Control and Prevention-National Institute for Occupational Safety and Health; *hqp0@cdc.gov*
Estimating Future Costs of the World Trade Center Health Program from Cancer Risk Data
 The James Zadroga 9/11 Health and Compensation Act of 2010 established the World Trade Center (WTC) Health Program. The WTC Health Program was begun on July 1, 2011, and was authorized to operate through September 2016. In 2015, Congress extended the Zadroga 9/11 Health and Compensation Act for an additional 75 years. The major objective of this study was to estimate the incidence and cost of 14 cancer sites covered by the WTC program for years 2016-2032. We formulated an equation that enabled us to estimate the number of responders and survivors that would join the WTC Health Program in each year. We also estimated the number of expected cancer cases by cancer type using a hypothetical cohort of responders and survivors that would potential join the program in each year. We followed the National Cancer Institute approach to estimate the direct medical costs of cancer (initial year care, continuing care, and last year of life care). The total number of cancer cases (new cases plus cases from previous years minus those who died) was estimated to grow from 3,333 in 2016 to 8,682 in 2032. The corresponding medical cancer cost for the WTC Health Program would grow from \$74.5 million in 2016 to \$184.1 million in 2032 in 2015\$. This is a 9.2% increase per year. To test the overall predictive power of our analyses, we compared the estimated number of cancer cases and costs with the actual number of cases and costs in 2015. Our model predicted 3,048 cancer cases in 2015 compared to 2,915 actual cases. Our cancer cost estimation for 2015 was a little bit higher than the actual cost. We estimated the cancer cost for 2015 to be \$68.9 million while the actual cost was \$42.9 million. One reason for this discrepancy could be the difficulty of the WTC program in assigning costs to cancer and non-cancer cases.

M4-E.1 Aven, T; University of Stavanger, Norway ; *terje.aven@uis.no*
Some Foundational Issues of importance for Risk Governance
 In this presentation the author makes some reflections on some fundamental topics within risk governance, highlighting risk conceptualisation, risk assessment, risk communication and perception, and decision making. Some of the theses discussed are: i) Current risk concepts and assessment practice are not providing suitable support for meeting the challenges we face today, ii) The effects of this is serious for risk communication, risk management and governance iii) There is a lack of appreciation of the need for managerial and political review that gives weights to uncertainties and weighs different concerns, which extends beyond risk analysis, and iv) The cautionary and precautionary principles are key pillars of risk management and governance.

M3-D.1 Azevedo, IL*; Vaishnav, P; Carnegie Mellon University; iazevedo@cmu.edu

Benefit cost and distributional effects analysis for solar PV in the United States

Solar irradiance varies by location and time, as do the private benefits – in terms of offset electricity purchases – of rooftop solar photovoltaics (PV). The health and environmental benefits of displacing a unit of grid electricity production, which stem from reduced emissions of carbon dioxide, nitrogen and sulphur oxides, as well as fine particulates, also vary by time and location. Furthermore, because pollutants are transported over large distances, the benefits of displacing grid electricity production may be felt far away from where the offset electricity was produced, and where the solar panel is installed. For example, the benefits of installing solar panels on a farmhouse in the countryside might be concentrated in the center of a densely-populated city, because the small improvement in ambient air quality there affects a large number of people. This distribution may have environmental justice implications. We perform a location-specific cost-benefit analysis that quantifies the county-level costs, benefits, and distribution of benefits for residential solar PV in the continental United States. We will also study how the environmental benefits and their distribution has evolved as the grid has changed; currently, in response to historically low natural gas prices, and in the future likely to due to regulations such as the US Environmental Protection Agency's Clean Power Plan. We will analyse the implications of these results for the subsidies needed to encourage adoption of alternative energies, and for environmental justice.

M4-A.3 Baik, S*; Davis, AL; Morgan, MG; Carnegie Mellon University; sunheeb@andrew.cmu.edu

Assessing the damage of large scale power outages to residential customers

Residents in developed economies depend heavily on services provided by electricity. While distributed resources and a variety of new smart technologies can be used to increase reliability, adopting them involves costs, requiring tradeoffs between cost and reliability. Making such tradeoffs requires accurate estimates of the value that customers place on the reliability of electric services. We develop a survey framework for helping individuals think systematically about the value they attach to reliable electric service. Our approach employs a detailed and realistic blackout scenario, full or partial (20A) backup service, questions about willingness to pay (WTP) using a multiple bounded discrete choice method, information regarding inconveniences and economic losses, and checks for bias and consistency. We apply the method to a convenience sample of 76 residents in Allegheny County, PA (interviewed for ~1 hour each). We find that respondents valued a kWh for the subset of services they assessed to be critical more than twice as much as a kWh for non-critical services. This difference increased as they received more information about the consequences of a blackout. With more information, respondents' uncertainty about how they valued full and partial backup services decreased. There was no evidence that respondents were anchored by their previous WTP statements, but they demonstrated only weak scope sensitivity. The results suggest that a low-amperage backup service can be cost-effective if there are frequent 24-hour outages, and becomes more feasible and affordable in regions expected to suffer longer widespread outages. In most cases, implementing the backup service is more cost-effective than buying a personal generator. Finally, we propose two methods to charge based on income levels, and show that implementing backup service without charging residential customers in poverty is economically feasible while creating a substantial amount of non-monetary benefit.

T3-B.2 Babcock, MD*; Wong-Parodi, G; Small, MJ; Grossmann, I; Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA 15213; mbabcock@andrew.cmu.edu

Stakeholder perceptions of water systems and hydro-climate information in Guanacaste, Costa Rica

In the face of changing environmental and socio-economic drivers, access to, understanding of, and the use of probabilistic climate forecasts and other sources of improved scientific hydro-climate information are important for informed risk management in the water sector. In order to extend previous research into the factors that predict forecast use, this paper characterizes and compares local stakeholder group perceptions of the water system and hydro-climate information in the seasonally dry province of Guanacaste, Costa Rica. Semi-structured interviews were conducted with a total of 40 participants from seven water-related groups (government, large and small farmers, hydroelectric managers, tourism businesses, local water committees, and the public). Interview results were used to compare mental models of the drivers of water systems and scarcity mitigation and adaptation options, and to explore stakeholder information needs, accuracy perceptions, and use. Our results suggest that: 1) while there appear to be similar perceptions of the drivers of rainfall and groundwater, there is a gap between groups in the use of forecasts, the awareness of management options, and the level of detailed understanding of how the interactions of the water system works; 2) there are potential mismatches between the information presented in rainfall forecasts and the stated and/or salient information needs of some stakeholders, specifically in the case of groundwater resources; 3) there appear to be different perceptions of forecasts even among groups that rate the accuracy of such forecasts the same; and 4) there appears to be a relationship between the use of forecasts and certain types of management actions such as long-term planning. Our findings may contribute to the development of communications that help stakeholders make informed risk management decisions about freshwater in semi-arid regions.

M4-G.3 Banan, Z*; Gernand, JM; Pennsylvania State University; zfb5010@psu.edu

Quantification of Emissions Exposure Risk from Hydraulic Fracturing in the Marcellus Shale Region of Pennsylvania

During the past decade, shale gas has become an important low-cost strategic energy source with considerable economic and environmental benefits. However, there still exist risks to human health and the environment caused by emissions from diesel engines which are used in shale gas development activities. These emissions are mainly characterized to be volatile organic compounds (VOCs), nitrogen oxides (NOx), sulfur oxides (SOx), and particulate matters (PM2.5 and PM10). These pollutants can cause acute diseases, such as respiratory symptoms, lung and heart diseases, and chronic health impacts, such as cancer. Therefore, public concern about industrial hazardous air pollutants (HAPs) has been focused on unconventional gas development activities. This study develops a model to quantify the level of environmental health risk associated with these emissions. The model is a damage-function approach which uses exposure concentrations and duration as input and models human health impact as the output. Exposure values are calculated from aerosol emission dispersion models of shale gas activities over the relevant areas, considering density and timing of these activities. A Gaussian plume model is used to simulate emissions concentrations. To develop comprehensive results, there is a need for dealing with environmental variability at each well location. Sensitivity analysis on the role of meteorological conditions on local pollutant concentrations helps to establish the probable range of exposure values at different locations. The output of the model is a map of probabilistic disease risk as a function of geographic area and emission rates. Based on these maps, we develop policy recommendations for density of shale gas development activity in time and space.

T2-A.3 Baroud, H; Vanderbilt University;
hiba.baroud@vanderbilt.edu

Modeling the risk of interdependent infrastructure systems: an analysis of water and energy systems under climate change uncertainty

Water resources management has become challenging in recent years due to a number of varying factors impacting water usage, demand, and availability. In addition to household consumption, water plays a critical role in the effective operation of other interdependent critical infrastructure systems such as transportation through inland waterways and electricity through thermoelectric and hydroelectric power generation. As a result, careful assessment of water demand and its future usage under uncertainty is an emerging research topic resulting in impactful outcomes on policy making and risk management. While prior studies have targeted the implication of different policies and climate change predictions on water resources, little attention is given to the development of models and approaches that account for the probabilistic risk and cost-benefit analysis of water management strategies given interdependent relations between water and other infrastructure systems. The purpose of this work is to model the interdependency of water and energy systems under uncertainty as both infrastructures are interconnected and are facing multiple future uncertainties that will impact their operations. This study develops an approach that integrates information related to the future behavior of water and energy systems. The framework developed will first identify interdependent relations between water and energy systems that govern their daily operations under normal conditions. In a second step, a probabilistic risk analysis will identify future scenarios that alter the balance between the two infrastructure systems and result in a shift in the demand as well as the limitation of resources due to uncertain climate-related forecasts. This study will assist in evaluating different water management strategies to address decreasing water resources and increasing power demands.

P.10 Barros, E*; Borges, MMF; University Centre for Disaster Studies and Research on the State of Paraná ;
edemilson.barros@gmail.com

SISDC Mobile: A support tool for municipalities for disaster management.

In Brazil disaster risk management is governed by Federal Law 12,608 of 10 April 2012. This law deals with, among other things, the powers of the Union, states and municipalities so that, within its powers to execute the National Policy protection and civil defense. In this sense, the State Coordination of Protection and Civil Defense of the State of Paraná (CEPDEC) has been developing since 2005, a system called Computerized System of Civil Defense (SISDC) to support municipalities in disaster management. The SISDC has been established as an important tool to support municipalities in disaster management, however, the CEPDEC noted the need to develop a specific tool for municipalities could improve the quality of their areas of mapped attention to the possibility of carrying out a mapping in remote locations, and subsequent transmission of information the SISDC. Thus, in partnership with the State of Paraná Technology Company (CELEPAR) in 2016 was released the mobile version of SISDC (available on google play store in two versions: training and system) which provides municipalities in the state the following features displayed: - Mapping of Attention Areas of flooding and landslides. Armed mobile version on your Tablet/Smartphone the operator can create a new area on a base previously registered map, marking points on the field or walking through the area. - Specific form for flooding area. - Specific form for registration landslides areas. - Individual registration form for residences in Attention Areas. The State Protection and Civil Defense Coordination believes that the implementation of this tool is a milestone in the progress of the Civil Defense in the state of Paraná, it is a unique, modern and functional tool that much will collaborate with the 399 municipalities in Paraná for that can make a proper risk management of disasters, increasing resilience and contributing to the preservation of life.

W2-C.1 Barrett, AM*; Baum, SD; Global Catastrophic Risk Institute and ABS Consulting; tony@gcrinstitute.org

Technology Forecasting for Analyzing Future Global Catastrophic Risks

Emerging technologies in several domains, including artificial intelligence (AI) and synthetic biology, are becoming increasingly powerful. While these technologies offer great benefits, they also pose hazards of accident, misuse or unintended consequences that could result in global catastrophe at some point in the future. Such risks can be significantly reduced with enough foresight and advance warning, but also can be difficult to characterize due to the general challenges of technological and long-term forecasting. For some technologies, the key factor may simply be when it is invented or available; for others, it may performance or affordability in a specific context. In this work, we primarily present an initial set of graphical and quantitative models of future development of AI technologies, as well as intervention options that could affect risks, derived from published literature. We also contrast with forecasting of other technologies such as in synthetic biology. Finally, we discuss general issues such as evaluation of forecasting performance, and integration of forecasting models in risk and decision analysis.

W2-B.1 Bartelt-Hunt, SB*; Sallach, JB; Snow, DS; Li, XL; Hodges, LH; University of Nebraska-Lincoln and Michigan State University;
sbartelt2@unl.edu

Methods Development and Environmental Research on Antibiotic Uptake into Food Crops

Increasing stress on freshwater supplies, a result of increasing global population and climate change, has made necessary the reuse of wastewater as a source for crop irrigation. Municipal and agricultural wastewater is a known reservoir for many biologically active contaminants including antibiotics. The use of wastewater for irrigation provides a pathway for antibiotics to be internalized into produce. To evaluate the risks from antibiotic occurrence in irrigation water, analytical methods are needed to accurately quantify antibiotics in food crops. We compared four methods for antibiotic extraction from vegetative matrices including freeze-and-thaw cell lysing, mechanical maceration, tissue sonication, and microwave-assisted solvent extraction. The methods were evaluated based on method detection limits, analyte recoveries, and sample preparation time. Freeze-and-thaw cell lysing provided the highest level of extraction efficiency on environmental samples and required the least amount of sample preparation while providing adequate detection limits and reproducible analyte recovery. In a follow up study, we investigated the influence of soil texture and drought conditions influencing antibiotic occurrence in soil and uptake into produce when antibiotics are introduced via irrigation water. The influence of drought conditions was found to be compound specific with increasing drought stress resulting in increased uptake of lincomycin and decreased uptake of oxytetracycline and sulfamethoxazole. To evaluate soil texture, the uptake of three antibiotic compounds (lincomycin, oxytetracycline, and sulfamethoxazole) was monitored in lettuce grown in three soils with different soil texture, all with low soil organic matter. Uptake as a function of soil texture was also determined to be compound specific. These results indicate that site specific information such as physical location and environmental conditions should be taken into account when determining the risks from antibiotic uptake by produce after irrigation with reused wastewater.

P.128 Bartlett, R; California Department of Public Health ;
russell.bartlett@cdph.ca.gov

Enhancing Environmental Risk Assessment with the Protocol for Community Excellence in Environmental Health

Organizations working in communities confronted with social and environmental stressors should apply balanced approaches that assess technical aspects of contamination and promote broad community collaboration. From October 2014 thru April 2016, the California Department of Public Health (CDPH) facilitated the Protocol for Assessing Community Excellence in Environmental Health (PACE EH) in a Los Angeles city challenged by environmental justice concerns. CDPH implemented PACE EH while conducting public health assessments (PHAs) at two Superfund sites located in the city. PHAs assess possible health risks to communities resulting from hazardous waste site contamination. The PACE EH unites communities and health agencies to evaluate and address community environmental health concerns collaboratively. Per PACE EH guidance, CDPH formed and cultivated a “Community Environmental Health Assessment Team” (CEHAT), a committee comprised of community residents, local organizations, and government stakeholders. The CEHAT gathered the public’s environmental health concerns using a CDC-based qualitative survey. CEHAT used the survey data to rank, assess, devise strategies, and carry-out action steps that are currently addressing the community’s most vital concerns. CDPH was able to foster robust support for the PACE-EH process from community residents and governance at the local, state, and federal levels. In the short-term the acquired multi-level trust allowed CDPH to: 1) seamlessly assess community concerns, 2) evaluate environmental contamination, 3) promote health information, and 4) quickly acquire feedback. CDPH is integrating portions of the PACE-EH results into the PHAs. The broader outcomes resulting from PACE EH are the community’s expanded capacity to address their most important environmentally related concerns and the creation of a positive space where state and federal agencies can effectively cooperate to conduct clean up and health promotion work in the future.

P.16 Bates, A*; Castellino, A; Mangalam, S; Retirement Homes Regulatory Authority; *angela.bates@rhra.ca*

A risk based framework to protecting the rights of residents of retirement homes in Ontario, Canada

This paper will be presented by the Retirement Homes Regulatory Authority (RHRA), who are responsible for overseeing Ontario retirement homes’ compliance with legislative requirements, and educating the public, the retirement home sector and residents about these requirements, the rights of residents, and best practices for the operation of retirement homes. The RHRA will discuss the particular challenges of building a risk framework to accommodate the organization’s broad mandate, which includes protection of residents’ dignity, respect, privacy, autonomy, security, safety, comfort, and informed choices about care options.

W4-E.1 Barton, CA*; Bingman, TS; DuPont;
catherine.a.barton@dupont.com

A risk-based framework for issues management

Organizational leaders want to anticipate and manage high-priority issues that have the potential to disrupt business or to become a crisis. This presentation discusses a risk-based framework for issues management that helps an organization identify, prioritize and manage emerging issues with the greatest potential for risk to the organization. It begins by deconstructing the risk equation to express the probability and business impact of an issue in a new way. The probability of an issue becoming a business problem is a combination of rising stakeholder concern combined with business relevance. The presentation includes a set of characteristics that can be used as indicators to assess this probability. The vast majority of issue management methods do not consider the impact of an issue in a way that has depth and power that speaks the language of the business. Here, business impact is characterized by conceptualizing potential outcomes associated with an issue and translating those outcomes into top-line and bottom-line financial metrics that will be meaningful to business-minded people who represent the ultimate decision-makers in a company. Probability and business impact associated with an issue can then be plotted on a nine-quadrant risk map to prioritize the issues with the greatest potential risk. The final step in the framework is to manage risk associated with an issue. The key to good risk management is good decision-making. Tools are presented for guiding discussions that will help an organization assess their options and develop alternatives. Finally, a series of case studies is presented, showing the application of the framework for managing several chemical issues.

T3-F.4 Bates, ME*; Linkov, I; US Army Corps of Engineers, Engineer Research & Development Center;
matthew.e.bates@usace.army.mil

Incorporating More than the Weather: Differentiating Reservoir Operations Based on Seasonally Varying Opportunity Costs and Value at Risk

Forecast-Informed Reservoir Operations (FIRO) is fundamentally a decision-analytic problem about tradeoffs between risk and benefits, usually for multi-purpose reservoirs (e.g., for flood control and water supply). Some portion of the risk and benefit calculations are informed by weather modeling, which is increasingly being investigated in this context. Other portions of the risks and benefits calculations can be informed by other types of models and data, which have received significant attention independently but less attention in a multi-objective, FIRO context. Explicit exploration of the subjective value tradeoffs between risks and benefits and their implications for reservoir operations have also not been sufficiently addressed. This presentation will present a framework for incorporating seasonal forecasts about the changing value at risk from flooding downstream of the reservoir (e.g., due to fluctuating agricultural production) and seasonal forecasts about changes in potential opportunity for water benefits (e.g., due to fluctuating environmental needs, urban water supply needs, hydropower opportunities) into FIRO. These factors deserve scrutiny alongside improved consideration of weather forecasts to help quantify the probability of flooding.

P.188 Baucum, MP*; Rosoff, H; John, RS; University of Southern California; baucum@usc.edu

Reactions to Terror: In the Air and on the Ground

Understanding the differential impact of terrorism across the various contexts in which it strikes is of paramount importance for researchers and policymakers who wish to keep up with terrorism's evolving nature. Extant literature has focused mainly on terrorism in the aviation sphere, largely due to the high-profile and disastrous nature of the 9/11 attacks. However, recent research has suggested that the threat of terrorism today looks much different than it did in 2001, shifting more towards soft-target attacks on urban spaces and public transportation systems. Given the apparent shift to low-security targets, the current paper aims to uncover how the context of an attack might affect the public's psychological and behavioral reactions. This study presented participants with mock news stories featuring 1) a suicide bomb on a public bus, 2) a cyberattack on a public train, or 3) a suicide bomb at an airport passenger terminal. Path analysis was used to model the relationships between pre-standing risk attitudes and post-scenario measurements of negative affect, risk perception, and intention to alter travel behavior. Analyses revealed that the attack context manipulation had its greatest impact through moderating the relationships between other risk-related variables. Results also replicated past findings regarding the nuanced role of negative affect in risk perception. We discuss the usefulness of Partial Least Squares path analysis in risk perception studies, as well as how our results reflect aviation's focal role in the Western terrorism narrative and how this might affect future research endeavors and risk communication efforts.

P.2 Beaudry, M*; Lemyre, L; Blust-Volpatto, SA; Boutette, P; Pinsent, C; University of Ottawa; mbeau174@uottawa.ca
Inter-organizational collaboration during complex risk events: Communication task performance and satisfaction in homogeneous and mixed stakeholder teams

During complex risk events, emergency management organizations are faced with the necessity to collaborate with external organizations that often have different cultures and command systems. To ensure the short and long-term success of these collaborations, it is important to understand the key drivers of performance and of stakeholder satisfaction in mixed teams. This study examined interorganizational collaboration using in vivo simulation in a public communication task related to a complex radiological event. Participants in this simulation were senior disaster and emergency management officers working in three types of organizations: the military, emergency response services (with incident command system), and public service organizations (without incident command system). Comparing homogeneous and mixed teams, we examined externally-rated performance (decision quality), self-rated process and outcome satisfaction, and self-reported team functioning. Nonparametric analyses revealed that externally-rated performance was significantly higher in homogeneous teams and that mixed teams experienced more frequent differences of opinion. Despite mixed teams experiencing more frequent differences of opinion, frustration with these was negatively associated with performance only in homogeneous teams. In mixed teams, performance was related to higher sense of belonging and broader leadership distribution. Satisfaction with problem-solving process in homogeneous teams was associated with performance, sense of belonging, and trust, while satisfaction with problem-solving process in mixed teams was associated with satisfaction with outcome. More research is needed to capture factors influencing performance in mixed interorganizational teams across various types of tasks, and across the risk management timeline. In particular, the role of social identity and shared governance are to be further investigated. Lastly, training may benefit from exercises and simulations in mixed teams.

T3-F.2 Beaudrie, CB*; Lyle, T; Long, G; Mills, T; Compass Resource Management Ltd. and University of British Columbia; christian.beaudrie@gmail.com

Managing Coastal Flood Risks: A Structured Decision Making (SDM) Approach to Mitigating the Impacts of Sea-Level Rise in Vancouver, British Columbia

Rising sea levels pose increasing flood risks for coastal communities, particularly major population centers along the British Columbia Coast. With a projected sea level rise of 1m by 2100, BC communities face the challenging task of understanding hazards, vulnerabilities, and consequences from flood events, and identifying suitable measures to protect multiple interests over large areas. This talk highlights the application of a Structured Decision Making (SDM) approach to evaluate the impacts of sea level rise and select mitigation options to reduce flood risks for Vancouver, British Columbia. The process involved a series of stakeholder workshops to identify interests that may be impacted, develop suitable mitigation alternatives, review performance of each alternative and consider trade-offs, and finally to develop recommendations for a suite of mitigation alternatives to protect vulnerable neighbourhoods across the city. To address the challenge of communicating complex risk information, stakeholders were engaged using multiple methods, including spatial illustrations of flood extents for a number of flood scenarios, risk curves, and interactive decision support tools to facilitate comparison of alternatives and trade-offs. This work breaks new ground in evaluating the implications of sea level rise on coastal communities, and provides a model for other communities grappling with the challenges of assessing and managing flood risks from a rising sea.

T4-B.3 Beaulieu, SM*; Mokhtari, A; Anderson, ME; Kelly, R; Swanson, S; Jaykus, LA; Neptune and Company, Inc.; sbeaulieu@neptuneinc.org

Not So Secret Agents in Retail Food Settings: Application of an Agent-based Model to Evaluate Norovirus Intervention Strategies

Previously, we presented a predictive risk model that simulated the interactions among agents and human norovirus (HuNoV) in a long-term care facility (LTCF). This agent-based model—the On-line Predictive Tool to Investigate Mitigation Alternatives for Norovirus (NorOPTIMAL-LTCF)—was developed to better understand disease transmission, exposure, and infection in a microenvironment. The model serves as a virtual laboratory for risk assessment practitioners and students, allowing the user to investigate interactions among multiple risk factors (e.g., poor personal hygiene, contaminated food, aerosolized viral particles). Building from our experience with NorOPTIMAL-LTCF, we developed NorOPTIMAL-Food, a predictive ABM intended for application to the food service industry. As with the LTCF version, NorOPTIMAL-Food supports the evaluation of interventions on the basis of cost and risk reduction. For the food service microenvironment, the model simulates interactions among agents and risk factors associated with the contamination, spread, and HuNoV infection. We used NorOPTIMAL-Food to test different intervention strategies that influence human behaviors and best practices. For example, we considered interventions intended to increase the sanitation compliance and efficacy for food contact surfaces, food safety measures, and operational practices. Preliminary results suggest that cost-effective risk control measures can be developed. For example, (1) food safety measures (e.g., proper handwashing and gloving) can decrease the likelihood of HuNoV spread within the facility via cross-contamination, (2) proper use of surface sanitizers and disinfectants can reduce the impact of cross-contamination, and (3) removing infected staff from the food service setting for at least 48hrs after the end of the symptoms can reduce the likelihood of an outbreak. This methodology offers a practical approach to evaluate the efficacy of interventions in the food service settings.

W3-B.1 Beaulieu, SM*; Stockton, T; Wind, J; Neptune and Company, Inc., Partners in Sustainability Integration (PSI); sbeaulieu@neptuneinc.org

Structured Decision Making Applied to Wicked Problems: Using Bayesian Belief Networks to Make Decisions Under Uncertainty
Structured decision making (SDM) provides a transparent framework to develop optimal solutions to complex problems. The process is reproducible and technically defensible, integrating science and values in an analytic-deliberative structure. However, because critical issues are invariably a function of values and preferences among stakeholders, we emphasize the importance of value-focused thinking throughout the early stages of the decision process. Value-focused thinking not only leads to a rich set of potential options and strategies, but it also ensures that the values, rather than the options, drive the decision. Simply put, by making values and preferences explicit, and providing a structure with which to “translate” these values and preferences into decision objectives, we create a process designed to select an option that optimizes overall value. The implementation of SDM involves probabilistic consequence modeling and, in this presentation, we advocate the use of Bayesian Belief Networks (BBN). BBNs provide a graphical, intuitive way to capture the complexity of the decision problem, with nodes representing variables in the “system” under study. The BBN provides for forward/backward reasoning, and supports sensitivity analyses to identify influential variables and value of information analyses to address sources of uncertainty. Ultimately, SDM provides insight into how our values, preferences, and assumptions influence the decision, and how we can make the best use of available science and data to arrive at optimal decisions. To illustrate the advantages of SDM, we chose a “wicked problem” at the nexus of food safety/security, energy usage, and water availability. In this hypothetical study, we demonstrate the relationship between value-based objectives and the evaluation of tradeoffs among economic, health, and environmental impacts. In addition, we explore value of information concepts and their importance to decision making under uncertainty.

T4-G.5 Becker, RA; American Chemistry Council; rick_becker@americanchemistry.com

Creating a Web Portal to Facilitate Access to Consumer Exposure Science Methods, Databases, and Projects

The Catalog of Consumer Exposure Initiatives (CCEI) web site was conceived as a pilot project to explore the utility of creating a portal to help users find and access publicly available exposure tools, databases, and projects that play important roles in the field of consumer exposure science. Creation of the CCEI was driven, in part, by the recognition that information on consumer product ingredients, exposures and use can be challenging to locate. As a portal, the CCEI is not intended to recommend or endorse specific data, models or methods; rather the goal is promote knowledge sharing that can maximize impact of ongoing activities and also better inform future research. The CCEI pilot web portal currently contains links to approximately 150 sites, including, for example, 1) links to consumer product ingredient disclosure and exposure initiatives by various product organizations or companies in the U.S. and Europe; 2) links to relevant activities by the USEPA and other government agencies to determine functional composition of consumer products, surveys on consumer uses of chemical products and research analyzing products from store shelves to define percent composition of specific chemical ingredients; and 3) links to methods, models and databases published in the scientific literature. The information in the CCEI can be accessed in multiple ways, including using an exposure framework graphical interface (nodes consisting of manufacturing, use, formulated product, releases/ transport to media and interaction with receptors; a live demonstration of this interface will be demonstrated).

W2-F.3 Becker, RA*; Manibusan, MK; American Chemistry Council ; rick_becker@americanchemistry.com

A Method for Quantitative Scoring of Causality for Side-by-Side Comparison of Confidence for Alternative MOAs (Including Case Examples)

Building from the IPCS MOA framework, which focuses on biological pathways of sequentially linked key events that culminate an adverse outcome (cancer), we have derived a straight forward method for quantifying evidence underpinning each key event within a postulated MOA and integrating the evidence across all the key events in a manner that produces an overall scientific confidence score. Information from in vitro, high throughput and high content technologies is mapped to specific key events within a postulated MOA. The evolved causality elements of essentiality, dose response and temporal concordance, consistency (among different biological contexts) and analogy (consistency across structurally similar chemicals) are used. We have calibrated and demonstrated this method with data of chemicals that are known to induce rodent liver tumors by specific MOAs (e.g., PPAR-alpha, cytotoxicity and sustained regenerative hyperplasia, and mutagenesis). This method enables a) quantifying the degree of confidence that a given substance produces cancer by a specific MOA and b) side-by-side comparison of numerical confidence scores for alternative MOAs for that substance. Such confidence scoring can be used to identify the predominant MOA, communicate the level of certainty associated with each MOA and provide scientific justification for selecting extrapolation methods to be used for human health risk assessment.

T3-G.4 Belova, A*; Greco, SL; Burnett, RT; Abt Associates, Public Health Ontario, Health Canada; anna_belova@abtassoc.com
Global Extrapolations of Fine Particulate Matter Mortality Impacts: A Comparison of Two Widely Used Concentration-Response Functions

Two types of risk analyses are increasingly conducted in many parts of the world: estimating the burden from a particular public health threat (e.g., air pollution) and estimating the benefits from reducing this threat. These analyses aim to understand the magnitude or nature of particular public health concerns and develop optimal risk management strategies. There is considerable interest in applying the knowledge base from countries with a long history of implementing public health risk analyses to support similar analyses in countries with limited data. We focus on extrapolation-based analyses of outdoor fine particulate matter (PM_{2.5})-related mortality. One approach is to use the results of an outdoor PM_{2.5}-mortality study developed in one country (e.g., US-based American Cancer Society [ACS] study) to estimate PM_{2.5} burden/reduction benefits in another country. This approach has a known upward bias in areas with higher PM_{2.5} levels than those measured in the source study and models with the log of concentration have been used to address this bias. Another approach is to use the Global Burden of Disease's Integrated Exposure-Response Function (IERF) which combines results of outdoor PM_{2.5} studies with indoor smoking and cookstove studies (having higher PM_{2.5} levels) to describe PM_{2.5}-mortality risk across a wide concentration range. Some contend that mortality risk estimation in areas with high outdoor PM_{2.5} should be done by applying the IERF rather than one outdoor PM_{2.5} study. We compare extrapolation from one study (ACS) with the IERF to estimate (1) the mortality burden of outdoor PM_{2.5} and (2) the benefits of a 100 tonne reduction in emissions of primary PM_{2.5} in 42 large cities around the world. This session will discuss findings, highlight discrepancies, and propose guidelines for when it may be acceptable to apply the less data-intensive single study approach. Also, we will compare the extrapolation-based results with available in-country evidence.

W4-H.2 Belova, A*; Mills, D; Abt Associates;
Anna_Belova@abtassoc.com

Public Health Co-Benefits of Climate Change Mitigation in the Philippines' Wastewater Sector

Background: In 2000, approximately 5% of the Philippine's estimated greenhouse gas emissions were attributed to the wastewater sector. At the same time, the combination of inadequate drinking water supplies and sanitation systems and services are among the main risk factors for intestinal infectious disease—and among the top 15 leading causes of death in the Philippines. Expansion of centralized wastewater collection and treatment facilities can improve public health and reduce greenhouse gas emissions. Methods: We assess the potential public health co-benefits of actions under consideration that would expand coverage of centralized wastewater treatment in the Philippines' that would also provide a greenhouse gas mitigation benefit over the period 2010-2050. Potential health benefits are quantified using a relationship estimated with cause-specific mortality rates from the 2013 Global Burden of Disease Project and data on the types and extent of sanitation coverage from the World Bank for 185 countries from 1990-2013. To help incorporate these co-benefits in standard economic assessments of infrastructure projects we monetize the avoided mortality using a Value per Statistical Life (VSL) obtained by adjusting a value for OECD countries for differences in Philippine income. Results: We estimate the planned increase in improved centralized wastewater treatment systems could result in 106 thousand avoided premature deaths from intestinal infectious disease over the study period with an associated value of \$98 billion (2010 USD, 5% discount rate). Conclusions: Select climate mitigation strategies in the Philippine wastewater sector could generate significant health co-benefits.

T4-A.2 BENOUAR, D*; ZELLOUM, H; EL HADJ, F; University of Science & Technology Houari Boumediene (USTHB);
dbenouar@gmail.com

A post-event investigation of the 2008 Ghardaia (Algeria) flood and debris flow disaster

This paper attempts, as a case study, to investigate, in a forensic style, the Ghardaia (Algeria) floods and debris flows of 1 October 2008 of which the official assessment of the catastrophe is very significant. Eight of the 13 districts of the surrounding Ghardaia province have been affected by the floods and 600 homes have been inundated in the town. However, considering the scale of the disaster – eight willayas were affected in a diameter of 30 kms along the River M'Zab and approximately 2,000 families in need. The floods also left about a 1,000 of people homeless and many other people are missing. Hundreds of people had to be rescued by helicopters and up to 600 houses are estimated to be destroyed in the rains of Tuesday, Wednesday and Thursday. It was reported in the press that 80 % of human and material losses, in the province of Ghardaia, caused by the flood, are mainly due to human error. The water pressure caused a 70 meter opening in the dam and the flood run at more 1200 m³/s on the city of Ghardaia. It is recommended to make a detailed analysis to determine the causes and reasons that led to the collapse of the walls of the dam of El Djerraf built there barely ten years. The geology of the site is to be considered in this context. It is known that the M'Zab region is a rocky area. Runoff is almost 100%. This is one reason that amplified the scope of flood of River M'Zab. There is also the fact that all the rivers operated at full capacity this: rivers Labiod, Erguedane, Laadiret, Noumirt and Nssa. At the time of the surge, the waters in their have encountered sewage system filled of garbage, tree trunks, plastic bottle and bags, etc. Urban fabric has been involved seriously in the amplification of this disaster as well as the lack of a warning system as the huge amount of water came from the city of Hassi Rmel at 126 kms of the site of Ghardaia. A catastrophe of such a scope cannot have a single cause. It can be only the result of several failures and thus need a forensic style of investigations to determine the root causes of the flood disaster.

M3-G.3 Belzer, RB*; Lewis, RJ; Good Intentions Paving Co. and Exxon Mobil Biomedical Sciences, Inc.;
luke@goodintentionspaving.co

Are Measured Differences in Pulmonary Function "Different"?

Characterizations of risk from ambient air pollutants often depend on chamber and observational epidemiology studies that measure differences in pulmonary function (e.g., forced vital capacity [FVC] and forced expiratory volume [FEV₁]). Previously we have shown that conventional protocols, such as those developed by the American Thoracic Society, may include substantial measurement error because not all maneuver data are collected and some data that are collected are routinely discarded. In this paper we calculate the probability that measured differences in FEV₁ values obtained before and after exposure to a pollutant are actually "different" — i.e., unlikely to have occurred by chance. Data from recent ozone chamber studies will be analyzed to illustrate how average FEV₁ declines observed may be more likely to occur by chance when measurement error is taken into account.

P.57 Bergion, V*; Rosén, R; Lindhe, A; Chalmers University of Technology; *viktor.bergion@chalmers.se*

Combining Quantitative Microbial Risk Assessment and Disability Adjusted Life Years to estimate Microbial Risk Reduction for Cost-Benefit Analysis in Drinking Water Systems

Waterborne outbreaks of gastrointestinal diseases can result in large societal costs. Health care costs, productivity losses, costs of illness and costs due to reduced trust in drinking water authorities are some examples. To mitigate waterborne diseases, microbial risk reduction measures can be undertaken. In order to choose the most appropriate microbial risk reduction measure(s), drinking water authorities need transparent and structured decision support. Quantitative Microbial Risk Assessment (QMRA) estimate the microbial risks in a drinking water system, and commonly, Disability Adjusted Life Years (DALYs) are used as a metric for potential negative health effects. We present a novel approach, combining QMRA and economic valuation of DALYs in order to estimate and monetise health benefits resulting from microbial risk reduction measures in a drinking water system as input for Cost-Benefit Analysis (CBA). Health benefits, other benefits and the costs were used to compare the different microbial risk reduction measures, using CBA. To include uncertainties in the CBA, Monte Carlo simulation was used for calculations of the Net Present Value (NPV). Lake Vomb in Sweden was used as a case study, in which different microbial risk reduction measures for On-site Wastewater Treatment Systems (OWTSs) were compared. Preliminary results indicate that connecting the ten OWTSs posing the largest microbial risk has the highest probability of a positive NPV in the CBA. This approach will make up a key part of a transparent and structured decision support framework for drinking water authorities. Furthermore, using DALYs as a health indicator, it is possible to compare mitigation measures that reduce both chemical and/or microbial health risks and to compare measures implemented in different parts of the drinking water system. The study was performed within the project "Risk based decision support for safe drinking water", funded by the Swedish Water and Wastewater Association.

W4-I.1 Besley, JC*; Yuan, S; Dudo, A; Michigan State University; yuanshup@msu.edu

Scientists' willingness to partake in public engagement as a function of controversy and riskiness

Research focused on scientists' public engagement attitudes and behaviors has escalated in recent years. This work has revealed scientists' propensity to partake in public communication and their preference for certain outreach modalities. Crucially, this work also continues to identify attributes that are commonly associated with scientists' willingness to participate in public engagement. This research presentation will contribute to this effort by examining the extent which scientists' public engagement behavior is influenced by the amount of controversy and risk they associate with their particular research area. In 2015/2016, the research team conducted a large-scale survey project of scientist members of eight professional scientific societies ($n = \sim 8,000$). The survey included questions about the amount of risk scientists think the public associates with their area of research and the level of controversy they associate with their field. Initial analyses using only a limited portion of the data suggest that scientists who see their field as being more controversial are more likely to have engaged in the past and more willing to engage in the future. Further, these results are consistent across several different modes of outreach. In contrast, the risk profile scientists believe the public associates with their research area are, at best, weak predictors of engagement behavior. Further, these views on risk and controversy are also either weak or non-significant predictors of prioritizing particular communication objectives and goals. Additional research based on the research team's entire data set will provide a more rigorous test of these relationships. Our efforts will provide much needed insights about the extent to which scientists' outreach is affected by the degree of controversy and riskiness they link to their particular research area.

M3-J.7 Betz, MB*; John, RS; University of Southern California; betzm@usc.edu

Fear and loathing following a terrorist attack on a commercial passenger plane

In the fifteen years following the events of September 11th, the Transportation Security Administration (TSA) has implemented a number of policy improvements to flight and airport security in response to numerous threatening events. However, within the changes implemented by the TSA, public perception of and possible reaction to potential terrorist attack scenarios involving air travel are still not understood. This talk reports on an experiment to assess the independent and interactive influences of seven systematically manipulated variables differentiating terrorist attack scenarios on US flyers' emotions, beliefs, and behavioral intentions. Manipulated variables include the following factors: (1) Attacker (passenger vs. insider), (2) Flight origin (domestic vs. foreign), (3) Suicide (person delivered vs. remotely delivered weapon), (4) Casualties (near-miss w/20 deaths vs. crash w/200 deaths), (5) Weapon type (conventional vs. non-conventional), (6) Location (airport vs. in-flight), (7) Airline (US vs. foreign carrier). Flyers recruited from an online subject pool are randomly assigned to one of eight unique combinations of the seven dichotomous factors, employing a 1/16 fractional replication design. After reading a graphic news story describing the particular terrorist attack and its aftermath, flyers respond to questions related to positive and negative affect, perceptions of threat, vulnerability, and risk perception, as well as behavioral intentions to fly in the near future. Individual flyer characteristics, such as sex, age, locus of control, risk taking propensity, and political orientation are included as covariates. The results of this study provide valuable insights into likely US flyer reactions to various terrorist attacks on commercial aviation.

W4-I.2 Bessette, DL*; Wilson, RS; Beaudrie, CE; Doohan, D; Culman, SW; The Ohio State University; bessette.2@osu.edu
Structured decision support for organic farmers: Lowering barriers, clarifying trade-offs and linking risk management strategy performance to farmer values.

In this research, we build upon previous work by the authors deploying active decision-support frameworks (DSF) across multiple risk contexts to engage a population in particular need of science-based, risk-focused, decision-support interventions: farmers. Managing weeds is often cited as the most problematic management challenge in organic agriculture, and a key reason why conventional farmers will not transition to an organic production system. Our past research indicates that organic farmers struggle to make the complex value-based tradeoffs required when predicting how diverse suites of weed management strategies perform over time. Due to the inherent complexity and uncertainty in the agroecosystem as well as the decision process (e.g., balancing short-term profit-based objectives against long-term sustainability-based objectives), farmers tend to rely more on past experience and simplifying heuristics than an objective deliberation of scientific facts and figures. Organic farmers could benefit from a set of tools helping them to more deliberately (versus heuristically) use the best available knowledge when making weed management decisions. As a result, we built a software-based DSF that incorporates tenets of structured decision-making (SDM) and value-focused thinking to present the predicted impacts of weed management strategies across diverse objectives (profitability, time and money spent weeding, soil health) and values (quality of life, social impact). Following an extensive advisory process in which organic farmers evaluated and revised the logic, measures, practices and values included in the DSF, we conducted a series of decision quality experiments to test the tool's effectiveness. Our results suggest that such a DSF should resolve much farmer uncertainty, lower barriers to experimentation with diverse management strategies on individual farms, and result in superior outcomes for organic farmers, their families, and society.

W4-B.2 Beyer, LA*; Hixon, ML; Kerper, LE; Consulting Company; lbeyer@gradientcorp.com

Caffeine in Energy Drinks: How Safe Is It?

Much negative press has been devoted to energy drinks and the caffeine contained in them. Concern has centered around possible effects posing "substantial risk" especially to individuals with hypertension and pre-existing cardiovascular problems. Yet Americans consume caffeine in hundreds of millions of bottles of energy drinks every year. Is it safe? We will address this question by evaluating the safety of caffeine in an energy drink in a manner consistent with a Generally Recognized as Safe (GRAS) determination. To do that we researched current caffeine consumption, quantified added consumption from energy drinks, comprehensively reviewed key toxicity studies, and conducted a detailed quantitative analysis. Then we evaluated whether caffeine consumption in an energy drink, combined with caffeine intake from other sources, would fall within safe limits of total caffeine intake. Finally, we set up a panel similar to a GRAS panel, which conducted an in-depth evaluation as to whether caffeine is safe under the conditions of its intended use in an energy drink.

W3-G.3 Bichteler, A*; Wikoff, DS; Harris, MA; ToxStrategies, Inc.; abichteler@toxstrategies.com

Constrained multiple imputation by chained equations: a case study in estimation and modeling on data missing below the limit of detection.

High proportions of data missing below the limit of detection (LOD) pose significant challenges to estimating population blood serum levels of many dioxin-like compounds (DLCs). Single substitutions, e.g. LOD/squareroot(2) in NHANES, are known to underestimate variability and to bias mean and upper bound estimates when missingness is high. Modeled relations with other markers, e.g. glycohemoglobin, are likewise unreliable. Pooling blood serum by sets of 8 individuals introduced in NHANES 2005/06 improved detection rates, but the resulting drop in LODs (by up to a factor of 10) further complicates matters: within-pool membership and weighting, therefore variability, are unknown, therefore plausible estimates of change over time untenable. In this case study of DLCs in 4 biennials of NHANES (2001-2008), we suggest a multiple imputation with chained equations (MICE) approach to meeting these challenges. Multivariate chained Bayesian regression models using other DLCs and related individual covariates (e.g. cholesterol, triglycerides) as independent variables and constraining the fitted value between 0 and the LOD resulted in credible distributions of concentrations in NHANES 2001-04. Convergence was not problematic, and imputation regression diagnostics demonstrated consistency with measured values. Stable survey weighted means, upper bounds, and uncertainty around those values were estimated. Using the variance calculated from retrospectively pooled NHANES 2003-04 individuals, we imputed 8 lognormal deviates for each pooled sample in NHANES 2005-08. With 4 biennials of multiply imputed individual data, we could trend population change over time, incorporating realistic variability while mitigating the plunge in LODs. These robust imputations also formed the basis for modeling diabetes risk, e.g. glycohemoglobin, with fully continuous DLCs, boosting power and precision while avoiding the pitfalls inherent in categorizing continuous variables.

M3-F.1 Bier, DM; Baylor College of Medicine; dbier@bcm.edu
Nutrition Evidence: What You See Is Not Necessarily What You Get

Evidence forms the basis of all scientific recommendations, including those dealing with nutritional risks and benefits. Because foods of some kind are eaten everyday by everyone, there is no true "null" control condition when one attempts to assess nutritional contributions to human public health risks. Moreover, methods for assessing dietary exposures, both quantitative and qualitative, are notoriously poor and long-term compliance with randomized trial diets has been demonstrably difficult to achieve. Because of the latter, observational evidence has played a much greater role in nutritional risk assessment than might be the case in other scientific fields. Nonetheless, limitations of nutritional observational studies that compromise the domains of validity of conclusions drawn therefrom have received only cursory attention. Particularly, but not exclusively, "big data" sets continue to be interrogated using historical approaches known to be suboptimal for "small data" sets resulting in the minimization of confounding effects due to the multiplicity of exposures and to interdependent highly-correlated environment-wide associations. As a result, convincing conclusions regarding the specificity of an individual nutrient as the responsible agent for health risks or benefits become debatable. Confidence is further compromised by lack of transparency in a priori registration of specific primary and secondary endpoint variables, declaration of pre-specified approaches to data analysis, opaqueness of post-hoc statistical manipulations, and reluctance to release primary data for alternative analysis. The consequences of these issues in defining the nutritional "Riskosome" will be discussed.

M4-C.1 Bier, VM*; Gutfraind, A; Lu, Z; University of Wisconsin-Madison, University of Illinois at Chicago; bier@engr.wisc.edu

Defensibility - a new concept in risk analysis

We define a system as defensible if modest investment of resources can significantly improve the outcome to the defender. After quantifying defensibility, we use empirical examples and stylized examples to show that some systems that appear highly vulnerable are actually highly defensible.

W3-E.4 Bjørnsen, K*; Aven, T; University of Stavanger; kjartan.bjornsen@uis.no

Ensuring constant risk levels by anticipating the development of risk-increasing gaps between rules and practice

A common critique of risk assessments is that risk is treated as a static property of systems, where accidents are considered as the result of a set of unfortunate random events, not taking into account how dynamical systems can migrate to states of higher risk over time. To meet this critique it has been proposed to ensure that the conclusions regarding risk levels are valid in the future by regularly validating the assumptions the risk assessment is based upon. In this presentation we propose an extension of this approach based upon the idea that common practice can deviate from written procedures and rules over time due to operators' ability to adapt their practices to meet the various system goals. The validity of several assumptions in a risk assessment can be dependent on operators following certain written procedures and rules, hence emerging gaps between these written instructions and common practices can alter the results of the risk assessment over time. We propose an approach to anticipate the development of such risk-increasing gaps based on linking assumptions to relevant written instructions, identifying deviations from written instructions that can invalidate assumptions and mapping various conditions that can support the development of such deviations. We argue that such an approach allows for improved assurance of constant risk levels in dynamic systems.

P.44 Black, PK*; Stockton, TB; Perona, R; Ryti, RT; Neptune and Company, Inc.; rtyti@neptuneinc.org

Application of Structured Decision Making to Radiological Air Monitoring

We employed an analytic-deliberative structured approach to a Hanford Site radiological monitoring program decision that integrates science with values and preferences. This value focused thinking approach facilitates transparent and defensible decision making, and aids in communicating monitoring rationale. The example application of structured decision making (SDM) evaluates management options for a Hanford Site air monitoring network decision. The fundamental objectives elicited from the decision makers included maximizing social sustainability and minimizing public health and environmental impacts. By shifting from an alternatives focus to a values focus an influence diagram is initialized that connects the management options with models and measures that are explicated connected to objectives. The influence diagram is populated with conditional probabilities using either existing information or elicitation resulting a Bayesian Network that captures in the decision uncertainty. The example SDM application demonstrates SDM's utility for monitoring program decisions as well as the ability to scale the relatively simple example SDM model to a more complex and holistic assessment of program objectives.

P.40 Bolus, KA*; Manning, KL; Stewart, RN; Dolislager, FG; Walker, SA; Oak Ridge National Laboratory; boluska@ornl.gov
Advances in risk assessment of farm product and biota intake in SADA version 6

The Spatial Analysis and Decision Assistance (SADA) freeware program is a joint research and development effort between the Oak Ridge National Laboratory and the University of Tennessee. For nearly two decades, SADA has enabled environmental risk assessors (over 18,000 registered) to situate risk and decision analytics entirely within a spatial context. SADA represents a substantial integration of toxicological data, risk models, and advanced geospatial methods, resulting in new approaches for directly developing risk informed sample designs, remedial designs, cost analysis, and uncertainty analysis within an open modeling environment. In the upcoming Version 6, supported by the U.S. EPA, modernizations include expanded graphics capabilities, integration of population data and distribution models, and improved chemical and radiological risk and dose models. Risk upgrades include substantial advancements in biota modeling. Previously, produce intake rates were based on general fruit and vegetable consumption rates. Now, produce intake rates are derived from 22 individual produce items that contribute to the overall produce risk. Mass loading factors have been expanded from a single MLF that was applied to all produce to 22 individual mass loading factors that correspond with the specific produce items that now make up the produce intake rates. Additionally, animal product intake rates have been added to the models including goat milk, sheep milk, duck, mutton, goat meat, rabbit, turkey, and venison. Formerly, the plant transfer factors used in these models were element-specific only. Now, transfer factors are specific to element, soil type, and climate zone. These new transfer factors are from the recent TRS-472 and TRS-479 from IAEA and from Science Report SC030162/SR2 from the Environment Agency of the UK and were used to replace most of the NRC generic values. Future plans are to utilize the spatial awareness of the location of each site assessed in SADA and apply appropriate site-specific exposure conditions to the assessment.

WI-G.2 Bogen, KT; Exponent Health Sciences; kbogen@exponent.com

Sustained Oxidative Stress and Dysregulated Adaptive Hyperplasia: Hypothesized Threshold-like Pathway for Most Chemically Induced Tumors

The somatic mutation theory of tumorigenesis is the key (if not only) basis of scientific plausibility for the hypothesis that increased tumor risk posed by chronic, low-level environmental exposure to any non-clastogenic but mutagenic chemical carcinogen can have a linear-no-threshold (LNT) dose-response relationship. New developments in cancer biology hint at an alternative paradigm, under which most chemical mutagens are not expected to increase tumor risk in proportion to dose at very low levels of chronic exposure. Specifically, the dysregulated adaptive hyperplasia (DAH) theory posits that: (1) tumors arise most efficiently only from a(ny) stem cell that (i) happens to be "activated" epigenetically to maintain a state of adaptive hyperplasia (AH), and (ii) additionally incurs a single, dysregulating mutation preventing transduction of the signal that normally terminates AH in that tissue; and (2) benign vs. malignant tumors in each tissue reflect protective vs. regenerative programs, respectively, of epigenetic AH that may occur and so be subject to such dysregulation (Bogen; *Med Hypoth* 2013; 80(1):83-93). Sufficiently sustained oxidative stress (SOS), but not lower levels of such stress, are observed to trigger Keap1/Nrf2/NF-kappaB mediated stem-cell recruitment, and sufficiently large exposures to an oxidative chemical dose typically can trigger SOS. Thus, experimentally or epidemiologically observed tumor risks associated with such exposures are explained by DAH theory in a way that also implies effectively zero increased tumor risk at relatively low exposure levels that do not induce SOS. This SOS-DAH hypothesis is discussed in view of two key experimental data sets involving tumors induced by dibenzo[a,l]pyrene and by aflatoxin B1.

P.12 Bonneck, S; ; mail@sabinebonneck.de
Can risk governance function without a risk council?

The carcinogenic mode of action of acrylamide was not doubted by any expert when the substance was discovered in food in 2002. The criteria for the precautionary principle were undoubtedly met and the reduction of acrylamide contents in a number of products was soon to be technically feasible. In spite of this, consumer exposure could not be minimized as the risk management was: a) not transparent: the risk management did not determine the extent of the acceptable risk. It neither introduced mandatory regulatory measures nor did it explain why it did not intervene; b) not efficient: eight risk assessments were commissioned between 2002 and 2015. The results did not go considerably beyond the knowledge of the early 1990s and were not relevant for further developing the risk management process. As no effort was made to set questions in individual research areas, a large number of research results were generated where the relevance for consumer health protection remains completely unclear; c) not effective: no risk assessment policy was issued. Therefore what remained concealed was the fact that the assumptions regarding the exposure assessments were not based on scientific facts and were also not in line with the precautionary principle. Furthermore, no options for management measures were developed and evaluated. The risk governance process could have been more transparent, more efficient and more effective if it had been supervised and coordinated by a risk council. This board should include representatives of all risk relevant disciplines that consider consumer protection as their highest priority. Only a higher-ranking risk council can ensure that solutions acceptable to the general public are found within a certain timeframe.

P.35 Borsuk, ME*; Thompson, JR; Kittredge, DB; Lindsay, M; Orwig, DA; Foster, DR; Dartmouth College; mark.borsuk@duke.edu
The consequences of climate change-driven land-use shifts in New England forests

Climate change is generating new opportunities, risks, and uncertainties for forest landowners. We are exploring how climate change is shifting land-use regimes in New England by altering human decision-making and how these changes, in turn, are affecting regional forest ecosystems and the provisioning of ecosystem services. In particular, we investigate how landowners respond to the direct impacts of climate change (including increased disturbance frequency) as well as to an indirect, socially-mediated impact in the form of carbon offset credits. We simulate the impacts of this changing climate and landowner behavior to quantify their effects on regional forest carbon stores, forest structure and composition, and timber yields. The project couples a multi-agent model to a process-based regional forest landscape model. The former is being used to propagate the behaviors of different land-owner functional types, while the latter is serving to assess the land-use regimes as they interact with climate change and natural ecosystem dynamics. Information to parameterize the models is coming from several social science data collection activities. One overarching hypothesis of our study is that forest land-use change in response to climate change is having greater near-term ecological consequences than climate change itself.

M4-J.1 Brügger, A*; Tobias, R; Monge, F; Cardiff University; brueggera@cardiff.ac.uk

A replication and extension of the socio-psychological model of climate change risk perceptions

Van der Linden (2015) recently introduced a model that combines cognitive, experiential, and socio-cultural factors as predictors of climate change risk perceptions. Our study built on this model and had two major goals. The first goal was to test the socio-psychological model of climate change risk perceptions in a socio-cultural context that is different from the context where the model was originally developed and tested (United Kingdom). More specifically, we tested the model with a large sample of the general population of Peru. The second goal was to extend van der Linden's model by (a) including additional concepts such as efficacy beliefs, cost-benefit considerations, and psychological distance and by (b) also considering actions that people may take to mitigate climate change and to adapt to its consequences. Data were collected by means of tablet-assisted structured face-to-face interviews with adults from the general public in the Cuzco region (Peru). Participants were selected by a random route procedure and interviews lasted between 50 and 90 minutes. Structural equation modelling was used to test the original and the extended model. We report findings on how well the model works in Peru and how well it can explain variance in people's willingness to respond to climate change risks. We then discuss the applicability and generalizability of the socio-psychological model of climate change risk perception to a Latin American country. Directions for future research and implications for theory are also discussed.

W4-I.3 Boyd, AD*; Furgal, C; Washington State University, Trent University; amanda.boyd@wsu.edu

Assessing a Participatory Approach to Risk Communication: The Case of Lead Exposure and Inuit Health

Indigenous populations residing in the Arctic commonly rely on traditional foods for their nutritional, spiritual and cultural benefits. However, some of these food sources have become contaminated with heavy metals or persistent organic pollutants. As a result of these contaminants, it is critical that risk communicators develop effective and culturally appropriate health messages about the risks and benefits of eating specific traditional foods. To address this challenge in the Canadian Inuit region of Nunavik, a committee was formed to advance risk management decision-making and communication around the topics of contaminants, nutrition and traditional foods. The Nunavik Nutrition and Health Committee (NNHC) includes local hunters, educators, health care providers, researchers, and communicators, among others. This study assesses both the challenges and advantages of utilizing an inclusive participatory approach to risk communication such as that employed by this group. In-depth interviews with members of the NNHC and an analysis of communication and meeting documents pertaining to decision making and development of messages related to one case were completed to provide insight into the risk management approach and how communication materials were developed and delivered. Study results reveal the importance of including members of the Inuit population in the design and dissemination of communication material. In relation to this approach, committee members were better able to: (1) access important local knowledge; (2) understand the perceptions of the populations; and (3) assess behaviors that impacted exposure to contaminants. We discuss the barriers and facilitators to using a participatory approach to make decisions, develop and deliver communications to Indigenous or vulnerable populations. This study ultimately provides insight into how a participatory approach to risk communication – that is inclusive of experiences, knowledge and skills – can result in more effective, culturally relevant risk communication campaigns.

M4-G.2 Bradley, L.J.N; Haley & Aldrich; lbradley@haleyaldrich.com

Coal ash risk assessments - a demonstration of resilience

Risk assessments have been conducted for coal ash in a variety of environmental settings and under a variety of regulatory programs to assess potential impacts to human health and the environment. This presentation provides a summary of the results of a number of these risk assessments, including several risk-based studies on the potential impact of unlined coal ash landfills on uses of groundwater and surface water, risk-based studies on the potential impact of unlined coal ash impoundments on uses of groundwater and surface water, the human health and ecological risk assessment results for the TVA Kingston ash release, risk evaluations for the Duke Energy Dan River coal ash release, risk-based evaluations of beneficial uses of fly ash and bottom ash, and results of a wide array of toxicity testing conducted for coal ash under the European Union's Registration, Evaluation, Authorization and Restriction of Chemical Substances (REACH) program. Taken in total, these evaluations do not support the claims of "toxic" coal ash or "environmental disasters" found on blogs and subsequently in the press.

T3-D.2 Brand, KP*; Campino-Ferrada, E; Telfer School of Management, University of Ottawa; kbrand@uottawa.ca
Exploring Quantitative links between Competing Summaries of Population Health Impact

A wide spectrum of seemingly disparate metrics have been favored by different disciplinary traditions as the yardsticks against which to "measure off" predicted population health impacts. While the qualitative co-relationships between these competing metrics are arguably well appreciated (e.g., many metrics display understandable a positive rank order co-relationships) the quantitative explication of many of these relationships awaits. To the extent that these competing metrics represent summaries of the same basic data (age-specific population, death, and morbidity incidence counts), algebraic relationships for translating among them (even if only approximate) ought to be obtainable. Moreover such algebraic relationships are bound to be of service; for one thing, enabling estimates to be translated from one metric to another. We have sought out such relationships (often approximate) using theory (e.g., well-worn insights from the Demography literature) and empirical data in tandem. In this paper we augment the existing human mortality data-base with a tool that renders stylized (and readily manipulated) age-patterns of cause specific mortality. Our purpose is to create a large and systematically indexed test-bed (of mortality rate, age, profiles) for examining/refining the behavior of posited algebraic relationships for relating competing summary measures to each other. We demonstrate utility of such a test-bed, applying it to the specific case of relating Health Expectancy and Health Gap based summaries of mortality impacts. A quantitative relationship is revealed and its performance is characterized with careful attention given to its contingency upon age patterns in mortality.

P.39 Brondum, M*; Wood, M; Linkov, I; United States Army Corps of Engineers ; matthew.c.brondum@usace.army.mil

Visualization of Life Cycle Assessment (LCA) Output

Practitioners of Life Cycle Analysis (LCA) are presented with the dual mission of conducting elegant analyses that veridically capture the environmental impacts of a process, and developing information that enables decision makers to come to a conclusion that is best for their organization. Practitioners' disposition for more detail combined with the inherent complexities of the analysis produce a scenario where decision makers are overwhelmed with information that makes their task more difficult (rather than easier) to accomplish. This phenomenon has been described as information overload and can lead a decision maker to use heuristic shortcuts that result in biased decisions. By simplifying data presentation, decision makers will be less likely to experience information overload. The effectiveness of information presented to decision-makers follows an inverse bell curve performance function, where very small or large volumes of information can handicap decision making capacity. One of the benefits of LCA is its ability to incorporate massive amounts of data, but that same benefit can become a hindrance if the results of an analysis are not presented carefully. In order to make effective use of the information supplied by LCA, tools are required to integrate the results in a clear manner that facilitates rational decision making. The goal of this presentation is to provide guidance on presenting results of a Life Cycle Analysis (LCA) in a way that enables decision makers in munitions acquisitions and range management to interpret and understand the impacts of munitions and training activities on environmental safety and occupational health (ESOH). Efforts are being made to improve information for munition acquisitions and range managers to make informed decisions. However, these improvements will only be useful to the extent that the improved information can be effectively communicated to those decision makers.

T2-C.1 Brevett, CAS*; Cox, JA; Department of Homeland Security, Chemical Security Analysis Center; CAROL.BREVETT@ST.DHS.GOV
Risk Reduction via Organoleptics?

The Chemical Terrorism Risk Assessment (CTRA), published by the Chemical Security Analysis Center within the Department of Homeland Security, is required by Homeland Security Presidential Directive-22, Domestic Chemical Defense. The CTRA quantifies the risk of chemical terrorism attacks to help inform and improve the US defense posture against such events. The CTRA models the acute public health risk from intentional contamination incidents including outdoor, indoor and chemicals supply chain attacks, and intentional adulteration of food and water. The model includes a module for organoleptic detection, which provides warning based on odor, taste or sight that the food, water or air is contaminated, which would trigger avoidance behavior and impact risk. Gaseous and volatile liquid CTRA chemicals often have an odor threshold or vapor detectors available, which warn of the presence of an unusual chemical; therefore modeling the effect of organoleptic detection on risk from a chemical terrorist attack is possible. For food and water targets, the major organoleptic detection method to warn of contamination is taste, for which much less data are available in the literature. Since this is a critical parameter needed to realistically model the risk from food and water contamination CSAC has developed estimation methods for organoleptic limits based on acidity, solubility, sodium and chloride ions. The methodology and calculation of organoleptic limits for selected chemicals will be presented and discussed as well as a comparison to published limits of detection of commercially-available, off-the shelf (COTS) instrumentation. Both of these approaches can be leveraged to reduce risk from intentional contamination events.

T4-E.1 Bronfman, NC; Cisternas, PC*; National Research Center for Integrated Natural Disaster Management; pamecisternas@gmail.com

Natural hazards and preparedness: A multi-hazard scenario

Nowadays, preparedness in front of natural disasters is one of the major issues faced by the governments. This task is even more complex when a community had to be prepared to multiple hazards. Thus the objective of this research was to study the degree of preparedness in three different localities regarding two natural hazards: earthquakes and floods. For this purpose, between November and December 2015, a face to face survey was applied on statistically representative samples of three localities in northern Chile; Copiapó, Paipote and Tierra Amarilla. A total of 480 people completed satisfactorily the survey. Preparedness in workplace, family and community was assessed, with the degree of worry regarding earthquakes and floods. Furthermore, social capital and evacuation experience in a major weather event occurred in these localities in March 2015 was measured. Our preliminary results suggests that there were significant differences in the degree of preparedness in front of earthquakes and floods. People declared a higher level of preparedness in workplace and family for earthquakes, rather than for an upcoming flood. Social capital was a relevant factor in the successful evacuation of the March 2015 event. Moreover the previous experience was not a crucial factor in the evacuation process.

T3-G.3 Brown, L*; Lynch, M; Abt Associates;
lauren_brown@abtassoc.com

Assessing the relationship between adult blood lead levels and cardiovascular disease related mortality

Lead is a highly toxic pollutant that can damage neurological, cardiovascular, and other major organ systems. The neurological effects are particularly pronounced in children. However, the recent literature has found that a wide spectrum of adverse health outcomes can occur in people of all ages. In addition, a threshold below which exposure to lead causes no adverse health effects has not been identified. This suggests that further declines in lead exposure below today's levels could still yield important benefits, in both adults in children. In a past analysis previously presented at SRA, we conducted a rigorous approach to identify and value adverse health effects associated with adult exposure to lead. Specifically, we presented a quantitative function relating adult blood lead levels to cardiovascular disease mortality risk using a single key study. Since our last presentation, two additional studies have been published that exposure to lead causes no adverse health effects in adults to cardiovascular disease mortality. Our presentation will review these three key studies and discuss the similarities and differences between them. Additionally, we will evaluate how the results of these studies inform the science on how lead exposure in adults is related to cardiovascular disease mortality and what questions remain. We will present our suggested quantitative function that relates a reduction in adult lead exposure to cardiovascular disease mortality based on these three key studies and translate this function into potential benefits for reduced exposure to lead in an adult population.

W1-C.1 Burns, WJ*; Decision Research;
william_burns@sbcglobal.net

Deterrence: Exploiting the connection between affect, risk perception and self-efficacy to demotivate an adversary

This presentation discusses an approach to understanding and facilitating deterrence in the context of domestic threats to commercial aviation and other high valued domestic targets. A theoretical framework is put forth for enhancing deterrence by exploiting the connection between affect, perceived risk, and self-efficacy. There is an extensive scientific literature that looks at the connection between these three factors and how to correct misperceptions. This study seeks to exploit these inherent biases as a way to deter an adversary from seeking to defeat a security system. An example is offered to illustrate the concept.

W1-F.1 Bryce, C*; Chmura, T; Moore, N; University of Nottingham;
cormac.bryce@nottingham.ac.uk

The value of privacy when data becomes commoditised: An experimental investigation

The rapid proliferation of smartphones and move towards integrated technological platforms by corporate organisations has led to an ever increasing amount of personal data being captured on a daily basis. Information once considered sensitive such as bank accounts, medical records, consumption patterns and geolocation are now considered the building blocks of new business for organisations. It is therefore unsurprising that privacy preferences and attitudes towards risk and privacy protection now play an important role in the digital age we find ourselves. During our online interactions we encounter organisations collecting our private data, either to construct personal advertisements, build a profile of our credit history, prevent us from terror attacks, or to improve our health. The value of this private data to organisations depends on the potential ability to forecast future behaviour or obtain competitive advantage from it. On the other hand the value our personal data has for us most likely depends on the benefits we gain when we share this data with those very same organisations. As the value of private data becomes commoditised the role and importance of research in the area of privacy will increase. In this current paper we conducted a series of incentivised stated preference discrete choice experiments in which individuals Willingness To Accept (WTA) payment for the disclosure of their private information was derived. We also included generic questions surrounding trust, risk, and appetite for risk within defined situations - allowing for a cross-analysis and correlation of perceived risk and actual observed risk with the data collected from the experiments. This provided a more rigorous understanding as to the effects of risk perception and individual risk appetite on personal information disclosure.

M2-J.9 Butler, JP*; Verner, DR; Petit, FD; Wall, TA; Argonne
National Laboratory; dverner@anl.gov

Climate Change and Infrastructure Adaptation

The National Climate Assessment and Development Advisory Committee recognizes that essential local and regional infrastructure systems will increasingly be compromised by climate change impacts. Furthermore, climate-related disruptions of services in one infrastructure system will almost always result in cascading disruptions to other infrastructure systems. Changing climate conditions in the United States are already taxing communities and infrastructure systems. Given that the impacts of climate change are most often experienced at a regional or local level, effective adaptation in a locally relevant context requires that decision makers have access to actionable information and analytical guidance. However, State, local, and private sector officials frequently highlight gaps in local-level modeling, climate scenario data, and local planning frameworks as barriers to climate change adaptation. Available data are often developed by and for the atmospheric and oceanic science communities. These projections of future climate conditions are not easily translated into local climate impacts; yet it is those impacts that are more directly actionable through engineering design, infrastructure management, and community planning practices. In this presentation, the gap between existing climate science capabilities and critical infrastructure adaptation needs will be discussed and a potential path forward proposed that highlights several tools and models to bridge the gap between national or regional climate model data and infrastructure design and management considerations. A case study will be presented that illustrates how these techniques can be operationalized, as well as how cascading failures resulting from climate change may be analyzed.

T4-I.3 Böhm, G; University of Bergen; gisela.boehm@uib.no
Hope or fear, outrage or guilt – which emotions do people feel in response to climate change? A comparison across four countries.
 This paper uses survey data collected in the ‘European Perceptions of Climate Change’ project and presents an international comparison of emotional responses of the public to climate change based on representative national samples (each N = 1000) from Great Britain, Germany, Norway, and France. Emotions are a strong motivational force and influence both judgments and behaviors in manifold ways. The present paper draws on appraisal theories of emotion according to which emotions are on the one hand based on specific cognitive appraisals of the situation and on the other hand trigger specific behavioral tendencies. Thus, the type of emotion that a person experiences indicates how the person evaluates a situation and which behavioral impulses the person is likely to experience. The following specific emotions were measured that have been shown to be important in the context of environmental risks (e.g., Böhm & Pfister, 2000, 2005, 2015): hope, fear, outrage, and guilt. Both hope and fear indicate that a person focuses on potential future consequences. While hope implies that negative consequences appear avoidable or positive consequences achievable, fear anticipates exclusively negative consequences. Behavioral responses resulting from hope or fear include mitigation, adaptation, and escape. Outrage and guilt are based on moral evaluations; outrage implying that others are seen as culprits whereas guilt results from self-blame. Behaviors following from outrage or guilt include punishment or compensation. The four countries will be juxtaposed with respect to their profiles of emotional responses to climate change. In addition, each country’s emotional profile will be related to underlying climate change risk perceptions and preferences for climate policies. Results document the important role and cultural diversity of emotional responses to climate change.

T4-A.5 Camp, JS*; Shaw, AR; Whyte, DC; Vanderbilt University; janey.camp@vanderbilt.edu
Use of Hazus and Regional Climate Models to Identify Vulnerable Transportation Infrastructure due to Future Extreme Precipitation Events

The Hazus flood model is commonly used for mitigation planning, but we propose that it can also be utilized for adaptation planning when used in conjunction with regionally downscaled climate models and other tools. Additionally, Hazus only minorly considers the impact to transportation systems, which serve as critical lifelines for communities in both times of response, recovery, and general livelihood sustainability. This presentation will provide an overview of methodology that can be employed for use of the Hazus flood model coupled with future climate projections to identify “at risk” transportation assets for more in-depth evaluation of their potential vulnerability and resilience to future flooding events. A case study demonstration of the concepts will also be presented using Tennessee-focused climatic and infrastructure data.

M4-B.2 Cains, MG*; Henshel, DS; Fair, P; Scott, G; Landis, W; Menzie, C; Indiana University, NOAA, University of South Carolina, Western Washington University, Exponent; mgcains@indiana.edu
Framework Development for Integrated Risk Assessment and Vulnerability Assessment: Charleston Harbor Deepening Case Study

The US Army Corps of Engineers (USACE) has been selected by South Carolina State Ports Authority to dredge the CH to a depth of 52 feet from the current depth of 45 feet (i.e. Post 45 Project). The completion of the Post 45 Project will make Charleston Harbor the deepest harbor on the East Coast which enhances the economic efficiency of commercial navigation and the local economy. The deepening of the Port of Charleston, SC may result in significant alteration in ecosystem ecology. The USACE will use hydraulic cutterhead dredging, hopper dredging, or mechanical excavation to generate an expected 40 million cubic yards of dredge material. While the USACE Environmental Impact Statement asserts there will be minimal negative impacts due to the harbor deepening, the EIS does not address impacts on ecosystem services beyond the service provided by wetlands. With Charleston Harbor as a case study, the overall goal of the Integrated Risk Assessment and Vulnerability Assessment project is to develop a holistic, cumulative watershed vulnerability and risk model that takes into account and incorporates key aspects of the Charleston Harbor watershed, integrating processes and stressors that interactively affect the human and animal populations and ecosystems at different spatial, temporal and biological scales, integrating human and ecological factors as well as ecosystem services. The development of a holistic framework for human health and the environment with ecosystem services for Charleston Harbor can be used as a case study comparison for the imminent harbor deepening of Wilmington, NC; Savannah, GA; and Jacksonville, FL. The presented research will discuss the considerations and criteria employed during the development of Charleston Harbor risk framework and conceptual model. The developed risk framework is a product of the adaptation and fusion of existing and relevant frameworks in order to address both the novel and universal risks with the Charleston Harbor watershed.

T4-D.5 Campbell, HE; Department of Politics and Policy, Claremont Graduate University; heather.campbell@cgu.edu
What if Revealed Preference Isn't So Revealing? Insights from Agent-Based Modeling and Complex Systems for the Practice of Benefit-Cost Analysis

One of the assumptions used in Benefit-Cost Analysis (and other Economics) is that revealed preferences provide a better measure of actors goals than do other methods such as surveys. In keeping with this, when there is a difference between preferences expressed in surveys versus observed social outcomes, the assumption is often made that the stated preferences are strategic, insincere, or otherwise untrue, and that the truth is shown through the outcomes rather than the statements. However, a key insight from the study of emergence in complex systems is that emergent outcomes may, in fact, be quite different from the preferred outcome of every actor. This can be tested through the use of Agent-Based Modeling (ABM), in which individual actors are assigned preferences and, due to the algorithmic nature of the process, they perform their stated preferences exactly, yet end up with undesired outcomes. Indeed, this insight fits with early work on segregation by Schelling, in which he was able to show that his agents ended up in neighborhoods that were more segregated than their preferences. But the implications of this for BCA, and the significant doubt thrown on the use of revealed preferences in complex systems such as cities, has not been brought into BCA practice. The proposed presentation will discuss evidence that revealed preference may be different from actual preference, and discuss implications for BCA practice.

T2-J.2 Campbell-Arvai, VCA*; Hart, PS; Raimi, KT; Wolske, KS; University of Michigan; vcarvai@umich.edu

The influence of information about carbon dioxide reduction (CDR) technologies on support for climate change mitigation strategies: A test of risk salience and risk compensation hypotheses
There is growing interest in the use of carbon dioxide reduction (CDR) technologies such as reforestation, bioenergy + carbon capture, and direct air capture, as part of a larger strategy to address greenhouse gas emissions and climate change. It is unknown, however, if these measures will reduce or augment the public's support for climate mitigation measures. Past studies suggest a number of competing hypotheses as to whether information about climate adaptation will increase or decrease support for mitigation measures. Theories under the category of 'risk compensation', e.g., rebound and negative spillover effects, suggest that learning about adaptation will reduce support for or engagement with mitigation efforts. 'Risk salience', however, posits that learning about climate change through communications about adaptation will increase the salience of and concern for climate change and lead to increased support for mitigative measures. In the case of this study, we sought to determine if a similar relationship exists between learning about the large-scale climate engineering efforts of CDR and support for other forms of carbon mitigation efforts. We used a national online survey-based experiment to test a moderated-mediation model describing the relationship between learning about CDR technology, perceptions of that technology, and support for climate mitigation policies and measures. Political ideology and trust in technology were included as moderators. Our results provide support for the risk salience hypothesis. However, endorsement of climate mitigation policies was dependent on the specific CDR technology described and its perceived efficacy; trust in technology and political ideology moderated this effect. Implications for the deployment of large-scale CDR technologies and continued support for and engagement in climate mitigation efforts are discussed.

T4-D.1 Cantor, RA*; Cross, PJ; Mackoul, CV; Berkeley Research Group; rcantor@thinkbrg.com

Challenges to product labeling: consumer protection or opportunism?

Investigations in the area of product labeling have expanded substantially in recent years. Regulators and consumer advocates are looking closely at labels designed to signal specific product attributes related to health, safety, environmental, and performance qualities. When the attribute information is challenged, it is becoming more common to encounter the related class-action litigation for damages to consumers from alleged mislabeling. Class-action litigation can be an expensive "bet-the-company" process for product producers. Given the growth of these matters and their high cost, it is worth investigating the economic foundations of the theory and methodology used to support mislabeling impact and damages claims. This paper examines how the economic theory of demand is employed to support a theory of impact and damages in mislabeling class actions. Other economic theories of supply and competition are often ignored, especially for their influence on product pricing. We also review the methodologies used by experts for plaintiffs to measure demand in mislabeling matters and contrast the reliability of stated preference versus revealed preference as a foundation for establishing class and estimating damages in tort litigation. We conclude with some thoughts regarding the social value of mislabeling class actions in the context of protecting consumers as opposed to merely enriching a legal community that might be exploiting advances in stated preference methodologies in a lucrative litigation area.

W4-E.4 CANJAR, HA; None; helen.canjar@sympatico.ca
Can Risk Analysis Improve with Decision Maker Education and Awareness?

Today's corporate world faces a multitude of challenges (financial transparency, governance, IT security, etc.) which often culminate in a zero tolerance for risk reality. Additionally, decision making in a corporate environment involves the risk tolerance levels of multiple stakeholders, conflicting objectives, and high-impact, high-cost uncertainties. Risk analysis (RA) can help mitigate the risks faced, but that can take time, a luxury in the fast-paced corporate world. After all, RA in this environment is a balancing act of real-time monitoring, forecasting, trend analysis, expectation management, strategy planning, and mind-reading. Alternatively, can organizations afford not to make use of risk analysis? With threats to corporate viability coming from all directions - employees, governments, competitors, regulations - the answer is NO. Notwithstanding time constraints and resource deprivation, how then do the tools get used, the analysis get done, the decision makers remain satisfied, and informed decisions get made? A clear and focused RA program is a significant contributor to these objectives. In fact, without a solid foundation, analysis becomes a matter of fire-fighting and short-cuts, both stepping stones on the path to analysis overload and loss of integrity. However, perhaps even more important to a successful RA program is decision maker education of RA and awareness of their beliefs about risk. Would the program be more effective if decision makers were aware of their framing effects and mental models? Would the company be more competitive if decision makers saw risk as something to be understood, not feared? That there are opportunities in the "danger"? Working with corporate and government decision makers, the author set out to test the hypothesis that exposing decision makers to select elements of risk analysis results in a positive impact on the program and the company. This presentation will share highlights of the study, key findings, and recommendations.

T2-F.4 Cao, S; Ponnambalam, K*; University of Waterloo; ponnu@uwaterloo.ca

A multidisciplinary approach for dam failure consequence analysis
River dam failures are catastrophes that can cost thousands in fatality and billions in economy. Accurately estimating the consequences of dam failures is essential to safe water, because it provides the basis for optimizing operational resources and evacuation plans. However, existing methods have major limitations: • Limited models considering only a few parameters (e.g., flood volume and flow); • Limited data considering only a few historical cases (e.g., less than 100 cases around the world); • Subjective estimation relying on opinions (e.g., severity understanding: vague or precise). We address these problems by developing a new systematic approach, which • combines quantitative models of water, terrain, demographics, society, transportation, economics; • utilizes data sources such as Google Earth, government reports, and social media data; • predicts and shows dam failure consequences through game-like simulation (e.g., SimCity). Previous methods on this topic are often limited within each isolated discipline. Our proposed research aims to break down disciplinary boundaries and integrate knowledge and methods from engineering, environmental science, social science, and public health.

M4-A.4 Carless, TS*; Fischbeck, PS; Carnegie Mellon University, Department of Engineering and Public Policy Engineering, ; tscales@andrew.cmu.edu
The Economic and Societal Impact of Baseload Power Generation on Local Communities

Comparisons between generating technologies are made using the levelized cost of electricity and life cycle greenhouse gas emissions, however the presence of power plants can have positive and negative impacts on local communities. Post-Fukushima, questions have been raised regarding the safety and impact nuclear power plants may have on the surrounding population. With respect to fossil fuel plants Davis et al. (2010) [The Effect of Power Plants on Local Housing Values and Rents] has found that communities living within 2 miles of power plants experience a 3-7% decrease in housing values. There is further evidence that those that live even closer experience larger decreases. The goal of this work is to investigate and examine relationship between societal and economic community indicators with respect to distance and generation technology. This work utilizes ArcGIS in conjunction with 2007-2011 American Community Survey block group data to analyze the characteristics of communities 0-5, 5-10, and 10-15 miles from each generating station. Welch's and paired t-tests to determine the significant statistical differences between the community socioeconomic indicators with respect to distances and generation technologies. This analysis finds that communities near nuclear power plants have a lower population of black residents and population density than communities near fossil fuel plants. However, despite having no statistical significant differences in educational attainment, communities around nuclear power plants have higher incomes, home values, and lower poverty rates.

WI-A.2 Caruzzo, A, AC*; Santos, LBL, LBL; Gyakum, J, JG; Joe, P, PJ; McGill University; amaury.caruzzo@mail.mcgill.ca
Critical Infrastructure Protection and weather-related events in Brazil and Canada: an overview

Extreme weather-related events as storms, wildfires, floods, and landslides are significant to the operation of critical infrastructures such as energy facilities, rail, roads, airports or information, and telecommunications systems. Over the years, both Brazil and Canada have faced several natural disasters related to these sort of infrastructures, which resulted in many deaths and losses of millions of dollars. The recent wildfire in Fort McMurray (Alberta province, Canada) when almost 100,000 were evacuated or the tragic weather event in Rio de Janeiro State (Brazil) in 2010 near two nuclear plants demonstrated how several infrastructures are still vulnerable to this weather-related hazards. It is essential to identify a set of mitigation actions for the protection of a critical infrastructure in an inevitable extreme weather event. However, the mitigation selection under weather or climate uncertainty can be a challenging process, and in many situations, can damage or compromise the infrastructure operations. The purpose of this research is to make a preliminary overview of the decision process in critical infrastructure protection under weather-related events and evaluate trends and opportunities in Brazil and Canada. We did a survey for the last 30 years associated with meteorological hazards and identified the historical contexts, main weather risks, and infrastructure vulnerabilities (separated by sector). We classified this overview in three groups (in Brazil and Canada): 1) List of critical infrastructures; 2) List of all-weather hazards; 3) Action plans and others official documents about Critical Infrastructure Protection. Although the analyses are primary, it is possible to identify several applications for Brazil and Canada related to weather hazards, the decision under uncertainty, risk analysis, and critical infrastructures protection.

P.68 Carless, TS*; Griffin, WM; Fischbeck, PS; Carnegie Mellon University, Department of Engineering and Public Policy Engineering; tscales@andrew.cmu.edu
The Environmental Competitiveness of Small Modular Reactors: A Life Cycle Study

The Energy Information Administration estimates the demand for electricity in the US will increase by 29% between 2012 and 2040. In an effort to mitigate climate change, the US has pledged to reduce significant greenhouse gas emissions (GHG) over the next ten years. To bridge this energy gap and reduce GHG emissions, an increase in nuclear power using small modular reactors (SMRs) may help meet future energy needs by providing affordable, baseload, and low-carbon electricity. Currently, there are no SMRs in commercial operation. This work conducts a prospective attribution life cycle assessment of an SMR. Monte Carlo simulation and sensitivity analyses are used to account for the uncertainties in the analysis. The analysis finds that the mean (and 90% confidence interval) life cycle GHG emissions of the Westinghouse SMR (W-SMR) to be 9.1 g of CO₂-eq/kwh (5.9 to 13.2 g of CO₂-eq/kwh) and the Westinghouse AP1000 to be 8.4 g of CO₂-eq/kwh (5.5 to 12.1 g of CO₂-eq/kwh). The GHG emissions of the AP1000 are 9% less than the W-SMR. However, when the nuclear fuel cycle is not included in the analysis the GHG emissions for the W-SMR and the AP1000 are effectively the same given the inherent uncertainties in the analysis. However, the analysis finds that both types of plants stochastically dominate the Generation II 4 loop SNUPPS. The mean (and 90% confidence interval) life cycle GHG emissions of the SNUPPS is 13.6 g of CO₂-eq/kwh (10.5 to 17.3 g of CO₂-eq/kwh). While the AP1000 has the benefits of economies of scale, the W-SMR's modular ability enables it to make up some of the difference through efficiencies in construction, operation and maintenance, and decommissioning.

W4-B.1 Catlin, MC*; LaBarre, DD; Ebel, ED; Williams, MS; Golden, NJ; Food Safety and Inspection Service; michecat@hotmail.com

Fit-for-purpose food safety risk assessments: leveraging available data to answer agency questions

As the public health agency of the United States Department of Agriculture, the Food Safety and Inspection Service (USDA-FSIS) is responsible for ensuring that the nation's commercial supply of meat, poultry, and egg products is safe, wholesome, and correctly labeled and packaged. FSIS conducts risk assessments to provide the scientific basis for its decisions in carrying out its public health mission. FSIS published, in conjunction with EPA, microbial risk assessment guidelines that emphasized the need to conduct assessments that are fit-for-purpose; that is, assessments that answer the specific risk-management questions underlying the decision. Many of the questions important to FSIS revolve around how to best focus its resources to protect public health. To that end, FSIS has leveraged the available data, including data from its own inspection and sampling activities, as well as illness data from CDC, to target its risk assessments specifically to answer the risk management questions at hand. Examples of the risk assessment approaches the agency has taken—and the data available that allow those approaches—will be discussed, including assessments to: i) modernize its hog slaughter inspection system, ii) track industry progress in decreasing microbial contamination, iii) make rapid determinations of the risks from specific incidents of FSIS-regulated products containing chemical hazards, and iv) respond to the detection of chemicals without established tolerances in FSIS-regulated foods.

P.45 Chabrelie, AE*; Mitchell, J; Norby, B; Michigan State University; alexandrechabrelie@hotmail.fr

An Exposure Based Multi-Criteria Decision Analysis (MCDA) Approach for the Risk Prioritization of Antibiotic Products

Antimicrobials are required in the production of cattle intended for the meat and dairy industries. Because the use of antimicrobials may contribute to increased antimicrobial resistance in bacterial communities across multiple environments over the life cycle of these products, it is important to rank risks associated with their usage. However, many existing data gaps limit the ability to quantitatively characterize risks across these diverse exposure pathways. Hence, this study develops a decision analytic framework, to prioritize risks based on exposure potential in order to inform stewardship initiatives. By using MCDA, several disparate types of information or criteria that play a role in the transmission of antimicrobial resistance can be integrated. First, information related to usage - quantities manufactured, prescribed and administered. Second, the properties of the antibiotic compounds themselves, such as their degradation kinetics and mechanisms; and properties driving accumulation in certain environmental compartments. Third, information related to their interaction with pathogens and commensals to exert selection pressure for resistance. Finally, criteria related to the availability of interventions or alternatives to potentially reduce usage. The approach developed will be presented based on a recent survey of antibiotics used in dairy cattle. The strength of this approach is the ability to integrate relevant statistical and mechanistic data with expert judgment, allowing for an initial tier assessment that can further inform research and risk management strategies.

P.202 Chakalian, P*; Larsen, L; Gronlund, C; Stone, B; Arizona State University; University of Michigan; Georgia Institute of Technology; pchakali@asu.edu

Risk Perceptions and Behavioral Adaptations to Coupled Environmental Hazards in Phoenix, AZ

How do individual characteristics and structural constraints explain variation in risk perceptions? what is that perception? and how does that perception shape individuals' thermal comfort, and behavioral adaptations to heat and power-failure hazards? Through an NSF Hazards SEES grant researchers at Georgia Tech, the University of Michigan, and Arizona State University have been investigating what would happen in Atlanta, GA; Detroit, MI; and Phoenix, AZ if the three cities suffered metro-wide power-failures that lasted several days during a concurrent heat wave. Over the summer of 2016 researchers at Arizona State University collected household survey's in Phoenix, AZ to help answer this question. Using a stratified random sample 149 survey's were collected that attempted to represent a wide range of geographies, housing-types, and demographics. The 67 question surveys were administered at respondent's doors on computer tablets, and took between 10 and 20 minutes to complete. Participants were given \$5.00 in compensation for their time. Respondents were asked about their perception of the seriousness of several environmental risks including their perceptions of the risks of extreme weather, power-failure, air pollution, and climate change. The results have been analyzed to compare perceptions between different hazards and between various groups of participants. This poster presents preliminary results from this work that indicate both amplification and attenuation of perceptions of these risks amongst geographically distinct groups of participants. These results provide directions for further investigation and could help increase the efficacy of risk management strategies in one of the countries hottest cities.

P.160 Chada, K*; Lane, C; Huang, Y; Zhang, G; Walderhaug, M; Toledo, S; Yang, H; U.S. Food and Drug Administration and Engility Corporation; kinnera.chada@fda.hhs.gov

Geographic Risk Evaluation and Assessment Tool (GREAT): Model for Transfusion Transmitted Infectious Diseases

Increased global travel and its association with risk of donors infected with emerging infectious diseases demand continuous evaluation of blood safety management policies. Donor deferral and blood screening are major risk mitigation measures to ensure safety of US blood supply. The Geographic Risk Evaluation and Assessment Tool (GREAT) was developed to rank geographic risk of infectious diseases, estimate geographic risk contribution and evaluate potential donor loss associated with donor deferral policies. The tool comprises embedded databases for major inputs such as geographic specific disease incidence, travels, immigration, existing geographic donor deferral, population demographics and others. The major outputs are geographic risk contribution and potential donor loss, risk reduction, false positives and positive predicted values associated with policy options for donor deferral, blood testing or combination of donor deferral with blood screening. The tool is developed in Java and utilizes ArcGIS Runtime SDK for Java (Esri Inc.) map support. GREAT features automated data mining for updating inputs, multi-format data importing, and high resolution visual presentation of model outputs. GREAT's framework caters flexible modification to perform risk assessment of emerging infectious diseases. The tool can be applied for geographic risk assessment for transfusion-transmission of vector-borne diseases like chikungunya, dengue, malaria, vCJD, or Zika. An example application of GREAT for evaluation of transfusion-transmitted Zika will be presented. We anticipate that GREAT will support an expedited process to evaluate risk mitigation options for emerging transfusion-transmitted diseases.

P.201 Chang, BS; Chen, YJ; Wu, KY; Chiang, SY*; China Medical University; sychiang@mail.cmu.edu.tw

Probabilistic risk assessment of the exposure to chlorpyrifos from some edible herbal medicine

Dietary exposure to pesticides from edible herbal medicine via food consumption is of particular concern. Chlorpyrifos, one of the organophosphate pesticides, has been previously detected in herbal medicine used. This pilot study was to assess the potential risk of chlorpyrifos exposure from some edible herbal medicine in Taiwan. The chlorpyrifos residues data in seven commonly used edible herbal medicine including Jujubae Fructus were released by Taiwan Food and Drug Administration (TFDA). Chlorpyrifos was detected in 24 out of 140 samples by gas chromatography-tandem mass spectrometry. The intake rates of edible herbal medicine were cited from the Taiwan National Food Consumption Database. These data were used as prior information. The posterior distributions of chlorpyrifos residues, daily intake, and hazard index for adults in Taiwan were assessed with the Bayesian statistics Markov chain Monte Carlo simulation by using the OpenBUGS software to overcome insufficient data. The hazard index was calculated to evaluate the noncarcinogenic health risk from chlorpyrifos exposure via food consumption of the edible herbal medicine. Based on the current RfD of 0.003 mg/kg bw/day for chlorpyrifos, the mean and the upper bound of 95% confidence interval of hazard index were calculated to be 0.06 and 0.17, respectively. These data suggest that it may pose no potential risk to human via dietary consumption of some edible herbal medicine.

P.77 Chao, KP*; Wu, KY; National Taiwan University; r04844004@ntu.edu.tw

The risk assessment of Carbofuran residue in vegetables and fruits in Taiwan from 2010 to 2015

Pesticides are widely used in agriculture to maintain quality of crop growth. However, the potential adverse health impacts from pesticides deserve to be assessed. Carbofuran is often detected in fruits and vegetables in Taiwan. Previous studies showed that carbofuran may cause cholinesterase (ChE)-inhibiting effect and is genotoxic. The objective of this study is to establish a probabilistic risk assessment of carbofuran in foods from 2010 to 2015. Existing acceptable daily intake (ADIs) of carbofuran were derived from the no observed-adverse-effect level (NOAEL), which lacks of perspectives of possibility. Thus, we used Benchmark Dose Software (BMDS 2.6.0.1) to calculate BMDL10 to replace NOAEL. Mean concentration (MC), Lifetime Average Daily Dose (LADD), and Hazard Index (HI) were calculated by the model of Bayes' theorem in Markov Chain Monte Carlo simulation (MCMC). The consumption data was obtained from the National Food Consumption Database. 19-65 years old adults are our target population. The study revealed that MC of carbofuran was 1.008×10^{-3} , 4.848×10^{-4} , 6.86×10^{-4} , 0.01629, 0.02656, and 4.245×10^{-3} ppm in six frequently detected foods. Moreover, the LADD of these six foods was 9.795×10^{-7} , 2.777×10^{-6} , 9.975×10^{-7} , 9.543×10^{-5} , 9.364×10^{-5} , and 1.936×10^{-5} mg/kg/day. Hazard quotient (HQ) was 1.91×10^{-4} , 4.11×10^{-4} , 7.85×10^{-5} , 0.01238, 7.187×10^{-3} , and 1.668×10^{-3} . HI was 0.02758. Although the HI showed that consumers are not subject to the potential adverse health effects, the aggregate health risks of carbofuran deserve particular attention. Moreover, residues of carbofuran reported on Taiwan Food and Drug Administration (TFDA) and Council of Agriculture still exceeded than maximum residue level (MRL), so it is necessary to revise management of carbofuran. Our findings recommend governing authorities to investigate long-term health effects of carbofuran in foods.

M3-B.3 Charles, AL*; Wang, H; Rysler, E; Schaffner, DW; Rutgers University, The State University of New Jersey; ann.charles@rutgers.edu

Quantitative microbial risk assessment for Salmonella on sliced tomatoes

This study develops a quantitative microbial risk assessment (QMRA) model to estimate the probability of illness caused by Salmonella on sliced tomatoes. The risk assessment considers a processing plant slicing 4000 tomatoes per day, and explicitly assumes that all contamination arises from tomatoes contaminated with Salmonella in the field. Extracted data, models, and user inputs were entered into an Excel spreadsheet, and the modeling software @RISK was used to perform Monte Carlo simulations. The following scenarios were considered: prevalence of positive tomatoes (1/30, 1/300 and 1/3000), initial pathogen concentration (0, 1, 3 and 6 log CFU/tomato), cleaning frequencies (no cleaning and once halfway through production), and slicing conditions (dry vs. wet tomatoes, manual vs. mechanical slicing). QMRA outputs considered were total number of illnesses, fraction of illness arising from a contaminated blade and total number of Salmonella positive servings. A higher Salmonella concentration (6 log CFU/tomato) and prevalence (1/30) resulted in the most illnesses. The number of illnesses was similar when tomatoes were processed dry or wet. Fewer illnesses occurred when a mechanical slicer was simulated, but the difference was only significant at higher concentrations (3 or 6 log CFU). The model predicted 40% of illnesses resulted from a contaminated blade when starting levels were low (0 log CFU). More illnesses (90%) were caused by blade contamination when tomatoes contained a higher concentration (6 log CFU/tomato). Cleaning halfway through production did not decrease the number of illnesses. Data gaps identified included: accurate information on concentration of Salmonella on positive tomatoes at harvest, transportation temperature, and consumer transport, storage and preparation data. Additional variables to be considered in future versions of the QMRA include slicing temperature (4, 10 and 23°C), blade thickness (3/8" and 3/16"), and tomato variety (Bigdena and Rebelski).

T2-B.4 Chapman, B; Pintar, K; Smith, BA*; Public Health Agency of Canada; ben.smith@phac-aspc.gc.ca

Modeling risks from VTEC across multiple pathways

The relative contributions of exposure pathways associated with cattle manure-borne Escherichia coli O157:H7 on public health are not fully characterized. Knowledge gaps in the relationship between environmental phenomena and human exposures confound the evaluation and implementation of risk-reduction initiatives. A multi-pathway QMRA model was developed to describe the fate of O157 in the environment and its impact on human health. Through the integration of existing QMRAs and exposure assessment models, we derived absolute and relative risk estimates for five exposure pathways originating from a single farm source, including; aquatic recreation, consumption of contaminated ground beef and leafy greens, direct animal contact, and the recreational use of a cattle pasture. The occurrence and quantity of precipitation, as well as survival and mobilization of O157 was simulated using novel climate, field, and river modules. Risks were predicted on a per-exposure basis, as well as a seasonal basis using an exposure-receptor profile. Additionally, the model was used to evaluate the efficacy of interventions affecting one or more exposure routes to predict the combined effect of pre-harvest interventions, as well additional downstream interventions. The model allows for comparison of risks across exposure pathways and a big picture view on the impacts of pre-harvest interventions to inform risk management for public health.

M3-E.3 Chatterjee, S*; Perkins, C; Brigantic, R; MacDonald, D; Pacific Northwest National Laboratory; samrat.chatterjee@pnnl.gov

Towards modeling time-varying dependencies in cyber-physical infrastructure systems

This talk focuses on the use of probabilistic graphical modeling and machine learning to address time-varying dependencies in cyber-physical infrastructure systems. An experimental architecture representing a power system is developed to simulate natural and human-induced disruptive scenarios. Probabilistic and statistical modeling approaches are then adopted to learn dependencies among system components that address power delivery and cyber communication functions.

W1-I.2 Chaudhry, R; Becton Dickinson ; *Rajan.chaudhry@bd.com*

Risk in ISO 14001:2015 – Environmental Management

ISO 14001 is an environmental management system standard. Along with ISO 9001, which is a quality assurance management system standard, 14001 has provided risk management guidance since the 1990s. This presentation will review the risk-related requirements in 14001's most recent version. Ways in which a global corporation has implemented has addressed this serves as a case study.

W3-G.2 Chen, Q*; Shao, K; Indiana University Bloomington;

chenqira@indiana.edu

A Novel Benchmark Dose Estimation Approach for Continuous Endpoints

Continuous data are widely used for benchmark dose analysis in health risk assessments. To assess dose-response relationship between chemical exposure and continuous endpoints, there are two major methods represented by the U.S. EPA's Benchmark Dose Software and the Netherlands National Institute for Public Health and the Environment (RIVM)'s PROAST software, respectively. The BMDS method assumes the continuous responses are normally distributed and the PROAST method uses a lognormal distribution assumption. They both fit dose-response curves to central tendency and calculate the BMD as a dose where the central tendency has changed a certain amount. However, these methods have some limitations in their ability to interpret and utilize animal data properly. Therefore, we are developing a new approach to modeling dose-response relationship for continuous endpoints which is hypothesized to be more sensitive to identify adverse effects and more computationally effective. In the proposed method, DR model will fit to quantiles (influenced by both location and scale parameters of a distribution) instead of central tendency to avoid estimating the variance parameter. Rather than the current definition of adversity (a certain change in mean or median), we will primarily define it as a cutoff (e.g., a critical effect) for BMD calculation. To evaluate and validate the proposed methodology, we will conduct simulation study and toxicological data analysis (using IRIS and NTP data) and compare the results with existing methods to better understand the characteristics of the proposed approach. Given preliminary results, this more generalized method (because central tendency is 50th percentile) and more flexible BMR definition are expected to have a better performance than the existing approaches and able to make the BMD estimate more biologically meaningful.

M3-E.1 Chen, Z; Rose, A; Wei, D*; University of Southern

California; *adam.rose@usc.edu*

Reduced-Form Modeling of Maritime Cyber Threats

The Center for Risk and Economic Analysis of Terrorism Events (CREATE) has developed a user-friendly software system to rapidly estimate the economic consequences of many of the threats to the US economy listed on the Homeland Security National Risk Register. This paper presents a new module to estimate the consequences of a major maritime cyber threat based on an analysis of a shutdown of the ports of Los Angeles and Long Beach, California, where 40% of all container shipments enter the US. The modeling approach is to perform computable general equilibrium analyses of the cyber disruption associated with the range of conditions relating to the extent and duration of the port disruption, the commodity composition of imports, supply-chain considerations, and resilience tactics. The consequences are especially sensitive to the extent of resilience relative to the use of inventories, ship-rerouting and production recapture. The simulation results will serve as data input for a reduced-form regression analysis that can be incorporated into the software system.

P.78 Chen, CC*; Wang, YH; Wang, SL; Huang, PC; Chen, ML;

Hsiung, AC; National Health Research Institutes;

ccchen@nhri.org.tw

Exposure sources and predictors of urinary phthalate metabolites in Taiwanese children

Exposure to phthalates is prevalent that is known to have developmental and reproductive effects in children. In this study, we measured nine phthalate metabolites in 228 children aged 0-12 years who participated in Risk Assessment of Phthalate Incident in Taiwan (RAPIT). Two urine samples were collected from each participated children between 2013 and 2016, as were exposure questionnaire items and (consumption) frequencies on diet, plastic food container, prepackaged beverages, microwave use, personal care products, toys, and indoor living environment. A mixed model was used to assess the associations between each of the phthalate metabolites and the corresponding scores of the potential exposure categories, with participants as random effects for intraindividual variation. Plastic food container or wrapping had significantly positive associations with mono-(2-ethyl-5-hexyl) phthalate (MEHP), mono-(2-ethyl-5-oxohexyl) phthalate (MEHHP), mono-(2-ethyl-5-hydroxyhexyl) phthalate (MEOHP), and mono-benzyl phthalate (MBzP) in 4-6 years boys. Frequency of microwave use was significantly associated with mono-n-butyl phthalate (MnBP) and mono-isobutyl phthalate (MiBP) in 0-3 years boys, MEHHP, MEOHP and MiBP in 4-6 years boys, and girls, respectively. Consumption frequency of meat and seafood was associated with MEHHP and MBzP in 4-6 years children and mono-ethyl phthalate (MEP) in 7-12 years boys. Indoor environment was associated with MiBP in 4-6 years girls and di-2-ethylhexyl phthalate metabolites (DEHP) and MnBP in 7-12 years boys. The findings suggest that plastic food container and microwave food heating is the main source of phthalate exposure in Taiwanese children, followed by phthalate migration in foods and indoor environment.

W3-B.2 Chen, Y; Paoli, G; Hartnett, E; Ruthman, T; Pouillot, R*; Van Doren, JM; Dennis, S; FDA/CFSAN; *Regis.Pouillot@FDA.HHS.GOV*

Using FDA-iRISK® to quantify uncertainties in tiered and probabilistic ways and implications for decision making

FDA-iRISK® is a Web-based probabilistic risk assessment tool that the Food and Drug Administration (FDA) makes available freely to the public (<http://foodrisk.org/exclusives/fda-irisk-a-comparative-risk-assessment-tool/>). It enables users to compare and rank risks from multiple foodborne microbial and chemical hazards and to predict effectiveness of prevention and control measures. In addition to the capacity to integrate the variability of exposure and dose-response model elements via Monte Carlo simulation, recent developments have enhanced the tool to estimate uncertainty via two methods: (1) a tiered method through step-wise evaluation of alternative scenarios and (2) a probabilistic method through 2D Monte Carlo simulation. The choice of the method will depend on the specific questions to be addressed, availability of data and other considerations. This presentation will illustrate the different degrees of complexity involved and considerations in setting criteria and stringency to evaluate model convergence. Examples of using 2D variability and uncertainty analysis for single food or multifood risk scenarios will be presented, and the implications for communicating results to inform decision making will be discussed.

P.107 Chen, KW*; Chuang, YC; Wu, C; Wu, KY; National Taiwan University; *duckgoway@gmail.com*

The risk assessment of radiation exposure and stochastic effect from Japanese Seafood for Taiwanese after Fukushima accident

On March 11, 2011, a magnitude 9.0 earthquake occurred at the east coast of Japan. It triggered powerful tsunami waves. At the same time, Fukushima Daiichi Nuclear Power Plant was disabled leading to releases of radioactive material. Taiwan has maintained a close relationship with Japan, and both people have similar diet habit. This study tried to evaluate the additional radiation exposure from the Japanese seafood and the stochastic effect was calculated. Until April 10, 2016, 84,140 pieces of Japanese food had been tested and 214 (2.5%) of them were found to be radioactive. Thirty five were seafood and 144 were tea products. Nineteen foodstuffs were tested positive only for their packages. The frequency of test positive reached climax at the end of 2011 and then decreased gradually. There have been no radioactive foodstuff since October, 2015. There were eight pieces of foodstuffs contaminated with I-131 during March and April, 2011, which may reflect short half-life (8.04 days). The mean level of Cs-134 in Japanese seafood is 0.01048 Bq/kg, and the 95% confidence interval is 0.008119 to 0.01528 Bq/kg. The annual intake of Cs-134 is 0.6794 Bq and the 95% confidence interval is from 0.04388 to 1.73 Bq. After considering the IPF (0.05), the mean annual intake of Cs-134 in seafood is 0.03397 Bq, with 95% confidence interval 0.002194 to 0.0865 Bq. The radiation is 6.45E-07 [4.17E-08, 1.64E-06]. The mean level of Cs-137 is 0.01152 Bq/kg [0.009833, 0.01582]. The annual intake of Cs-137 is 0.758 [0.03027, 1.995]. After considering the IPF, the mean annual intake of Cs-134 is 0.758 Bq [0.03027, 1.995]. The radiation is 4.93E-07 [1.97E-08, 1.30E-06]. The total radiation from the Japanese food after considering IPF is 1.14E-06 [6.14E-08, 2.94E-06]. The stochastic effect is 4.78E-06 [2.58E-07, 1.23E-05]. The radiation exposure from the Japanese seafood is much lower than the Codex intervention exemption level (1mSv per year). The stochastic effect calculated with the IPF 0.5 is 4.78E-06 [2.58E-07, 1.23E-05].

P.79 Chen, Y.J*; Wu, J.Y; Huang, S.Z; Wu, K.Y; National Taiwan University and Public Health; b99605044@ntu.edu.tw

Estimations of health risk in food, by national food sampling analysis, to Taiwan

The aim of this study was to evaluate three indicators: Lifetime Average Daily Dose (LADD), Hazard Quotient (HQ), Lifetime Cancer Risk (LCR), to estimate health risks and rank the sampling order. The priority sampling list will enhance the efficiency of annual food monitoring program. Residual data was provided from Public health bureau and the intake data was from the National Food Consumption Database (NFCD). The exposure assessment of these chemicals used the Bayesian method combined with Markov Chain Monte Carlo simulation (MCMC). Besides, we collected reference doses (RfD) and cancer slope factors (CSF) from EFSA, Codex, US EPA and Food safety commission of Japan. The lowest RfD we took with LADD to calculate HQ and LCR. We also aggregated the HQs of some specific kinds of food to calculate Hazard Index (HI) to inform the government of high risk food. The study showed assessments of 52 compounds with concentration detection. The highly concerned chemicals that had HQ values greater than 0.2 were 29.3 (Acrylamide), 2.49 (Cyhalothrin), 2.05 (Cyfluthrin), 1.59 (Tolfenpyrad), 1.29 (Permethrin), 0.986 (Fludioxonil), 0.965 (Difenoconazole), 0.569 (Arsenic), 0.451 (Flufenoxuron), 0.370 (Acesulfame Potassium), 0.280 (Saccharin), 0.254 (Chlorpyrifos), 0.222 (Buprofezin), 0.213 (Dinotefuran). Moreover, LCR of carcinogens was greater than $1E-06$ needed to be concerned and addressed: 3.18~0.318 (Aflatoxin G1), 2.93E-02 (Acrylamide), 2.18E-05~2.18E-06 (Aflatoxin B1), 5.58E-06~5.58E-07 (Aflatoxin B2), 1.87E-06 (Chlorothalonil). Aflatoxin has a significant difference in Hepatitis B carrier account for up to 13.18% Taiwanese population. To explain, in non Hepatitis B carrier group, CSF of Aflatoxin B1 is 0.2, however, in Hepatitis B carrier group, CSF is 0.02 (ng/kg-day)⁻¹ (Felicia Wu et al., 2013). The authorities should pay attention on Acrylamide because its HQ was the highest and LCR was the second rank among all chemicals. A review of risk management protocol of food should be considered since compliance with current regulations may be inadequate in safeguarding health.

W2-H.4 Chiu, HA; Texas A&M University; wchiu@cvm.tamu.edu
Next generation human health decision-making incorporating population and inter-individual variability

The rapid advance of high-throughput testing and other new biological technologies has the potential to address a broad range of needs in health risk assessment. One important need is for risk assessments to adequately characterize uncertainty and variability, so as to provide decision-makers with a sense of the confidence in estimated risks and the extent to which susceptible individuals are protected. New and emerging tools, methods, and approaches to characterize uncertainty and variability are beginning to be incorporated into risk assessment. A common theme for all these approaches is the integration of population-based data and experimental models with probabilistic computational/statistical models. For instance, existing reverse dosimetry modeling approaches provide a characterization of toxicokinetic uncertainty and variability in relating in vitro concentrations to in vivo exposures. On the other hand, approaches to address uncertainty and variability in toxicodynamics or downstream disease processes are only beginning to be explored. Methodologically, a new probabilistic framework developed by the World Health Organization provides a potential means to integrate both old and new data streams together, while also providing more quantitative and transparent characterizations of risk. Taken together, these new approaches have risk management implications related to specifying the acceptable levels of uncertainty, population incidence, and magnitudes of effect in a particular risk context.

W4-G.3 Chimeddulam, D*; Wu, KY; Yu, HL; National Taiwan University; dalai.chimka@yahoo.com

A Physiologically Based Pharmacokinetic (PBPK) Model for PFDoDA in Rats and Humans

This work developed the model for PFDoDA, one of longer-carbon chain PFAAs, which were less studied, but, of growing great concern in risk assessment of exposure due to their increasing environmental emissions and bioaccumulation in wildlife. To help risk assessment of PFCs in reducing this uncertainty and broadening the scope for other PFCs, we aimed to develop a physiologically based pharmacokinetic model (PBPK) for PFDoDA in rats and extrapolated to humans. A structure of a PBPK model was time-dependent and flow-limited and consists of five essential compartments: liver as a target organ for liver recirculation and protein binding of PFDoDA, richly perfused tissues, poorly perfused tissues, adipose, and kidney as a specific tissue for the excretion. Model development and simulation were performed by using software packages of MATLAB and Simulink graphical user interface (GUI). Tissue:blood partition coefficients were estimated based on the method of unified algorithm developed by Peyret et al. 2010. Michaelis-Menten kinetic parameters were used to describe the binding to liver protein and renal excretion and reabsorption, and the corresponding parameters were estimated by fitting the model. The developed models were validated by comparing the model predictions with the measured blood concentration-time course data for corresponding chemicals at the different dose levels. A PBPK model for PFDoDA in rats have been developed for the first time and validated. This new rat PBPK model allows toxicological risk assessment predicting point of departure for toxicity of PFDoDA to set human exposure limit and toxicokinetic behavior of the chemicals through interspecies extrapolation. The interspecies extrapolation of rat PBPK model was successfully done using the interspecies allometric scaling in the physiological parameters of the human body and some adjustments in the chemical-specific biochemical parameters.

W4-A.2 Chopade, PV*; Chatterjee, S; North Carolina A&T State University, Greensboro, NC, USA, Pacific Northwest National Laboratory, Richland, WA, USA; pvchopad@ncat.edu
Exploring functional relationships among multiple infrastructure networks

Secure and reliable operation of multiple infrastructure systems is essential for sustaining modern societies. Network representations of these infrastructure systems are often utilized to conduct topology-based vulnerability analysis for a given system. This talk focuses on functional aspects of these infrastructure networks and mapping of critical functions across multiple infrastructure networks. Experimental results using graph-theoretic approaches for varying network structures, mapping schemes, and failure modes are also discussed.

T4-F.4 Chopade, PV*; Crowther, KG; Zhan, JZ; Roy, K; North Carolina A&T State University, Greensboro, NC, USA, MITRE Corporation McLean, VA, USA, and University of Nevada-Las Vegas, USA; pvchopad@ncat.edu

Framework for computational risk analysis of large networks

Understanding risk and vulnerabilities associated with functional aspects of a large complex network is difficult, because it requires significant computation and network metrics calculations. On the other hand if the network is small it wouldn't be a problem but when the network is enormous such computation would take too long to compute as it involves using the device memory and a lot of resources. Another challenging factor is implementing complex networks when most of the work is based on theoretical computers. Some alternative approaches come within reach of analyzing complex networks, such as graphing distributed computing. The multilayer and multi-community approach of complex interacting networks will be useful for understanding dynamic nature and making real-time decisions based on that understanding. Such real-time decisions are required for today's and the next generations' large complex network and its associated systems. Any complex network is composed of multiple interconnected and dependent components—including physical, communication, computer, information, and operational security elements. Unfortunately, vulnerabilities or failures can happen at the interfaces (i.e., multiple small failures can cascade to create overall system problems). In preparing for these, most risk methods break down because they require "people" to consider all possible "what can go wrong" events. Instead, we need to create computational framework i.e. algorithms that investigate permutations of network failures to computationally innovate our response to system failures (i.e., risks). Therefore, overcoming this problem requires designing a system with much more efficient pruning. In this work we present a computational framework for analyzing the multilayer and multi-community network robustness, associated vulnerabilities which help to assess risk and uncertainty associated with various threats. Proposed method uses threat, vulnerability, and consequence assessment information and statistical data to calculate quantitative risk levels.

P.3 Chuang, YC*; Wu, KY; National Taiwan University; mcy1979@gmail.com

Development of Cloud-Based Food Safety Assessment System from Post-Market Surveillance with Bayesian inference via Markov Chain Monte Carlo technique.

To ensure food safety and quality, post-market surveillance of Food Products have been implemented by local Health Bureaus yearly in Taiwan. Over 4000 cases have been inspected from markets and vendors per year and the Surveillance items are including pesticide residues in agricultural products/rice, veterinary drug residues in foods, heavy metal contents in fruits/vegetables/ rice and Mycotoxin in commercial foodstuffs. The high compliance rate of Post-Market Surveillance results are ranged from 87.2%-100% to show the food safety was well-managed through current regulatory standards in 2015 TFDA annual report. However, the health risk level in current status is hard to quantify to improve the performance of risk management. For conducting a health risk assessment, the challenges are as follows: 1). the detailed inspection information was scattered in local Health Bureaus individually without appropriate compilation. 2). the monitoring dataset from post-market surveillance which is highly censored data may produce biased exposure concentrations. Thus, cloud-based application and Bayesian inference with Markov Chain Monte Carlo technique (BSMCMC) can be adapted to overcome the problem of Food safety assessment from post-market surveillance simultaneously. Cloud storage database can provide friendly interface to local Health Bureaus without spatial limitation to collect inspection information that are including the sampling size, residuals concentration, food manufacturer, detection limits of instrument, and uncertainty. The proper prior distribution can be created by utilizing collected data to yield the posterior distribution of mean residual concentration which is combined with the likelihood function of Bayesian inference model. Therefore, the uncertainty of risk assessment from highly censored data will be reduced by BSMCMC model. The cloud-based Food safety assessment system not only assess health risk level with limited dataset but also improve the efficiencies of managing resource in risk management.

M4-I.1 Chosewood, KC; National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention; ahx6@cdc.gov

Connecting Cumulative Risk and Total Worker Health

Modern working conditions are changing and new risks are emerging more rapidly than ever before. And for many workers, traditional hazards continue to cause injury and illness and contribute to the development of chronic diseases at an alarming rate. To safeguard workers, organizations require novel, comprehensive strategies to better protect and promote the safety, health and well-being of workers. In 2011 the National Institute for Occupational Safety and Health launched the Total Worker Health® program. Today, Total Worker Health® is defined as policies, programs, and practices that integrate protection from work-related safety and health hazards with promotion of injury and illness prevention efforts to advance worker well-being. This approach seeks to craft safer jobs that create both a sustainable income and positive health outcomes for all who work. To be successful, this approach demands a new examination of risk, a more holistic understanding of the determinants, antecedents, interactions and relationships of exposures, both hazardous and ameliorative. It demands models and methods that account for risks encountered by workers, both while working and while off the job. This presentation will examine the potential for use of cumulative risks approaches in the design and implementation of total worker health interventions and research.

M3-H.3 Cifuentes, LA; Pontificia Universidad Católica de Chile; lac@ing.puc.cl

Risk and development perspectives from the Southern Hemisphere

Risk analysis can be a formidable tool for helping decision-makers take public decisions that improve the welfare of society, especially in a developing society where resources are scarce and needs many. Though some countries in Latin America have formal process to appraise the social benefits and costs of public investments and regulations (for example, Chile has a long tradition of cost-benefit analysis of public infrastructure projects), many risks are overlooked, until they are realized and their consequences can not be avoided, sometimes with catastrophic consequences. In this talk we present examples from the natural disasters and environmental area, and point out to some of the factors that contribute to ignore these risks, and what can be done to improve the risk analysis process in a development context.

T3-D.3 Cifuentes, LA*; Borchers, N; Pontificia Universidad Católica de Chile; lac@ing.puc.cl

Benefits of air pollution abatement across gender and socioeconomic position.

Social benefits from air pollution abatement are often used as a justification for emission control measures. In a benefit cost analysis decision framework, these benefits are weighted against the costs of control, with little consideration for distributional issues, i.e. which part of the population bears the costs and which one the benefits. This work looks at the differences in the benefits from reductions in health impacts from air pollution, and their relative importance. We look at the differences across gender and socioeconomic position. We investigate the importance of differences in health effects base incidence rates, of the unit risk, of different exposure reductions, and of differences of willingness to pay to avoid health effects. Data for the analysis comes from analyses of air pollution abatement conducted in four Chilean cities that have different socio-demographic characteristics. The results show that unitary benefits can vary by as much as factor of 2. Without getting into ethical considerations, we discuss the implications of these results for designing air pollution abatement programs and measures.

T3-J.3 Clarke, CE*; Budgen, D; Hart, PS; Stedman, RC; Jacquet, JB; Evensen, DTN; Boudet, HS; George Mason University; Cornell University; University of Michigan; South Dakota State University; Cardiff University; Oregon State University; cec54@cornell.edu

How Geographic Distance and Political Ideology Interact to Influence Public Perception of Unconventional Oil/Natural Gas Development

A growing area of research has addressed public perception of unconventional oil and natural gas development via hydraulic fracturing (“fracking”). We extend this research by examining how geographic proximity to such extraction interacts with political ideology to influence issue support. Regression analysis of data from a fall 2013 national telephone survey of United States residents reveals that as respondents’ geographic distance from areas experiencing significant development increases, political ideology becomes more strongly associated with issue support, with the liberal-partisan divide widening. Our findings support construal level theory’s central premise: that people use more abstract considerations (like political ideology), the more geographically removed they are from an issue. We discuss implications for studying public opinion of energy development as well as for risk communication

P.23 Clausen, JE*; Gomez Quiroga, G; ITESO University; xavierclausen@me.com

Key role of capacity building and participation in promoting the improvement of articulated risk and impact assessment system in Western Mexico

Articulates Risk and Impact Assessments are part of good governance systems. The Guadalajara Metropolitan Area (GMA) is the second largest in Mexico. The current urbanization of the periurban territories has intensified the effects of air emissions, vulnerability of the local aquifers to depletion and pollution, degradation of the best agricultural soils and important loss of forest coverage; thus endangering one of GMA’s main sources of good quality drinking water and resilience capacity to climate change. During the last years, collaborative efforts with the UN sustained a new vision for regional spatial and urban planning in GMA, incorporating a new approach to environmental governance, and an articulated system of risks and impact assessment. Urban models, mixed land use, proximity agriculture, sustainable transportation, environmental health and integrated water resources management are all issues valued during risk assessment scoping process. The ongoing capacity building on risk-impact assessments at local camp, collaboration with international organizations, enriched NGOs’ and citizen participation; all contributed to triggered a government political will to assess and improve the regional decision analysis and risk assessment system’s structure and performance through legislation from a best practice perspective. This poster discuss if investing in capacity building and participation in general, can nudge governments to do the next step and introduce risk assessments legislation.

M4-I.4 Clougherty, JE; University of Pittsburgh; jcloughe@pitt.edu
Integrating non-chemical and psychosocial factors into occupational cumulative risk assessment

Socioeconomic factors and chronic stressors (e.g., noise) are increasingly shown to both confound and modify relationships between physical exposures (e.g., air pollutants) and many health outcomes. As a result, in recent years, environmental cumulative risk assessments (CRAs) have begun to incorporate non-chemical stressors, including psychosocial stressors, into estimations of risk. Because physical and psychosocial factors influencing total exposures and susceptibility may arise from both the community and occupational environment – and exposures derived from one setting may modify impacts of exposures derived from the other – there is an increasing need to incorporate community environmental factors into occupational CRAs, and vice-versa In this presentation, Dr. Clougherty will discuss the current state of the knowledge on combined effects of pollutants and psychosocial stressors on health, and describe new methods for quantifying, and accounting for, potential confounding and effect modification by non-chemical stressors in environmental and occupational CRAs.

T4-E.2 Cogger, N; Massey University; *N.Cogger@massey.ac.nz*
Consequences of biological hazards: A systematic mapping of the literature

Agriculture and processing of products accounts for 8% of New Zealand's GDP and over half of our export earnings which makes the New Zealand economy and society are vulnerable to the risk associated with the biological hazards, such as foot-and-mouth (FMD). While the likelihood of an FMD incursion is extremely low the consequences to New Zealand would be extreme. Recent economic modelling of a wide-spread FMD incursion predicted that in the year following the incursion nominal GDP would decrease by \$13.8 billion (8%), exports will fall \$14.4 billion, on-farm employment in meat and dairy would fall by over 20% and employment in meat and dairy processing would drop by 79% and 89%, respectively. In order to improve New Zealand's preparedness for FMD a detailed assessment of the full range of impacts on the economy, people and environment is required. The aim of this study was to conduct a systematic mapping of the literature surrounding wide-scale biosecurity events to better understand the impacts. While systematic reviews have been used for some time in medicine this is the first time the approach has been applied to answer questions around how people experience events. The FMD specific events include the review are outbreaks in the United Kingdom, Europe, Korea and Japan. The non-FMD specific events were the Classical Swine Fever in Netherlands, the Equine Influenza outbreak in Australia. Researchers searched the peer review and grey literature (e.g. government reports) to identify potential papers. For each paper the follow was reported: the event, the nature of the field of research (e.g. observational, qualitative) and the impacts reported. This paper will present the results of the systematic mapping.

M2-I.1 Cohen, I.G.; Deubert, C.*; Football Players Health Study at Harvard University; *cdeubert@law.harvard.edu*
What are the key legal and ethical issues motivating the attention to NFL player health?

This presentation discusses the work of the Law & Ethics Initiative of The Football Players Health Study and the background for the Football Players Health Study at Harvard University. The Law and Ethics Initiative, led by the Petrie-Flom Center for Health Law Policy, Biotechnology, and Bioethics at Harvard Law School, encompasses a variety of distinct projects with the primary goal of understanding the legal and ethical issues that may promote or impede player health, and developing appropriate responsive recommendations. In particular, the Law & Ethics Initiative is grounded in the idea that to meet the challenge of protecting and improving player health, it is necessary to move beyond clinical issues to simultaneously address structural and organizational issues as well. The presentation will also provide a background on the Occupational Safety & Health Act, the jurisdiction of the Occupational Safety & Health Administration ("OSHA"), and the legal framework under which OSHA could attempt to regulate the NFL workplace.

W4-B.3 Cohen, JM; Gradient; *jcohen@gradientcorp.com*
Nanoscale Substances in Food: Small Materials Raise Big Questions

The increasing number and variety of engineered nanomaterials (ENMs) used in food and food contact materials raise concerns regarding potential hazards and risks to human health. ENMs are used for a wide variety of applications from enhancing the strength and reducing the weight of food packaging materials, to helping eliminate foodborne pathogens. The unique physical-chemical properties that provide their desirable functionality may also impart unique bioactivity that could potentially lead to human health hazards and risks. Tools for evaluating risks across the life cycle of nano-enabled products are emerging though major data gaps still exist, especially regarding characterization of consumer level exposures. Furthermore, most animal and cellular toxicity studies to date focus on freshly generated nanoscale materials that are not necessarily representative of consumer-level exposures. ENM properties relevant for biointeractions can vary greatly between the raw material, the nano-enhanced food or food contact substance, and any releases that may occur across the life cycle of the nano-enhanced product. Regulatory agencies in the U.S. (EPA, FDA) are currently trying to understand and manage potential risks to human health and the environment, though no nano-specific regulation yet exists. Meanwhile, nano product registries and mandatory reporting practices are emerging in Canada, France, Belgium, and other EU nation states, intending to facilitate monitoring and prevent potential hazards. In light of the ubiquitous nature of nano exposures from food, there is continued need for methods to integrate nano-risk assessments across the life cycle of nano-containing products.

W4-E.2 Collier, ZA*; Lambert, JH; University of Virginia; *zacollier@gmail.com*
Resilience of Gantt Project Schedules to Emergent and Future Conditions

The Project Management Institute has described that only 54% of projects finish on time, and only 38% finish both on time and within budget. While current, widely-used methods for project scheduling, including CPM and PERT, are able to incorporate probabilistic scheduling data, these methods are generally limited by vague estimates of most likely, optimistic, and pessimistic task durations. There is a need for project managers to proactively schedule tasks in a way that is linked to specific risks facing the project, including disruptive events associated with climate, markets, economics, technology, demographics, behaviors, and other emergent conditions. This presentation describes a method that links scenario-based preference analysis with Gantt-type project scheduling, where the influence on task priority and durations is assessed across a selection of emergent and future conditions. The method enables project managers to identify whether and how a schedule is resilient to particular disruptions, and to identify how schedule resilience can be improved. Illustrative case studies will include transportation corridors, fuel supply chains, infrastructure of developing countries, and energy grids.

T4-J.1 Collins, MB*; Harthorn, BH; Satterfield, T; Copeland, L; SUNY-ESF; mbcollin@esf.edu

Place-based hazard risk perception: Spatial disproportionalities in the context of fracking

This paper explores various spatial aspects of hazard risk acceptability judgments among US publics. Although we focus specifically on fracking activity and account for related regional intensity and overall presence, we also compare fracking acceptability to that of other known hazards (e.g. solar power, nanotechnology, climate change, etc.). Towards this end, we present two complementary analyses—the first using state-level data and the second looking specifically within the state of California. To begin with, our state-level comparative analysis examines fracking-specific public risk acceptability judgments among those who live where fracking intensity is high to those who live where there is lower (or no) fracking presence. In addition to intensity comparisons, we also compare judgments between publics located in places that can be classified as contributing to up/midstream activity (e.g. exploration, production, refining, processing, etc.) to those not who are located in such areas. In addition to fracking-specific analysis, we also compare fracking findings to hazard acceptability more generally across US states, allowing us to look deeper at how fracking differs from other known hazards acceptability judgments. To compliment the broader state-by-state comparison, we look more specifically at fracking growth and acceptability within the state of California. Our findings for this research are based on data from a large (n=2500) nationally representative environmental risk perception survey of US publics. In addition to speculating about the spatial nature of acceptability judgments across a landscape where risks are centralized and potential benefits are somewhat more diffuse, this paper also presents empirical findings that contribute to the ongoing debate about the upstream, midstream, and downstream perceived costs and benefits of technological development.

M2-J.8 Connelly, EB*; Lambert, JH; Linkov, I; University of Virginia; ec5vc@virginia.edu

Resilience analysis to inform priority-setting

Infrastructure management and policy decisions are complicated by deep uncertainties that can arise from surprising emergent conditions, multiple and oftentimes competing objectives, and diverse and changing stakeholder preferences. Investments thus need to be made with consideration of multiple possible futures over the lifetime of the infrastructure system. Current risk-based policies are insufficient and need to be supplemented to account for the resilience of infrastructure investments. Resilience should be considered both with respect to the physical system as well in terms of the strategic priority-setting. An approach is described that incorporates methods for strategic planning, risk analysis, and sustainability analysis. The presented resilience analysis methodology is applicable across a wide range of disciplines for informing management policies and other decisions subject to future uncertainties. The method is demonstrated for investments in alternative energy supply chains. The results reveal initiatives or investments that are high priority across a range of future scenarios. In addition, the results of this resilience analysis can serve to guide future research and development priorities.

T2-G.1 Conklin, DJ*; Chen, LC; Srivastava, S; University of Louisville and New York University; dj.conklin@louisville.edu
Cardiovascular Effects of Exposure to Harmful and Potentially Harmful Constituents (HPHCs) of New and Emerging Tobacco Products

On June 22, 2009, the Family Smoking Prevention and Tobacco Control Act gave the FDA authority to regulate new tobacco-derived products. To inform FDA's decision-making, biomarkers of exposure and biomarkers of injury from dose-dependent exposure studies are needed to identify the most toxic new tobacco-derived products. Emerging tobacco-derived products include electronic cigarettes, smokeless tobacco (e.g., snus) and hookah that contain, deliver and/or generate a number of harmful or potentially harmful constituents (HPHCs). Smoking is the leading cause of preventable deaths with nearly half of smoking-related mortality linked to cardiovascular deaths, and about 90% of the cardiovascular and pulmonary disease risk (non-cancer) is attributed to acrolein, an unsaturated, toxic aldehyde. Acrolein and other aldehydes amongst the greater than 8,000 chemicals in tobacco smoke represent arguably the most toxic of the HPHCs in tobacco products. As aldehydes are present in electronic cigarette aerosols, we investigated the toxicity of acrolein on cardiovascular disease endpoints using both acute and chronic dose-dependent exposures in mice. Thus, mice were exposed to varying intensities of acrolein, e-cigarette, tobacco smoke, nicotine or smokeless tobacco, and urinary metabolites of aldehydes were measured as biomarkers of exposure. Accordingly, the effects of acrolein on platelet-leukocyte aggregate formation (clotting), circulating levels of immune and endothelial progenitor cells, and atherogenesis (in apoE-null mice) were biomarkers of injury. Similarly, these outcomes were compared with the effects of e-cigarette aerosol (two doses of nicotine) exposures. The elucidation of the relationships between biomarkers of exposure and biomarkers of cardiovascular injury will provide data ranking the differential toxicity of tobacco products and acrolein an HPHC, and will inform design of future human studies to estimate cardiovascular disease risk of new tobacco products.

T4-G.4 Cowan-Ellsberry, CE*; Greggs, WJ; CE2 Consulting, LLC; Soleil Consulting, LLC; cellsberry@gmail.com
Tiering Consumer Product Exposure Tools

New research initiatives have resulted in increased ability to understand and predict how consumers are exposed to chemicals in products used in and around the home and office. Part of these efforts has focused on advancing the accuracy of consumer product exposure models that quantify daily exposures to ingredients in these consumer products. In fact, within the past year EPA has updated its Consumer Exposure Model (CEM) which is used within EPA's Office of Pollution Prevention and Toxics (OPPT) for new and existing chemical assessments. In addition, EPA's National Exposure Research Laboratory (NERL) developed the SHEDS-HT tool to provide exposure assessments for prioritization of large numbers of chemicals used in consumer products. Several tools have also been developed or recently updated in the EU for the REACH process to predict consumer exposures, including the ECETOC TRA, the ESIG EGRET tool and the RIVM ConsExpo model. The US and EU models are similar in that they all include 1) inhalation, 2) ingestion and 3) dermal exposure from use of consumer products. In many cases, they also include indirect or secondary exposures for these routes, e.g., exposure to chemicals on surfaces from product use. However, these tools represent varying levels of sophistication and were developed with different objectives in mind as well as different uses within consumer exposure assessment. In this presentation, these US and EU tools and their predictions will be compared to assist in understanding how these tools complement each other and can be positioned within a tiered exposure assessment framework.

W2-F.1 Cox, TL;
Popken, DA; Kaplan,
AM; Plunkett, LM*;
Becker, RA; Cox
Associates;
TCoxDenver@aol.com
**How Well Do High
Throughput Screening
(HTS) Assay Data
Predict in vivo Rodent
Carcinogenicity of
Pesticides?**

Recent research (Kleinstreuer et al., 2013) has suggested that high-throughput screening (HTS) data from assays with possible relevance for hallmarks of carcinogenesis can usefully predict the carcinogenic classification of certain pesticides. This talk will describe an independent replication and extension of these results; most (but not all) of them could be reproduced. However, correcting the misclassification of a single chemical in the test set changed the overall conclusion about the correlation between predicted and actual carcinogenicity classifications of a set of pesticides from significant to not significant. Furthermore, for the pesticides used for model validation, the accuracy of prediction was no better than chance for most (about three quarters) of the chemicals (those with fewer than 7 positive outcomes in HTS), suggesting that the predictive model was not useful for these chemicals. Although the rodent responses modeled (e.g., mouse liver tumors, rat thyroid tumors, rat testicular tumors, etc.) may not be biologically relevant to human responses, the data suggest that further research with HTS assays and improved "black-box" prediction models might help to predict reliably the classifications of in vivo carcinogenic responses in rodents for about a quarter of the pesticides considered, potentially reducing the need for testing in laboratory animals.

M2-E.4 Cox, T; Cox Associates and University of Colorado; *tcocoxdenver@aol.com*
Automating Causal Judgments in Risk Analysis

How can data be used to quantify the fraction of health, safety, and environmental effects (e.g., daily or yearly mortality counts or accident counts in a population) caused by controllable conditions, such as current exposures or workplace practices, in order to correctly predict how changing these conditions would change the frequencies of adverse effects? How reliably can such predictive causal relations be determined from relevant data, e.g., from exposure-response data with relevant covariates, and how certain can we be about the answers? Such questions of causal analysis and inference have often been addressed using weight-of-evidence systems in regulatory risk assessments, Koch's postulates in microbiology, and Bradford Hill considerations in epidemiology. But applying such considerations typically requires expert judgment, and expert judgment about causes is notoriously unreliable, being shaped by well-documented heuristics and biases (as discussed in Tversky's *Thinking, Fast and Slow*). This talk discusses and illustrates the possibility of automating valid causal inference by applying currently available machine-learning, causal discovery, and artificial intelligence technology to automatically formulate and test causal hypotheses and quantify potential causal relations identified in the data. Principles and the practical potential for fully automated causal analysis and modeling from data are illustrated using epidemiological data on air pollution health effects, analyzed with the free Causal Analytics Toolkit (CAT) software for users of Excel in Windows (<https://regulatorystudies.columbian.gwu.edu/causal-analytics-toolkit-cat-assessing-potential-causal-relations-data>).

W3-F.3 Cox, T; Cox Associates and University of Colorado;
tcoxdenver@aol.com

More objective causal interpretation of exposure-response data

Given any two positive variables indicating exposure and adverse response in an exposed population, it is always possible to find statistical models that will show a positive association between them (e.g., using the model $E(Y | X) = kX$ where $E(Y)$ is the expected response, X the exposure, and k is interpreted as a generalized "potency parameter" relating them. If X and Y are both positive, then k must be as well.) However, findings of positive statistical associations in selected statistical models may reveal nothing about how, if at all, changing exposure would change responses. In particular, the slope of a regression line relating Y to X need have no relation to how Y would change if X were changed, notwithstanding widespread misinterpretation of regression coefficients as indicating precisely this. Much of the association between X and Y may be due to model specification errors and uncertainties, omitted measurement errors, coincidental historical trends, p-hacking, and other non-causal sources of exposure-response associations. This talk will describe the effects of such modeling biases on recent estimates of exposure-response relations for fine particulate matter (PM_{2.5}) and elderly mortality risks. It will explain how ensembles of non-parametric models and other advances in machine-learning and statistical modeling methods can be used to help automatically detect, quantify, and correct for such biases, and will show that, in key data sets, such corrections reduce or even eliminate the adverse health effects previously attributed to PM_{2.5} exposures. An implication of this work is that using relatively objective methods of data analysis can lead to much smaller risk estimates than methods that give larger scope to subjective modeling choices.

W3-A.1 Crowther, KG; MITRE Corporation; kcrowther@mitre.org
Identifying and Management Cyber-Physical Risks in Smart Buildings

Many risk analyses begin by identifying all the what-can-go-wrong events up front. This works well to drive a compliance exercises to enforce due-diligence or for static one-time projects, but fails to capture emergent phenomena that may threaten a system (e.g., cyber vulnerabilities of physical security systems), hyper-targeted, rare events (e.g., gun-shots to specific cooling system on infrastructure assets), or unconventional threats (e.g., swarms of unmanned systems to deliver explosives to critical assets) - for which there is LITTLE OR NO DATA and little to no experience with certain risk sources until the events are happening. This research presentation focuses on risks from emerging advanced technologies in smart buildings. It begins by reviewing several hundred recent exploits to building access and control systems that impact the security and safety of the building or its occupants (e.g., physical access control systems, video surveillance systems, electronic security systems, fire and life safety systems, heating/ventilation control systems, smart lighting systems). It describes risk-based protection objectives for understanding how these and future sources of risk emerge. It describes approaches for accounting for and managing risks from advanced technologies as they emerge. While this research focuses on smart buildings, we believe that the results could be generally applied against critical infrastructure risk management.

T2-J.3 Crosman, K; Bostrom, A*; University of Washington;
abostrom@uw.edu

Perceived efficacy, action, and support for climate change risk reduction

Behavior change has the potential to reduce greenhouse gas emissions meaningfully (Dietz et al., 2009). To assess barriers to such change, recent climate change risk perception studies (e.g., Truelove and Parks, 2012; Thaker et al., 2014) have asked questions like: Do people think they personally or collectively are able to take action to reduce the risks of climate change? Do they think that those actions will slow or stop global warming? Building on these studies, we surveyed MTurkers (N=1013) to investigate climate change risk perceptions, and perceptions of individual, collective and government efficacy across a variety of possible mitigative actions. Initial findings raise interesting questions about climate change as a common-pool resource problem, as well as how individuals' beliefs influence personal choices. Respondents assess a broad range of specific personal-level actions (e.g., reducing household energy use by 20%) as easy for them personally, but more difficult at a collective level. At the same time, respondents perhaps predictably assess personal actions as ineffective when taken by individuals, but effective if taken at the collective level. These beliefs together lay the groundwork for a classic common-pool resource problem, where the incentives for cooperation are low because realizing benefits requires cooperation, which is perceived as unlikely. Further, individual beliefs about being able to take individual-level actions (i.e., self-efficacy) are associated with reporting action to slow or stop global warming. However, no such relationship exists between actions and perceptions of the effectiveness of those same actions at reducing global warming. Thus while individuals who assess personal-level actions as easy appear more likely to take those actions than those who assess actions as more difficult, initial results suggest that how effective the individual expects those actions to be in mitigating climate change is immaterial.

P.170 Crump, KS; Van Landingham, C; McClellan, RO*; Private Consultant; roger.o.mcclellan@att.net

A case study in data access, exposure assessment, and extended analyses: diesel exhaust exposure and lung cancer

The International Agency for Research on Cancer (IARC) in 2012 classified diesel exhaust as a "human carcinogen" largely based on findings from the Diesel Exhaust in Miners Study (DEMS) conducted by NIOSH and NCI scientists. This action raises the question - Are results of analysis of DEMS data sufficiently robust to support Quantitative Risk Assessment? DEMS was designed to test for an association between exposure to Diesel Engine Exhaust (DEE) and lung cancer in workers in 8 nonmetal mines from dieselization through 1997. Respirable Elemental Carbon (REC) was used as a metric for DEE and estimated from diesel Horse Power (HP), earlier measurements of CO in mines and assumed relationships among HP, CO, and REC. Cox proportional hazard models revealed a statistically significant association between REC and lung cancer in the total cohort and ever underground workers. Statistically significant associations were also observed in a nested case-control study controlling for smoking. The authors of this abstract with private industry support gained access to DEMS data and extended the original analyses. Uncertainties in REC estimates using CO as a surrogate for REC prompted us to develop alternative REC estimates using only mine specific HP and ventilation in CFM. The alternative REC exposure estimates were applied in a conditional logistic regression of the case-control data. Trend slopes calculated with new REC estimates were not statistically significant. Slopes were smaller by a factor of 5 without control and factors of 12 with control for radon exposure compared to slopes in original analyses. The varied results from different analyses should be considered in conducting quantitative risk assessments using DEMS data. This study illustrates the value of data sharing, construction of alternative exposure estimates and conduct of alternative analyses.

M3-J.8 Cui, J*; John, RS; University of Southern California; jinshucu@usc.edu

Effects of Psychological Distance and Cumulative Sequences on Near-Miss Appraisals

Prior near miss experiences have been identified as a contributing factor in responses to risks of disasters. Researchers have demonstrated that a near miss event could lead individuals to interpret the risk as either vulnerable (i.e., disaster that almost happened) and take precautionary measures, or resilient (i.e., disaster that could have happened but did not) resulting in no protective action under the belief that the near miss demonstrates the robustness of the status quo to extreme events. The current study hypothesizes that whether near misses are viewed as vulnerable or resilient is determined by the psychological distance (PD) between the decision maker and the near miss events. Moreover, this study focuses on sequential near misses and anticipates that a disaster is viewed as more distant with the accumulation of near misses over time. We conducted a behavioral experiment in which 100 respondents were exposed to a sequence of 20 events. The 20 events varied in outcomes of non-disaster, disaster, and near miss. Specifically, the 20 events contained 4 disasters, 4 non-disasters, and 2 sequences of 6 sequential near misses. Two dimensions of psychological distance (spatial and hypothetical) were manipulated in each near miss sequence using a within-respondents design. Each sequence of 6 near misses contained all 6 combinations of PD (two levels of spatial PD by 3 levels of hypothetical PD). Spatial PD was manipulated in terms of geographic distance between the decision maker and the disaster (proximal vs. distal); hypothetical PD was manipulated in terms of likelihood of the disaster (high vs. medium vs. low). Respondents predicted less risk of a disaster and were less likely to engage in protective measures when a near miss event is psychologically distant (either geographically or probabilistically) to the decision maker. Results also indicate that respondents were less willing to take precautionary measures as they experienced more near misses, suggesting a cumulative near miss cry-wolf effect.

W4-H.4 Cullen, AC*; Anderson, CL; Biscaye, P; Lawrence, A; Sace, R; Evans School, University of Washington; alison@u.washington.edu

Policy implications of gender associated differences in risk attitudes and perceptions among farmers in Mali and Tanzania

For many international development organizations, one theory of change is that the introduction of a new technology "shock" will start poor households on a pathway out of poverty. Adoption rates of these technologies, however, often fall short of expectations. Our observation is that many development interventions reasonably identify the risks to individuals of maintaining the status quo (e.g., continuing to plant with low drought resistant local seed or using local money lenders), but few recognize the risks to individuals of adoption (e.g., planting a seed that has not evolved in-situ in the face of unexpected climate/environmental stresses, or having legal recourse to recover funds lost to fraud). Previous research has shown that men and women, on average, have different risk and social preferences and may therefore see different value propositions in response to investment opportunities (Gneezy et al., 2003; Gupta et al., 2005; Niederle & Vesterlund, 2007; Croson & Gneezy, 2009; Fletschner et al., 2010; Charness & Gneezy, 2012; Anderson et al., 2014; Cullen & Anderson, 2016). We use data from the Farmer First Household Survey collected from both husbands and wives in 1,766 farm households in Mali and 1,997 farm households in Tanzania to test whether attitudes and risk perceptions differ systematically between male and female respondents in this setting and across risk domains. Further, we analyze whether factors other than gender are associated with differences in attitudes and perceptions, such as worldview, parenthood, marital status and beliefs about self-efficacy. Understanding if, and how, men's and women's preferences differ would allow organizations to better design interventions targeting a sub-population, such as women, to increase the likelihood of adoption of new technologies or approaches, or to better design broad-based interventions that do not inadvertently make certain sub-populations worse off, or actually increase the odds of negative outcomes.

WI-C.2 Cui, J*; John, RS; Rosoff, H; University of Southern California; jinshucu@usc.edu

Defender-User Coordination and Attacker Deterrence in a Three-way Behavioral Cyber Security Game

This study focuses on cyber attackers' choices in a three-way cyber security game involving attackers, defenders, and users. An attacker can choose to attack the defender (a 2-step action) or the user (a 1-step action) or not to attack. Conversely, the defenders and users select either a standard or enhanced security level. In Experiment 1, a total of 175 respondents played as attackers over 20 rounds of the game and were incentivized based on their performance. The uncertainties involve both defenders' and users' security choices, as well as exogenous uncertainty about the outcome. Defenders' and users' marginal security levels were held constant, while the relationship between their security levels was manipulated as either complementing, substituting, or nearly independent. In Experiment 2, a total of 497 respondents played as attackers over 30 rounds of a similar game where the outcome of attacker's move was only contingent upon defenders' and user's security levels. The relationship between defenders' and users' strategies was again manipulated as either complementing, substituting, or independent. We found that there was greater deterrence (cyber attackers choosing not to attack) for negatively correlated defenses than for independent defenses in both experiments. The effect was stronger under exogenous outcome uncertainty. We also manipulated defenders' and users' marginal security levels in Experiment 2. As predicted, there was greater deterrence associated with greater likelihood of enhanced security for both defenders and users. Attackers were more likely to attack defenders (users) when defenders (users) had greater likelihood of standard security than users (defenders). In addition, we found that attackers were more likely to shift from attacking users to defenders after learning users had enhanced security. Attackers were less likely to continue the second step of defender hack (deterred) after learning defenders had enhanced security.

T3-I.3 Cunningham, TR; National Institute for Occupational Safety and Health; TCunningham@cdc.gov

A Behavioral Perspective on Risk

Although it is not always a focus of risk analysis efforts, behavioral science has a rich history of interventions for mitigating risks associated with the workplace. This presentation will offer a behavioral perspective on addressing occupational risk. In particular, leadership decision-making and the description of consequences will be highlighted to further the discussion of a common language of risk across disciplines.

P.104 De la Yncera, NC*; Lopez, E; Lorenzo, A; Universidad Autónoma del Estado de Morelos ; *nadiosyncera@gmail.com*
Psychosocial intervention to strengthen community resilience to disasters

Facing suitably risky situations and disasters constitute a priority of our society, due to the rising of its effect in recent years. In this study will be presented the experiences and results of two investigations, one carried out in Cuba and the other in Mexico. The first one is related to the application of the Innovation Project: "The Improvement of the psychosocial coping styles while having emergency situations and disasters", which was put into practice at the coastal area of the community of Coloma, in the municipality of Pinar del Rio, In Cuba (2010- 2014); the second one is about some job experiences in the municipality of Yautepec, in Mexico, related to the community resilience while facing disasters and natural threat (2015-present). In both cases, an Investigation-action methodology is used for the actions planned. We concluded, the first stage of the study must be headed towards an approach to the psychosocial aspects that must of the time are unnoticed, are minimized or are not considered in the management of the risks. In this regard, social representations, risk perceptions, and the way to face disasters have been explored. We observed there are different actions that we considered to be learned lessons. We have also looked into the protecting factors that are turned on because of severe events as well as the risk factors and the vulnerability that coexist. We have detected some resilience pillars that activate during such adversities. We presented some psychosocial strategies that contribute to the resilience in order to avoid and/or minimize the damage that is provoked by the disasters in every aspect of people's daily life, as well as to contribute to the community welfare.

W2-I.4 De Marcellis-Warin , N*; Backus , A; Warin, T; Harvard Center for Risk Analysis, Harvard T. Chan School of Public Health, Polytechnique Montreal, HEC Montreal and CIRANO; *nathalie.demarcellis-warin@polymtl.ca*
Shale Gas and Hydrofracking in the US: Analyzing Conversations on Twitter

Nowadays, millions of people comment in real-time, tweet, retweet, etc. Users can optionally choose to provide location information for the Tweets they publish. This information can be accurate if the Tweet is published using a smartphone with GPS capabilities. In this paper, we attempt to analyze the conversations on Twitter about shale gas and fracking in the U.S., using the Nuance-r platform. We used geolocalized Tweets in the U.S. using keywords and hashtags such as #shalegas, #fracking, #hydrofracking, #frackingwastewater, #frackquake, etc. and specific shale plays names such as #Marcellusshale, #Uticashale, #Barnettshale, etc. The tweets were collected by the Harvard Center for Geographic Analysis between September 2012 and December 2015. We present the distribution of tweets across the U.S. by year. Word clouds help to highlight important words and topics addressed in the tweets. We identify the hashtags used and the evolution from 2012 and observe than more hashtags were used in 2014 and 2015. Not only the data (content of the tweets), but also the metadata are interesting. Indeed, the content allows us to do some sentiment analysis (both emotions and polarity) and thus map positive and negative comments about shale gas and fracking and topic of the discussion (benefits, jobs, earthquakes, environmental impacts, health impacts, etc.). With the metadata, we can map with latitude and longitude data where tweets originate and compare to the shale plays' location. We can thus add a spatial dimension to the conversations and explore the spatial relationships between hydrofracking sites and public engagement with fracking-related issues.

P.133 De Marcellis-Warin , N*; Backus , A; Harvard Center for Risk Analysis, Harvard T. Chan School of Public Health, Polytechnique Montreal and CIRANO ; *nathalie.demarcellis-warin@polymtl.ca*
FrackMap : A Tool to Communicate about Fracking and Potential Environmental and Public Health Impacts in the United States

In recent years, unconventional oil and gas developments (including hydraulic fracturing and horizontal drilling) have increased exponentially across the United States. These activities have raised concerns in some communities about potential environmental and health issues/impacts, especially on people living in communities proximate to hydrofracking sites. FrackMap was created using the Harvard WorldMap, a public domain collaborative mapping platform. FrackMap brings together a range of fracking related datasets (oil and gas permits, shale formations, horizontal legs, reports of specific chemical used, etc.). Moreover, we are in the process to add several layers onto the map. In particular, a new layer will help visualize the current scientific knowledge and peer-reviewed literature about potential environmental and health issues and impacts associated with U.S. shale gas plays. We identified peer-reviewed articles published during the last 10 years including location data and we map them by state and by shale play. Another layer will map geolocalize Tweets in the US using keywords and hashtags such as #shalegas, #fracking, #hydrofracking and specific topics #frackquakes, #frackingwastewater, etc. These tweets provide some interesting information about people's feelings and risk perception. FrackMap is an innovative tool to communicate through maps and interactive data visualization.

T4-H.1 Delborne, JA; North Carolina State University; *jadelbor@ncsu.edu*

Reflections from the National Academy of Science committee on non-human gene drives and responsible conduct

In June 2016, the National Academy of Sciences released a report on non-human gene drives and issues of responsible conduct. This report resulted from ten months of research, public meetings, webinars, committee meetings, and collaborative writing by a team of interdisciplinary scientists, social scientists, and humanists (including the presenting author, Jason Delborne). The report addresses issues ranging from the state of the science of gene drive to risk assessments to public engagement to governance of gene drive research and development. This presentation will highlight key conclusions and recommendations from the NAS report and reflect upon the media coverage and public discourse since the report's release.

W4-F.2 DeLeo, PC*; Ciarlo, M; Pacelli, C; Greggs, WJ; Williams, ES; Brooks, BW; Scott, C; Wang, Z; American Cleaning Institute; EA Engineering, Science and Technology; Soleil Consulting; Baylor University; pdeleo@cleaninginstitute.org

Cleaning Product Ingredient Safety Initiative: Development and application of an approach for high-throughput screening-level human health risk assessment for nearly 600 ingredients

The American Cleaning Institute (ACI) has undertaken a screening-level risk assessment for all ingredients used in consumer cleaning products sold by its' members in the United States. An inventory of 588 ingredients was created based on a survey of 900 products. Ingredients were assigned functional use classes to denote purpose and aid in estimating concentration specific to product use. To establish concentration at the point of exposure, our team mined product sheets, generic formulations, scientific publications, trade literature, and government reports. For each unique ingredient in each product type, minimum and maximum concentrations were established. Exposure models for the intended uses of each product were gathered from existing resources, and covered the following routes of exposure: direct and indirect dermal, indirect oral, and direct inhalation. Intake estimates were then calculated for children and adult women, including upper and lower bounds of potential exposure, and accumulated based on use of multiple products. To provide hazard data for each ingredient, a database of over 6,000 relevant data points was compiled from published hazard studies. In some cases, existing risk assessments or safety assessments from authoritative bodies were found which demonstrate ingredients as safe at exposure levels greater (generally much greater) that would be found through cleaning product use. Where an authoritative body safety finding was not available and relevant for an ingredient, a no observed adverse effect level (NOAEL) was derived from the hazard database. Based on the cumulative exposure estimates and NOAELs, margins of exposure (MOEs) were calculated based on each exposure pathway. The exposure estimates, NOAELs and MOEs were published via an internet clearinghouse together with supporting information: <http://www.cleaninginstitute.org/cpisi>.

W2-I.3 Demuth, JL*; Morss, RE; Palen, L; Anderson, K; Watts, J; Barton, M; National Center for Atmospheric Research; jdemuth@ucar.edu

Examining the dynamic ways people evaluate and respond to evolving hurricane risks

Hurricanes are dynamic, evolving in space, time, and (un)certainly. Skillful hurricane forecasts are available days in advance and are updated and refined as the event unfolds, and this weather risk information is used by public officials to inform recommended protective actions (e.g., evacuation orders). An unprecedented ability exists to communicate this dynamic hurricane risk information via multiple sources and channels, including with social media. Because hurricane risks and communication about them are dynamic, so too are the ways that people evaluate and respond to them. This presentation will discuss two, complementary ways that we are studying these dynamic processes. First, we analyze Twitter data--which offer a quasi-real-time, longitudinal record of users' perspectives--collected during Hurricane Sandy. Using these data, we examine people's risk information behaviors, perceptions, and responses with a focus on when these processes occurred, changes in them, and connections among them as the hurricane threat evolved. We also explore the influence of people's past experiences and vulnerabilities on these processes. Second, we perform experiments with a spatially explicit, agent-based model (ABM) that inputs historical storm information and forecasts, which are passed among different types of agents (e.g., broadcasters, public officials, publics) through information networks. Public officials decide whether to issue evacuation orders, and this information, along with the hurricane forecasts, is used by public agents. The ABM can be used to examine how different hurricane risk information, with different levels of uncertainty and skill, propagates through the information system and influences information-seeking behaviors, risk perceptions, and protective responses as the storm approaches. The Twitter data and ABM analyses together help develop deeper understanding of how, when, and why people respond to evolving hurricane risks in the ways that they do.

W1-J.1 Demski, C*; Evensen, D; Pidgeon, N; Cardiff University; demskecc@cardiff.ac.uk

Delivering energy transitions: the importance of trust

Previous research has explored the range of values underlying societal preferences and attitudes towards sustainable energy transitions, highlighting how these preferences are also dependent upon trust in institutions and governance arrangements. In particular, it is stipulated that decreased trust would negatively affect the 'social licence to operate' that industry and government will need for safely and reliably delivering long-term, sustainable low-carbon transitions. In this presentation we build on this work to examine public perceptions of different actors and their relationships within the UK energy system (e.g. government, energy companies, individuals) in more detail. Drawing upon existing qualitative and newly collected survey data (n=3000) we examine the roles and responsibilities that our respondents ascribe to different actors and whether people believe that these actors can and will contribute to the delivery of desirable energy transitions in its various forms. In doing so we draw on established trust literature to examine both judgments of competence and relational trust and apply these judgments to the context of decision-making within energy transitions. We pay particular attention to the importance of relational trust in the form of value similarity, which has been emphasized as principally important for informing people's judgments. As such, we examine relational trust both directly, in terms of perceived value similarity, and indirectly, by comparing people's own values to those energy system actors are perceived to hold. Through this analysis we build an understanding of the beliefs that inform people's perceptions of, and trust in, different actors. In turn, these beliefs are likely to influence people's distribution of responsibility as well as willingness to take on personal responsibility for the delivery of desirable energy transitions.

M2-C.1 Dillon-Merrill, RL; Georgetown University; rld9@georgetown.edu

Decomposing the Intention to Act

In order to understand people's willingness to take action to mitigate a risk, we introduce a model that extends beyond the traditional idea that simply believing there is a problem will lead to action. Our model proposes that in addition to a belief that a problem exists, individuals' belief that there are actions they can personally take to stop the problem and their belief that now is the right time to act are two important precursors to their intentions. This model is compared to both the Theory of Reasoned Action and the Theory of Planned Behavior. Respondent data from several different problem areas will be discussed.

T2-J.1 Dixon, GN*; Ma, Y; Hmielowski, J; Washington State University; graham.n.dixon@gmail.com

A conflict on consensus: Current critiques and future outlook on climate change consensus messaging research

Efforts to improve science communication in the U.S. are often complicated by deep divides between scientists and the lay public. A 2015 Pew Research poll, for instance, reports wide disparities between what these two groups believe about a variety of issues, such as climate change, vaccination, and genetically modified (GM) foods. Closing these gaps has been a major priority for many scientists and policymakers. However, efforts to do so have been fraught with inconsistent findings and recommendations. Touted as a panacea to scientific misinformation, some researchers suggest messages emphasizing a scientific consensus help to close belief gaps between scientists and the lay public for issues like climate change and vaccination. Other researchers find consensus messaging to be less effective for audiences whose views do not already conform to the scientific consensus, as well as those who are less receptive to scientific authority. Furthermore, others have leveled criticism of consensus studies' measurement validity and analytic approaches. With many organizations relying on consensus messaging to reach skeptical audiences, inconsistent findings on consensus messaging necessitate further inquiry. This project investigates this issue with a critical review of the research, while also providing new empirical findings that shed light on the future of consensus message research.

M2-G.2 Dourson, ML; TERA Center, University of Cincinnati; doursoml@ucmail.uc.edu

The concept of hormesis and application in risk assessment

Hormesis is a dose-response concept that is characterized by a low-dose adaptive effect and a high-dose adverse effect. This presentation will show the basic premise behind hormesis and explore whether it is generalizable to the point of being useful for risk assessment. Specifically explored will be whether hormesis is independent of biological model, endpoint measured, chemical class, mechanism and/or inter-individual variability. Hormesis may also provide a framework for the study and assessment of chemical mixtures, incorporating the concept of additivity and synergism. Because the hormetic biphasic dose response may represent a general pattern of biological responsiveness, it may become progressively more significant within toxicological evaluation and risk assessment practice.

M4-I.2 Dotson, GS; Centers for Disease Control and Prevention (CDC)/National Institute for Occupational Safety and Health (NIOSH); fya8@cdc.gov

Efforts to Address the Challenges of Integrating Occupational Risk Analysis and Cumulative Risk Assessment

People are exposed throughout their lifetime to agents and stressors that may adversely affect their health and well-being. These agents and stressors may originate from different sources such as the environment, residence or workplace. The interaction of these stressors with each other along with individual factors, such as genetics and lifestyle choices, may further modulate the health consequences. Characterizing the combined, or cumulative, risk associated with these interactions has received increased attention in recent decades and has resulted in the development of cumulative risk assessment (CRA) approaches. To date, CRA has primarily been used to investigate environmental and community health issues with limited, or no, focus on occupational health. Large durations of a person's life is spent conducting work-related activities and occupational health is a key component of public health. This presentation will discuss on-going research efforts underway at the National Institute for Occupational Safety and Health (NIOSH) to incorporate CRA procedures into occupational health. Emphasis will be placed on describing the unique challenges to developing and conducting occupationally-focused CRA capable of characterizing the impact on workers' health associated with multiple stressors arising from occupational and non-occupational settings.

WI-H.2 Driedger, SM*; Greenberg, J; Dubé, E; University of Manitoba and Carleton University and Institut National de Santé publique du Québec; michelle.driedger@umanitoba.ca

A Canadian national perspective on vaccine hesitancy: Results of an online survey regarding a wicked risk communication problem

This presentation reports the findings of a Canadian national online survey to parents (n=1,000) of children aged 5 and younger in November 2015. The objectives were to assess parental understanding of childhood immunizations, identify trusted sources of information for vaccine-related content, and find out which communication strategies parents considered most effective. We found that the vast majority of parents consider vaccines safe and effective, and trust doctors and public health officials to provide credible vaccine-related information. However, a concerning number believe or are uncertain whether there is a link between vaccines and autism, worry that vaccines might seriously harm their children, or believe the pharmaceutical industry is behind the push for mandatory immunization. Also, despite the common assumption that social media are becoming a major source of health information, and thus present a threat to public health communication, most parents still rely on traditional media and official government websites for credible information about vaccines and vaccine preventable diseases. Finally, parents reported high levels of support for pro-vaccine messaging that has been demonstrated in previous research to have little to no positive impact on behaviour change, and may even be counterproductive. These results are highly relevant in a context where public health officials are expending significant resources to increase rates of childhood immunization and combat vaccine hesitancy. The data offer insight into where parents stand on the political and public debate about mandatory vaccination, what aspects of vaccine science remain uncertain to them, which information sources they use and trust, how they look for information and whom they trust during periods of health emergency or crisis, and which communication strategies are considered most effective in persuading vaccine hesitant parents to immunize their children.

P.27 Drummond, C*; Fischhoff, B; Carnegie Mellon University; cdrummon@andrew.cmu.edu

Putting on your thinking cap: completing a warm-up reasoning task produces critical but biased evaluations of scientific evidence
Prior research suggests that the motivation to maintain personal beliefs leads individuals to evaluate scientific evidence more critically when it opposes their beliefs (Lord, Ross & Lepper, 1979; Kunda, 1990). We test whether a “putting on your thinking cap” manipulation, in which participants complete a warm-up scientific reasoning task before reading scientific evidence, will reduce the degree to which participants’ evaluations are biased in favor of pro-attitudinal scientific evidence. In our experiment, proponents (N=302) and opponents (N=303) of the Affordable Care Act (ACA) were recruited to take an online survey. Participants were randomly assigned to read a news article describing one of two real scientific studies. The studies used nearly identical methods and data, but only one found positive effects of the ACA on access to healthcare. In the “thinking cap” condition, participants were randomly assigned to complete a warm-up reasoning task, the Scientific Reasoning Scale (SRS; Drummond & Fischhoff, 2015), which consists of eleven short scientific reasoning problems, before reading the news article. In the control condition, the SRS was administered at the end of the study. We found that participants who read pro-attitudinal articles judged the scientific evidence to be of higher quality than those who read counter-attitudinal articles, and that the magnitude of this bias did not differ in the “thinking cap” and control conditions. Instead, we found a main effect of the “thinking cap” condition such that participants who took the SRS before reading the article judged the science to be of lower quality. Our results indicate that putting your thinking cap on increases critical thinking but fails to reduce bias due to prior beliefs. We discuss the implications of this research with regards to public skepticism of science.

W4-J.1 Duintjer Tebbens, RJ*; Thompson, KM; Kid Risk, Inc.; rdt@kidrisk.org

Polio eradication and the role of subpopulations for risk management

The April 2016 coordinated global cessation of all oral poliovirus vaccine (OPV) containing serotype 2 strains represents a major milestone in the polio endgame. If successful, the endgame will include global eradication of wild poliovirus (WPV) serotype 1 and coordinated cessation of OPV containing serotypes 1 and 3. Stopping WPV transmission increasingly requires a focus on specific subpopulations missed by national immunization efforts, with the success of the global effort depending on immunizing under-vaccinated communities while at the same time sustaining sufficient efforts in the rest of the population. Achieving high enough confidence about eradication and the true absence of WPV circulation requires high-quality surveillance that can detect signals from both the general population and under-vaccinated subpopulations. Outbreaks of circulating vaccine-derived poliovirus may arise soon after OPV cessation from subpopulations insufficiently vaccinated with OPV prior to cessation. If the world can rapidly respond to and control these outbreaks, then the main long-term source of risk comes from rare patients with primary immunodeficiencies who may harbor an infection for many years or (un)intentional releases from poliovirus manufacturing sites or laboratories. Given the reality of global variability and the existence of under-vaccinated subpopulations, models that aim to inform risks and decisions related to disease eradication depend on their ability to appropriately characterize these groups. We discuss the challenges of developing such models in the context of the inherently poor data quality for under-vaccinated subpopulations, recognizing that the properties that complicate disease eradication typically correlate in under-vaccinated subpopulations (e.g., poor routine immunization, poor surveillance quality, high poliovirus transmissibility, low vaccine seroconversion).

T3-G.2 Druwe, IL*; Burgoon, LD; Oak Ridge Institute for Science and Education, US Environmental Protection Agency, National Center for Environmental Assessment and US Army Engineer Research and Development Center, Environmental Laboratory; druwe.ingrid@epa.gov

Bayesian Re-Analysis of Lung Tumor Incidences in CD1 Mice Resulting From ‘Whole Life’ Exposure to Inorganic Arsenic

From 2011 to 2014 the Waalkes research group at the NIEHS published a series of ‘whole-life’ animal studies of CD1 mice that had been exposed to either 0, 50, 500 or 5000 ppb inorganic arsenic (iAs) via drinking water. The researchers concluded that mice exposed to 50 and 500 ppb (iAs) had a greater incidence of lung tumors but the mice exposed to 5000 ppb did not. This conclusion was challenged by three established scientists who questioned the results who reasoned that CD1 mice are known to produce spontaneous lung tumors. Many of the concerns raised have centered on the uncertainty of the tumor incidences in the control animals. If these assertions proved true, the Waalkes studies would be less informative for human health risk assessments of iAs. Using a Bayesian approach we performed the analysis requested by those challenging the results, specifically, we tested the null hypothesis: The control animal lung tumor incidences reported by the Waalkes group in 2011 are not different from the incidences reported in 2014. Using a flat prior we modeled the studies as Bernoulli distributions and used a region of practical equivalence approach (ROPE) analysis to assess if the results came from the same distribution. We integrated the control animal incidence data from all of the studies using a flat prior with the 2011 study as our posterior and updated our prior to integrate the subsequent studies. We also applied this approach to analyze the lung tumor incidence data from animals exposed to iAs in these same series of studies. Our analyses showed the data support the finding that exposure to iAs increases lung tumor incidence in CD1 mice at 50 and 500ppb, but not at 5000 ppb, with odds ratios of 3.1:1, 3.5:1 and 1.2:1, respectively. Thus, based on the published experimental data, we confirm that the Waalkes studies demonstrate iAs exposure increases lung tumor incidences in CD1 mice. Disclaimer: The views presented in this article do not necessarily reflect current or future opinion or policy of the U.S.EPA and the U.S. Army Corps of Engineers

T4-B.4 Duret, S*; Pouillot, R; Fanaselle, W; Papafragkou, E; Williams, L; Liggans, G; Van Doren, JM; Food and Drug Administration; Steven.Duret@fda.hhs.gov

Modelling the impact of ill food employee behavior and interventions on Norovirus transmission in retail food establishments

Human noroviruses are the major cause of foodborne gastroenteritis within the United States. These viruses can be transmitted to food products via contaminated human fecal material or vomit from symptomatic and asymptomatic infected food employee. In retail food service environment, most foodborne outbreaks are traced to food employee contamination of food not intended for heat treatment before consumption. We developed a quantitative risk assessment model to quantify and study the risk associated with norovirus transmission to consumers through food contaminated by infected food employees in the retail food setting. More specifically, this study focused on the impact of ill food workers experiencing symptoms of diarrhea and vomiting and of potential control measures for the transmission of norovirus to foods. A discrete event model was selected as the most appropriate model framework as it allows the description of various consecutive tasks of food employees such as food preparation, food assemblage and visits to restrooms. The model examined the behavior of food employees regarding exclusion from work while ill and after symptom resolution and preventive measures limiting food contamination during preparation, such as handwashing, glove use, and other sanitation practices. The model also analyzed the impact of hand washing efficacy. This presentation will focus on the description of the model framework, assumptions, and the inputs, highlighting strengths and limitations of this approach.

T3-C.4 Ede, JD*; Shatkin, JA; Vireo Advisors, LLC;
jede@vireoadvisors.com

State-of-the-art nano risk assessment frameworks and their relevance for decision making

As nanomaterials increasingly enter the market, the importance of adequately assessing their risk is widely recognized. Around the world, various governmental agencies, international organizations and institutions are developing risk assessment frameworks for nanomaterials, highlighting the special considerations needed when compared to conventional materials. We critically reviewed available concepts for nanomaterial testing frameworks, each developed for the purpose of gathering data to evaluate the human health and environmental risks of nanomaterials. We assess and compare each framework for information requirements, intended priority (e.g. occupational, environmental, human health) and regulatory alignment. In addition, we complete a detailed analysis of each framework in terms of testing requirements for evaluating risk. Our analysis highlights the special considerations necessary for nanomaterials and we evaluate the relevance of each framework for decision making.

P.198 Eisenberg, DA*; Kitsak, M; Ganin, A; Linkov, I; Alderson, DL; Arizona State University; daeisenb@asu.edu

Multilayer Command and Control Networks

The expansion from studying complex networks in isolation to multilayered systems that link separate networks together is one of the fastest growing areas of research in network science. Command and control (C2) systems are sociotechnical systems comprised of interdependent networks of physical infrastructure, information and knowledge sharing, social hierarchy, and goal-driven activities, suggesting that they should be studied via this new multilayered network paradigm. Despite a growing body of research, multilayer network studies continue to overlook fundamental structures and functions of C2 systems, diminishing the capacity of experts to translate research into practice. In this poster, we outline contemporary C2 theory, how it relates to multilayer network analysis, and detail meaningful approaches to analyzing C2 systems with multilayered methods that inform real-world practice. Specifically, we review the characteristics of physical, information, cognitive, and social networks which comprise C2 systems and provide examples from military, emergency management, and civilian infrastructure domains in which they have been studied. We use this knowledge to inform more complicated multilayer structures that combine inherently different networks and analysis methods, such as nodal centralities, network structures, and dynamics. Taken together, this work integrates necessary knowledge from C2 and network literature to provide a basis for relating fundamental multilayer network research conducted on abstracted or synthetically generated systems to their real-world counterparts.

W4-A.3 Eisenberg, DA*; Park, J; Kim, Donghwan; Seager, TP; Arizona State University, Hongik University; daeisenb@asu.edu
Bridging sociotechnical networks for critical infrastructure resilience: South Korean Case Study

Critical infrastructure system (CIS) resilience depends on the functionality of technical components and the actions taken by people to plan and prepare for, absorb, recover from, and to adapt to unforeseen events. The majority of empirical work, however, analyzes CISs isolated from their social context, limiting the practicality of derived conclusions. Network science has emerged as one approach to model the components and interactions in CISs, yet the disparate nature of the nodes, links, and flows within social and technical networks limit the feasibility of combining systems into a single analysis. Here, we study how social and technical networks influence each other by linking a network model of electric power crisis management organizations in South Korea (Korea hereafter) to a corresponding electric power grid network. First, we develop a social network via Korean crisis management protocols and use betweenness to determine organizational contribution to information sharing and crisis coordination during blackouts. Second, we implement cascading failure models in a Korean power grid network and generate time-varying sub-networks of the Korean interorganizational system by relating predicted infrastructure losses to organizations. We analyze the resulting social networks to characterize which organizations are most impacted by blackouts and which organizations contribute to crisis coordination across multiple blackout scenarios. Results show that Korean power companies receiving equivalent treatment in crisis management protocols are affected by blackouts in markedly different ways. Also, the comparison between static and time-variant analyses indicate that the networked roles of organizations shift dramatically depending on power system dynamics. Taken together, this work generates new understanding of how blackouts influence interactions among Korean organizations and is a first step towards sociotechnical CIS resilience analysis.

W4-F.1 Eisinger, FA; Paoli-Calmettes Institute Marseille, France ; Aix Marseille Université, UMR_S912, IRD, 13006, Marseille, France ; INSERM, UMR912 (SESSTIM), 13006, Marseille, France ; eisingerf@ipc.unicancer.fr

From evidence based to preference based medicine

After years of authoritative decision making by presumed knowledgeable doctors for uninstructed patients, followed by the reign of Evidence Based Medicine (EBM) used by doctor to pave a therapeutic way with the patient, we are now facing the emergence of "preference based medicine" where patients feel sufficiently informed to make their own decision. The emergence of EBM was, not only a shift from intuitive decision making toward more scientifically approved decisions, but also affected the doctor-patient dynamics, moving from a paternalistic physician toward a shared decision. Indeed three "actors" take part in the medical decision process: the patient, the physician and the "knowledge system". Until the early ninetens physicians were entitled to make decisions based on their acquired experience. Later knowledge production shifted from case reports (experiential) towards comparative prospective surveys (experimental). Besides this evolution of knowledge production and access we also face a sociological transformation of the legitimacy of the medical choices. There's a growing modification of the current balance between the doctor and the patient as the 'knowledge system' can be directly accessed by virtually anyone; moreover, there's conversely the emergence of direct-to-patient marketing. Patient empowerment moves what constitutes the right decision from being based on "why" one should do something towards "who" shall decide. It is now widely accepted and promoted that the person seeking treatment should decide if and which one he wants. It is easily acceptable when options lead to small outcomes' differences, but may be harder to accept when the patient choose counterproductive interventions. To help increase preparedness for the emergence of this preference based medicine, we must first address three issues: Who is the owner of the body? Is a health a good like any other? In countries with a collective funding is there a collective voice for decision making?

W2-B.2 Eleblu, J*; Danquah, E; Dzidzienyo, D; Bosompem, K; Keese, P; University of Ghana; paul.keese@gmail.com

Biorisks – a generic risk assessment framework for organisms

Plants, animals and microbes are essential for our physical and mental well-being. However, some organisms are serious threats to public health, food production, biodiversity and trade. In addition, there are potential risks arising from organisms used for biocontrol, GMOs, or organisms derived from synthetic biology. This presentation describes a generic risk assessment framework that covers all types of living organism and satisfies a broad range of management and/or regulatory goals. Most risk assessment approaches for organisms are specific to a group of organisms (eg plants) or operate within a specific context (eg the Cartagena Protocol on Biosafety under the Convention of Biological Diversity that is limited to risks from transboundary movement of a GMO). A common generic approach is the adaptation of the USEPA risk assessment approach used for chemicals. However, organisms possess highly distinctive properties such as reproduction and have complex, dynamic behaviours shaped by more than two billion years of evolution. In addition, the terminology of a chemical risk assessment (exposure, dose response) is inappropriate for organisms. For example, invasiveness (for plant or animal pests) or infectivity (for pathogens) is a better descriptor than exposure. Therefore, this generic risk assessment framework is based on common biological attributes of organisms that are associated with increased invasiveness/infectivity (such as establishment, reproduction, dispersal, persistence and gene transfer) or have the potential to cause economic, social or environmental harm (including ill-health, reduced biotic or abiotic quality, or reduced functional value from ecosystem services). Furthermore, this framework outlines the importance of terms such as vulnerability and resilience for evaluating biorisks.

M2-J.7 Emanuel, RN; University of Maryland, Johns Hopkins University Applied Physics Laboratory; roy.emmanuel@gmail.com

Resilience Metrics: Gaps and Extensions

The concept of resilience describes a system's ability to cope with a disturbance, either by resisting failure or persisting in a degraded state until the system returns to a desired level of performance. The focus of this study is on the value of resilience metrics in the decision-making process. This study takes three types of resilience metrics, identifies gaps in their decision-support, and extends the metrics to cover these gaps. The three metrics in the study are quotient resilience, expected system degradation function, and integral resilience. The gaps are explicitly-defined time horizons, metrics capable of dealing with dynamic stakeholder need, and substitutability of system performance over time and among systems. Each metric is applied to a series of fundamental models, system dynamics models and discrete event simulations. The performance of each metric is compared to identify weaknesses and strengths relative to each other and relative to common metrics such as availability. The desired outcome is a metric, or family of metrics, that can be applied to complex systems and models to assess resilience as an aide to stakeholders making trade-off decisions in design and support.

T3-H.2 Elsensohn, JE*; Burrack, HJ; Brown, ZS; Kuzma, J; North Carolina State University; jeelsens@ncsu.edu

Comparative risk analysis for agricultural genetic pest management technologies

The application of genetic pest management (GPM) against invasive species has been discussed for decades, but recent advances in genome editing have moved the field closer to having products ready for real world deployment. GPM uses technologies to alter the genomes of pest species to effect control, either through population suppression or by making pests refractory to pathogens. One GPM technology, which utilizes self-limiting lethal genes, recently received government approval for open field experimentation in the United States. The approved genetically modified mosquito and diamondback moth have faced substantial social pushback, and open releases of these insects have yet to be carried out, indicating the importance of evaluating both environmental and social risk factors in the deployment of GPM products. *Drosophila suzukii* is a relatively new invasive pest of small fruit crops causing significant economic damage for fruit growers worldwide. This destructive fly is the subject of a large research effort to develop sustainable and effective control strategies. Several different GPM techniques are being explored for their use against *D. suzukii*, including sex-specific lethal genes and gene drive. While researchers continue efforts to create transgenic *D. suzukii*, a comparative risk analysis will be conducted to assess the various socioeconomic, political and environmental factors associated with the different GPM technologies. Expert elicitation and stakeholder engagement will be used to inform and validate the analysis, and identify each group's specific concerns. This comparative risk analysis allows for relative comparison between different GPM strategies and highlights how the intrinsic properties of each technology may affect their use. The analysis will provide important feedback to technology developers by identifying high risk factors during the development phase, giving researchers the ability to proactively address those risks within their control.

P.190 Eosco, GM; Eastern Research Group; gmeosco@gmail.com

Making the Case for Watches, Warnings, and Advisories: Results from a Case Study Analysis of NWS Forecasters and Partners

NOAA's National Weather Service (NWS) forecasts hazardous weather situations and issues watches, warnings, advisories (WWA), and other information products to convey the threats posed by these events. These products are intended to help communities prepare for and respond to hazardous weather to protect people's lives and property. To better understand how the NWS and its stakeholders perceive and use the current system, Eastern Research Group, Inc. (ERG) worked with the NWS to develop an online case study survey instrument (using Qualtrics) that asked participants (including NWS forecasters, emergency managers and broadcast meteorologists) to respond to a series of open-ended questions about a particular hazardous weather event where the messaging did (or did not) work well from their viewpoint or from the viewpoint of their community or audience. This survey resulted in a set of case studies that provided insights into: (1) The strengths of the current WWA system from a hazard messaging standpoint. (2) The weaknesses surrounding the WWA system from a hazard messaging standpoint and how these weaknesses relate to potential solutions. (3) Whether changing the current WWA language is desired by stakeholders. A total of 706 case studies were qualitatively analyzed. ERG used a mix of inductive and deductive approaches to analyze these data. For the first phase of the work, ERG conducted an inductive, bottom-up analysis to detect theoretical patterns in a subset of the data with no preconceived notions of particular findings. In the second phase of the analysis, the theoretical patterns were analyzed to develop emerging themes and associated keywords. These keywords were then used to employ a deductive, top-down approach to identify and summarize the recurring themes in all of the remaining case studies. The major findings, challenges, and limitations from this study will be presented.

T4-D.3 Estrin, AE*; Lasher, AB; Nolan, NM; Levine, JC; Willig, JA; Brewer, VA; Chen Parker, C; Markon, AO; Nsubuga, J; Wolpert, BJ; Grant, EA; Federal government; andrew.estrin@fda.hhs.gov
Using FDA adverse event data to estimate the avoided risk of allergic reactions from bakery products through recalls

The Food and Drug Administration (FDA) Amendments Act of 2007 required FDA to establish the Reportable Food Registry (RFR), an electronic reporting system used by industry, to submit reports when there is reasonable probability that FDA-regulated food will cause serious adverse health consequences. According to RFR's 2009-2013 annual reports, undeclared allergens account for 30%-44% of primary reports—most resulting in recalls. Bakery products account for the largest share of primary reports from undeclared allergens (20%-24%). We use adverse event reports citing allergic reactions from bakery products from FDA's Center for Food Safety and Applied Nutrition Adverse Event Reporting System (CAERS) to estimate average risk per serving from bakery product allergens. After adjusting for self-reporting and under-reporting, we apply the per case health cost of an allergic reaction from Minor et al. (2014) (\$2,563) to the total number of CAERS cases citing bakery product allergic events. Based on 2013 Nielsen scanner data, we estimate the number of annual retail bakery product servings sold (~38.5 billion); based on USDA food consumption data, we obtain the ratio of annual away-from-home to at-home grain consumption (~0.44843) and calculate total annual exposure at ~55.8 billion servings. We apply the estimated value of the risk per serving to the number of servings of recalled bakery products estimated from CFSAN recall information. This may overstate avoided risks from undeclared allergens to the extent that CAERS includes allergic reaction reports citing intake of products with labels that do and do not fully declare allergens on their labels. We incorporate uncertainty into the estimates of self-reporting and under-reporting biases, the health cost of an allergic reaction, and exposure to bakery products using @Risk simulations to compute a 95% confidence interval for the risk per serving and avoided costs of allergic reactions from bakery product recalls.

T3-J.1 Evensen, D*; Demski, C; Pidgeon, N; Cardiff University; evensend@cardiff.ac.uk

Ethical foundations of paying for energy transitions

Whilst much research has focused on the need for energy system change and the types of changes that are most crucial, little research has explored who is responsible for paying for these transitions and/or what the public sees as their role in absorbing costs associated with such changes. Risk mitigation associated with (1) climate change, (2) a decaying energy infrastructure, and (3) social disparity in access to energy is in part dependent on public willingness to support plans for energy system change. Individuals' own financial standing and personal experience with energy system actors certainly influence thoughts about who is responsible and personal willingness to accept costs for transitions (such as increasing use of low carbon energy, helping vulnerable groups pay for energy, and increasing the reliability of the energy supply). Nevertheless, a limited body of previous work also highlights the relevance of ethical considerations, particularly thoughts about procedural and distributive justice, for shaping perceptions of costs associated with energy transitions. Our study, via a nationally representative survey of residents in Great Britain (n=3000), explores how perceptions of the extent to which the energy system is procedurally just and distributively just (both constructs variously operationalised) affects: (1) public perceptions of which actors are responsible for energy system change and (2) willingness to accept personal costs associated with such changes. We also examine the relative importance of these ethical commitments compared with other values that might motivate thoughts about responsibility and willingness to accept costs. Regression analysis and structural equation modelling reveal that beliefs about procedural and distributive justice are more predictive of some energy system goals than others. We discuss the implications of the public's ethical commitments for risk communication and policy about costs associated with energy transitions.

T4-J.2 Evensen, D; Cardiff University; evensend@cardiff.ac.uk
Is fracking morally wrong? How to answer the question.

Since 2009, a growing body of social scientific research has explored public perceptions of 'fracking' (shale gas/oil development). This work focuses on what people think and why, often examining thoughts about risks and benefits. More recently, researchers have explicitly begun to identify ethical concerns as primary factors motivating perceptions about fracking. Distributive justice concerns feature prominently in this incipient literature, as reflected in presentations in this symposium attending to disproportionality and inequality. Disruptions to sense of place and place attachment associated with fracking have also emerged in research literature in the last couple years as leading concerns about fracking; such threats could represent moral issues. A third type of ethical concern associated with fracking (by the public, but rarely in research literature) is violation of ostensible rights. These three issues: (1) distributive justice, (2) place attachment (related to perfectionist aims and virtue ethics), and (3) arguments about rights infringement make the ethicality of fracking a complex topic. Importantly, these leading areas of ethical contention on fracking reveal that common definitions of 'risk' need to be expanded, re-operationalised, and revolutionised when considering this issue (or energy development broadly). Social scientific measurement of 'risk perceptions' about fracking rarely adequately accounts for: (1) the potential threats (or benefits) arising from changes in place attachment, (2) infringement of rights as threats to social structure, or (3) the extent to which distributive issues affect perceptions of more typical risks (e.g., to water quality, air quality, roads, local economy, etc.). This presentation is primarily theoretical; I consult a range of ethical schools of thought to reveal what a system for ethically evaluating fracking could look like, analysing the merits and drawbacks of different philosophical approaches.

T4-B.5 Fanaselle, W*; Duret, S; Pouillot, R; Papafragkou, E; Liggins, G; Williams, L; Van Doren, J; Food and Drug Administration, Center for Food Safety and Applied Nutrition; wendy.fanaselle@fda.hhs.gov

Results and lessons learned from the risk assessment of norovirus in retail food facilities

Norovirus is the leading cause of all foodborne illnesses globally and also within the United States. Most of these illnesses can be traced back to food contaminated from the feces or vomit from infected food employees in the retail food establishment (or restaurant) setting. Food in these settings is most frequently contaminated via contact with the soiled hands of infected food employees. A quantitative risk assessment was developed to evaluate the risk of norovirus foodborne illness from infected food employees during food preparation, and the efficacy of control measures as a function of the degree of food employee compliance with these control measures. This presentation will discuss the results of the risk assessment model. More specifically, it will review the results of various routes of norovirus transmission in the retail establishment and the impact of control measures evaluated through 'what-if' scenarios. The control measures evaluated include exclusion of ill food employees from the food establishment, handwashing, facility sanitation, and "no bare hand contact". The results and lessons learned from this model in determining effective control measures for norovirus foodborne illness, may help to provide a focus in planning future training, communication strategies, and/or policy direction.

W4-A.4 Fang, Y-P*; Sansavini, G; ETH Zurich; sansavig@ethz.ch
Optimum post-disruption restoration for enhanced infrastructure resilience under uncertainty

System restoration and its contribution to the resilience of infrastructure networks following disruptions have attracted much attention in recent years. Optimization approaches are usually used to guide the identification and scheduling of restoration strategies for rapid system functionality reestablishment under limited resources. Most of the related studies rely on deterministic assumptions such as complete information of resource usage and deterministic duration of the repair tasks. However, restoration activities are subject to considerable uncertainty stemming from subjective expert judgment and imprecise forecasts that may render the scheduling solution obtained by a deterministic approach suboptimal or even infeasible under some uncertainty realizations. This paper proposes a stochastic mixed integer programming (SPMIP) approach to deal with the problem of deciding how and when to execute each repair activity of failed components with the objective of maximizing system resilience. The inherent stochasticity is represented using a set of discrete scenarios in which each scenario is associated with a probability of occurrence and a realization of activity durations and available resources. A tailored solution technique based on Benders decomposition is utilized to handle the computation burden. The Swiss high voltage electric power transmission network is employed for case study and the reported results demonstrate the benefits of using the stochastic model as opposed to its deterministic counterpart.

T4-G.2 Fehrenbacher, MC*; Bevington, C; Hall, F; United States Environmental Protection Agency; fehrebacher.cathy@epa.gov
Advances in Exposure Assessment: CEM Updates and OECD Use Code Activities

The U.S. Environmental Protection Agency's Office of Pollution Prevention and Toxics (OPPT) is responsible for assessing and managing risks to chemicals under the Toxic Substances Control Act (TSCA), including potential risks associated with consumer exposure. Exposure assessors within OPPT develop assessments of consumer exposure for new chemicals which have yet to be commercialized, as well as existing chemicals, which are in commerce. In general, the data with which to assess consumer exposure to chemicals in products reviewed by OPPT is quite limited. For new chemicals, manufacturers or importers must provide the Agency with information 90 days prior to import or manufacture of non-exempt new chemicals. Companies are not required to develop new information, but must submit information on the identity of the chemical, detailed description of the consumer use, production volume for each use identified, the weight percent of the chemical in each use, function of the chemical in the consumer product, and application of the product. For existing chemicals, OPPT generally uses readily available data in the literature and from other sources when developing the exposure assessment for consumer use of chemicals. Where data are not available, models may be used to supplement available data. Several activities are underway to enhance and update OPPT's data and methods used for assessing consumer exposure for new and existing chemicals. These ongoing activities include updating the Consumer Exposure Model, enhancing the Organization for Economic Cooperation and Development's internationally harmonized codes for products and articles, and updating information relevant to assessing consumer exposure to chemicals in products and articles, such as formulation information and generic scenarios. The views of the authors of this abstract are those of the authors and do not represent Agency policy or endorsement.

W4-B.4 Fasano, JM; U.S. Food and Drug Administration; jeremiah.fasano@fda.hhs.gov

Updating FDA/CFR's Guidance on ingredient safety assessment: the path forward for Redbook

FDA must assure its toxicology toolbox keeps pace with advances in science and technology. Food ingredient safety is a hot-button issue for many people these days. The level of public awareness has increased exponentially as a result of readily available multi-media stories on food ingredient uses. The time is right for FDA to ask the question of whether or not the guidance in the Redbook used in the assessment of food ingredient safety represents an articulation and application of the best science to garner an understanding of the toxicity profile of food ingredients. This project is complex and large in scope. FDA must ensure that actionable guidance, developed with extensive input from stakeholders, begins to become available as soon as reasonably possible. At the same time, stakeholders must have adequate information to understand the overall direction of the project and the context within which individual sections of the guidance will function. This presentation will discuss FDA's goals, strategy, and 'roadmap' for this project.

P.163 Ferson, S*; Sentz, K; Applied Biomathematics, Los Alamos National Laboratory; sandp8@gmail.com

Epistemic uncertainty in agent-based modeling

Traditional approaches to handling uncertainty in agent-based models employ Monte Carlo methods to randomly sample parameters and probabilistically determine whether and how a behavior or interaction rule is realized by an individual agent. A simulation of all agents thereby represents a single realization from among many possible scenarios, and simulations with many replications are used to reveal differential probabilities and the likelihoods of extreme results. Unfortunately, Monte Carlo is a poor way to project epistemic uncertainty through a complex model, and it is an unsatisfying scheme for representing the uncertainty about volitional choices of agents. Adding epistemic uncertainty to agent-based models properly requires the ability to (1) characterize stochastic drivers imprecisely, (2) specify agent attributes and other quantities as intervals, probability distributions, or p-boxes, and (3) execute behavior rules in a way that respects uncertainty in their conditional clauses. When uncertainty makes the truth value of the conditional clause of any rule unclear, the simulation should hold that the rule both fires and does not fire. This may result in subsequent uncertainties elsewhere in the simulation including the status of attributes of agents, even perhaps whether an agent exists or not. These facilities advance agent-based modeling to uncover a more comprehensive picture of the effects of epistemic uncertainty, which can be vastly more important than aleatory uncertainty. We compare this approach with traditional simulation using only Monte Carlo methods to reveal the differences between these two approaches to uncertainty.

P.186 Fiebelkorn, SA*; Meredith, C; British American Tobacco, Research and Development, Southampton, Hampshire, United Kingdom ; stacy_fiebelkorn@bat.com

Combined Incremental Lifetime Cancer Risk for Nitrosamines: a comparison of combustible cigarette and e-cigarette emissions

Eight nitrosamines have been identified by the US FDA as Harmful and Potentially Harmful Constituents (HPHC) in tobacco smoke. Some of these have been detected in e-cigarette emissions. Combined Incremental Lifetime Cancer Risk (ILCR) can be used to prioritise toxicants based on published cancer potency values and estimated human exposure. We present here the results for 14 nitrosamines (NNK, NAB, NAT, NNN, NDBA, NDEA, NDELA, NDiPA, NDMA, NDPA, NEMA, NMOR, NPIP and NPYR) based on yield data for cigarette and e-cigarette emissions reported by Margham et al. (Chem. Res. Toxicol., 2016, 29 1662–1678). Inhalation unit risks (IUR) or oral cancer slope factors (CSF) published by the USEPA or OEHHA are available for 11 of the nitrosamines. CSFs were converted to IUR assuming a human daily breathing volume of 20m³ and 70kg body weight. For NAB, NAT and NDiPA no published cancer potency values were identified and measured yields for e-cigarettes were below the limit of detection or not quantifiable. The ILCR for each nitrosamine was calculated by multiplying the IUR by estimated daily exposure for the two product types. Daily exposure was based on average daily usage estimates and machine generated yields. The yields used are based on measured values or derived from limits of detection or quantification. For the nitrosamines, the combined ILCR due to continuous smoking exposure, based on a simple additivity model, was estimated as 4.22 x10⁻³, while for e-cigarettes this was estimated as 1.2 x10⁻⁵. Further, assuming that nitrosamines below the limit of detection or equivalent to air blank level are not present, the adjusted combined ILCRs become 4.19 x10⁻³ for smoking and 2.7 x10⁻⁶ for e-cigarette use, representing almost three orders of magnitude difference. Since CSF data used is generally based on oral rather than inhalation exposure and for liver rather than lung lesions, further assessment based on inhalation data is recommended when such data becomes available.

T4-D.4 Finkel, AM*; Johnson, BB; Univ. of Pennsylvania Law School and Univ. of Michigan School of Public Health; afinkel@law.upenn.edu

Innovative experiments to explore possible mis-estimation of the net benefits of environmental, public health, and safety regulations
Many aspects of cost-benefit analysis (CBA) are controversial, but ironically, the mechanics of how to quantify the effects of both risk reduction and cost on human welfare has received less attention. This new project presumes that altering conventional methods of benefit and cost valuation in two particular ways might change which regulations pass or fail the cost-benefit test, and might alter the maximally net beneficial regulatory option for a given regulation. First, stated-preference estimates of the “value of a statistical life” (VSL) deliberately preclude altruism, and confront subjects with tiny costs and minuscule probabilities of personal mortality in order to value public programs benefiting (and costing) the entire nation. Secondly, CBA tallies only the total number of lives saved by a regulation or its total cost, regardless of whether individual mortality risks are concentrated or whether the costs affect some businesses or consumers disproportionately (hence it is oblivious to the diminishing marginal utility of money). We are currently designing two large survey experiments will probe these simplified assumptions and offer principled, quantitative alternatives. The first survey will estimate the “VSL with shared purpose”; it will test for (and isolate) the effects of paternalistic versus non-paternalistic altruism, and will pose the tradeoffs as both a user-defined acceptable range of cost for a fixed number of lives saved and a user-defined minimum number of lives saved for a fixed regulatory cost. A second survey will test the assumption that individuals regard the welfare effects of risk or cost at any level as linear, using subjects’ ratings of how dire they view varying hypothetical individual probabilities of harm and varying personal costs. This experiment is designed to reveal whether there are de minimus levels of either risk or cost that can sensibly be rounded down to zero, and/or intolerably high levels that should not be counted as merely proportional to the effects at lower levels.

M2-I.3 Finkel, AM; Univ. of Pennsylvania Law School and Univ. of Michigan School of Public Health; afinkel@law.upenn.edu
Risk-based governance options for improving NFL player health and safety

This presentation arrays and explores a spectrum of governance options, ranging from most to least plausible given current scientific information and political/budgetary realities, for how the U.S. Occupational Safety and Health Administration (OSHA) might involve itself in reducing risks to NFL football workers. Building on the previous talk, I begin by describing how OSHA construes “material impairment of health or functional capacity,” and explain that the kind of neurocognitive decline seen in former football players amply qualifies as a condition OSHA could regulate. I then explain how OSHA might estimate the individual working-lifetime risk of an NFL player experiencing neurocognitive decline, either from symptom surveys and/or from the evolving case series of autopsies where the pattern of lesions now known as “chronic traumatic encephalopathy” (CTE) has been documented—and I relate first-cut risk estimates to the 1/1000 benchmark the Supreme Court set in 1980 as the lowest risk that must be unambiguously deemed “significant.” The spectrum of governance options described begins with purely informational “nudges,” continues through the concept of an “enforceable partnership” OSHA pioneered in the late 1990s with other industry groups, and includes the prospect of OSHA initiating one or more enforcement cases under its General Duty authority, either on its own or in response to an employee complaint of a reducible hazard. The presentation concludes with a description of a hypothetical OSHA standard governing repeated head trauma in the NFL and in other industries and occupations where concussions and sub-concussive impacts are endemic. In the past, OSHA has intervened to require medical monitoring and return-to-work guidelines, and it could do so without also requiring changes to the workplace—although in several high-profile cases (e.g., Sea World), OSHA has impelled changes to how entertainment industries expose workers to risks.

W3-E.1 Flage, R*; Guikema, SD; University of Stavanger (Roger Flage) and University of Michigan (SD Guikema); roger.flage@uis.no

Conceptualizing and handling uncertainty in predictive data models for risk analysis

Predictive modeling using data models is increasingly used in the context of risk analysis. These models are founded in statistical learning theory and can be used to provide predictions of quantities of interest in a risk assessment. Often these predictions are given as single, seemingly deterministic values, without conveying information about the uncertainty involved. In the present paper we take a hard look at the use of predictive data models in risk analysis and ask how uncertainty is being conceptualized and handled. In doing so we take a two-step approach: First, we review all papers published in the journals Risk Analysis and Reliability Engineering and System Safety in the period 2011–2015 that do predictive modeling and summarize how they handle uncertainty. A four-tier hierarchy is introduced for classifying how uncertainty is dealt with in these. Second, we take a hurricane outage model and run it for a designed storm scenario and then discuss different sources of uncertainty and how they could be better conveyed.

P.24 Florin, MV; Linkov, I*; IRGC, Switzerland and US Army Engineer R&D Center, Boston; ilinkov@yahoo.com

IRGC resource guide on resilience

Responses to disasters, both natural and technology-related, often show the limitations of traditional risk assessment and management. In the context of risk, resilience has been discussed as both a supplement and an alternative to conventional risk management. IRGC describes resilience as a risk management strategy when there is much uncertainty about impacts and the need to prepare to cope with surprises. Both governments and industry explicitly call for resilience-based risk management. Even though the field is fluid, mapping risk and resilience in the context of governance as well as summarizing how resilience has been manifested, managed and measured in different fields and sectors is needed. The IRGC 'Resilience In And For Risk Governance' (RIARG) resource guide stresses the importance of including resilience as an important component of the risk governance process, including in research, policy, strategies, and practices. IRGC's objective with the guide is to propose an annotated bibliography of existing ideas and tools for integrating risk and resilience and measuring resilience and the effectiveness of actions taken to build it. The guide focuses in particular on metrics for resilience assessment and instruments for resilience management. It aims to encourage the development of methods for resilience quantification. The resource guide is composed of invited authored papers, which the poster will present, highlighting both the variety of approaches to resilience as well as common features and dynamics. It is designed to help scientists and practitioners working on risk governance and resilience evaluation, by giving them background information on the various perspectives and guiding them to the best available literature sources. The resource guide was developed in 2016 and will be launched at IDRC 2016.

WI-E.1 Foreman, JE; ExxonMobil Biomedical Sciences, Inc.; jennifer.e.foreman@exxonmobil.com

Uncertainty Analysis- A Necessity for Transparency

A systematic risk assessment (RA) is a time consuming and very detailed process that can often contain hundreds of pages and in depth discussion of scientific details. What are often brought forward from these assessments for decision making/communication are single point estimates, while the assumptions and uncertainties of the assessment are lost, which may therefore provide a false sense of precision. Many factors can influence the final PoD including experimental variability, quality of data, and underlying regulatory tenets (e.g. precautionary principle). All of these influencing factors and many others encompass the underlying uncertainty of the RA, which is not reflected in the PoD. Though this uncertainty is often articulated within a RA, and the importance is clearly recognized, the approach to account for uncertainty and communicate the level of uncertainty that exists in a given assessment is something with which the RA community continually grapples. New methods of uncertainty analyses are under development. Having a clear and understandable manner to communicate the uncertainty in a RA is a necessity for transparency. Without an understanding of the uncertainty incorporated into a RA any decision makers, risk managers, or the public are unable to make judgments of how to use the information provided. Additionally clear documentation of the uncertainty that was accounted for in an assessment allows for scientific dialogue and potentially understanding of what data could be generated to improve the precision of the assessment. Clear uncertainty analyses tools offer promise as an improved means of communicating and conveying uncertainty to regulatory decision makers, risk managers, and the public. Uncertainty analysis is an important component of transparency, which is critical for scientific dialogue and progress.

T3-A.2 Ford, MJ*; Abdulla, A; Morgan, MG; Carnegie Mellon University and UC San Diego; ayabdulla@ucsd.edu

Evaluating the cost, safety and proliferation risks of small floating nuclear reactors

It is hard to see how our energy system can be decarbonized if the world abandons nuclear power, but equally hard to introduce the technology in non-nuclear energy states. This is especially true in countries with limited technical, institutional, and regulatory capabilities, where safety and proliferation concerns are acute. Given the need to achieve serious emissions mitigation by mid-century, and the multi-decadal effort required to develop robust nuclear governance institutions, we must look to other models that might facilitate nuclear plant deployment while mitigating the technology's risks. One such deployment paradigm is the Build-Own-Operate-Return model, under which a reactor is fueled in the developed nation where it is built, shipped to a site, operated and then returned unopened to the developed state. Because returning small land-based reactors containing spent fuel is infeasible, we evaluate the cost, safety and proliferation risks of a system in which small modular reactors are manufactured in a factory, and then deployed to a customer nation on a floating platform. This floating SMR would be built, owned and operated by a single entity. We developed a decision model that allows for a comparison of floating and land-based alternatives considering key IAEA plant-siting criteria. Abandoning on-site refueling is beneficial, and floating reactors built in a central facility can potentially reduce the risk of cost overruns and the consequences of accidents. However, if the floating platform must be built to military-grade specifications for steel, welds, and inspections, then the cost would be much higher than a land-based system. The analysis tool presented is flexible, and can assist planners in determining the scope of risks and uncertainty associated with different deployment options.

M4-D.5 Forouzanfar, MH*; GBD 2015 researchers and collaborators, ; Institute for Health Metrics and Evaluation - University of Washington; mforouzanfar@gmail.com

The Role of the Global Burden of Disease Estimates in Managing Global Health Risks

The Global Burden of Diseases, Injuries, and Risk Factors study 2015 is the latest update to a series of studies initiated by the World Bank and WHO in the 1990s. Mortality and disability for more than 300 causes of death and morbidity were estimated as well as the burden of 79 risk factors. The health burden of diseases and risk factors is quantified for all countries between 1990 and 2015 and for subnational areas for some countries, such as China, Mexico, Brazil, and Kenya, by detailed age and sex. The risks were included based on availability of solid data and effect on health; outcomes of the included risk factors were included if the causal association with the risk was convincing by evidence. The comparative risk assessment (CRA) is the primary approach for estimating attributable burden of risks in GBD. Different data sources were used, and risk-specific methods and analytical tools were invented to tackle lack of data or data scarcity to estimate the three necessary inputs for population attributable fraction (PAF) calculation: distribution of exposure to the risk, relative risk of a specific outcome for every level of exposure, and a theoretical minimum risk level. The attributable burden from different causes of mortality and morbidity is summed to calculate total burden associated with the risk factor. Burden of different risks is also aggregated in different levels up to three main categories of environmental and occupational risks, behavioral risks, and metabolic risk factors. In this presentation, I will present the GBD approach, and assumptions plus different types of data sources and methods used to assess the health burden of different risks for different populations. Moreover, some highlights of GBD results will be presented such as transition of countries risk profile by socioeconomic development and decomposition of the risk factor burden trend by change in population growth, population aging, baseline rate, and the exposure to risk.

W3-E.3 Francis, RA*; Sahlin, U; Schmitt, K; George Washington University, Lund University, and Concordia University; seed@email.gwu.edu

Thoughts on robust uncertainty analysis for infrastructure climate resilience investments

Infrastructure decisions require a long-term view that, due to the limitations in predicting future states of climate with high precision, precludes precise specification of the stochastic properties of an event of interest. Risk assessors have historically planned such projects using safety factors. We ask if safety factors are adequate buffers against climate change type of uncertainty, and reflect on what is required of a robust uncertainty analysis for infrastructure climate resilience investments. To illustrate this challenge, we study the use of precise and imprecise probabilities as measures of uncertainty on assessed climate change impact of low-impact development (LID) installations for reducing combined stormwater and sanitary sewer overflows (CSOs). We use historical data to fit predictive models for CSO events with, and without, LID technology installation. Our analysis uses CSO and rainfall data from Spokane, WA, USA, and Washington, DC, USA. Using downscaled precipitation projections from the CMIP5 database, we demonstrate the implications of altering the measure of uncertainty when assessing resilience under current and under future conditions, according to the level of uncertainty in climate change projections.

W2-C.2 Frankel, MJ*; Proper, M; Scouras, J; Johns Hopkins University Applied Physics Laboratory; michael.frankel@jhuapl.edu
Nuclear Winter: Science and Policy

Climate concerns presently stand very much at the intersection of science and public policy. How to manage a perceived warming are the stuff of impassioned ideological cum scientific debate. Much less publicized is another component of the climate risk universe which has gained renewed attention in some corners of the academic scientific community; one in which there is no dispute over its anthropogenic origin and one that perversely leads to global cooling. And that is the prospect that a "limited" nuclear war, confined to a "modest" exchange of weapons between regional powers such as an India and Pakistan, would have physical effects far beyond the geographical boundaries of conflict. In the 1990s, government interest in the "original" nuclear winter scenario associated with a large arsenal exchange between the Cold War superpowers, seemed to wane after a decade or so, coinciding with the precipitous drop in the deployed arsenals of the US and Russia and with the changed political circumstances following the demise of the Soviet Union. But predictions made with more modern calculational tools now assert that such a local regional engagement, casting a pall of smoke and soot that would spread around the globe, intercepting sunlight and precipitating a nuclear winter-like agricultural catastrophe and stripping the ozone layer, would ultimately cause the deaths of billions of human beings situated far from the contending powers. We will present a review of the state of uncertainties associated with these predictions and discuss available risk management policies.

M3-H.2 Francis, RA; George Washington University; seed@email.gwu.edu

What Does Transformative Risk Assessment Practice Look Like for Development?

Risk assessment has the potential to transform the trajectory of infrastructure and economic development. Risk assessment is critical to development because it enables the efficient allocation of resources while accounting for potential externalities and adverse impacts of economic development. For risk assessment to be an important source of insight into infrastructure projects in the development context, the questions of transformative risk assessment must be addressed—Who structures risk problems in the development context?; How is important information shared among stakeholders?; Is risk information understandable and transparent to stakeholders; and, Who owns risk information in the development context? These questions are meant to contribute to a broad discussion that will help guide future efforts of the SRA Risk and Development Specialty Group.

T2-I.4 Fred Boelter, FWB; RHP Risk Management Inc.; fboelter@rhprisk.com

Bridging the Divide between Speaking Technical and Hearing Personal

Decisions about risk acceptability are made personally by the individual. The basis of personal decisions vary depending on bias, heuristics, knowledge, skills, benefit, and reward. The communication of occupational risk characterization is more than a technical discussion with stakeholders. If we get the intangible chronic topic of health right, the tangible acute topic of safety will follow.

P.143 Fredrickson, ML*; Boyd, AD; Furgal, C; Colorado School of Public Health, Washington State University, Trent University; michelle.fredrickson@outlook.com

Media Coverage of Mercury Contamination in the Arctic

Media can affect public views and opinions on environmental hazards and public health. This is especially true of issues that are relatively unknown or poorly understood to many affected populations such as the risks associated with mercury contamination. It is well recognized now that mercury is a global issue with levels in the environment reaching significant concern even in distant locations of the globe, such as the Arctic. There is an increasing need to communicate about the risks of contaminants to both the Indigenous populations who live in these regions and those elsewhere who may be able to impact policy and public discourse on the issue. In order to better understand how the issue of mercury contamination in the Arctic has been presented in the media, a content analysis was conducted across fourteen newspapers in the Canadian North and South. During the past decade, a total of 10,424 articles from the 14 newspapers contained the word 'mercury.' Articles focusing on mercury contamination in the Arctic were analyzed in detail. There were a total of 81 relevant articles, with 58 of these articles appearing in northern publications and 23 appearing in southern publications. This study analyzed how different news sources presented the health risks of mercury in the Arctic, how mercury was defined, if any pathways of personal efficacy were provided, who was quoted as an information source and where the article originated. Results demonstrate that very few Indigenous people were cited as sources, the articles often failed to describe mercury at all, and many did not provide direction to support personal efficacy. Results are discussed in relation to agenda-setting theory, which asserts that the media sets the agenda for what the public thinks about. This study provides insight into how communicators can improve the development of environmental health risk messages.

M3-I.4 Furgal, C*; Boyd, AD; Trent University, Washington State University; chrisfurgal@trentu.ca

A Mental Models Approach to Informing Risk Communication about Contaminants in the Arctic

According to a recent review by the Council of Canadian Academies, Canadian Arctic Indigenous populations are currently facing a food insecurity crisis. The Territory of Nunavut reports the highest level of household food insecurity among an Indigenous population outside the developing world. Nearly 70% of all homes report challenges accessing safe and adequate amounts of nutritious food on a daily basis. It is for this reason that Nunavut communities require the most current information regarding availability, accessibility and quality of local food resources. Arviat, a community located in the Territory of Nunavut, is one such community that needs current information about the viability and feasibility of culturally acceptable food options for its' population. Since the early 1970s, residents of Arviat have been hunting beluga whales and consuming only the maaqtaq (blubber and skin). Since that time, meat, a potentially viable source of protein, which used to previously be consumed is now routinely given to the dogs or discarded. This project uses a mental models approach to explore the current perceptions and misperceptions regarding the safety of beluga whales as a traditional food item in this community. During 2015, in-depth mental model interviews with 30 Inuit residents of Arviat were completed. Interviewees included representatives from numerous groups in the community such as hunters, elders, women of childbearing age, youth and those who traditionally prepare food. Participants also completed a card-sorting exercise designed to assess their perceptions of traditional foods. Results illuminate the challenges in communicating about "invisible" risks, and indicate the potential role that concern over contaminants may play in the consumption of traditional food items today. The results of this study may inform similar cases throughout the world where the legacy of past contaminant advisories is currently unknown or where uncertainty exists regarding the impacts of previous contaminant perception on current diet behavior.

W4-C.4 Friesen, SK*; Bayne, I; Poursina, S; Government of Canada; shaye.friesen@drdc-rddc.gc.ca

Establishing resilient programs: using a risk based approach for informing the distribution of investments in public safety and security science and technology

The Canadian Safety and Security Program (CSSP) initiated a project aimed at establishing a risk based approach for informing the distribution of investments in public safety and security science and technology (S&T). This framework consists of four building blocks: the development of a distribution of investment concept; a common evaluation framework that enables the comparison of risks across public safety and security domains; standardized terminology that recognizes the fundamental differences in how risk is defined by various CSSP communities of practice (e.g., Critical Infrastructure Protection; cyber Security; Natural Hazards; Explosives, etc.); and a classification schema that informs investment decisions at the Portfolio level. This presentation briefly introduces the CSSP mandate, how it is managed, and organizational history. It describes how the project team adopted a "spiral" development process that incorporated active collaboration with key stakeholders during each phase of the project methodology, which consists of iterative several phases: (i) data collection efforts compiled through a literature review, comprehensive risk and interviews; (ii) preliminary modelling that identified strategic decision nodes and critical information requirements needed to support trade-off analysis; (iii) requirements definition that leveraged architecture framework techniques to structure the problem space; and (iv) evaluation to refine requirements and evolve the CSSP risk framework using validation and verification. The CSSP has already undertaken a series of risk assessments to populate the framework, the results of which are informing a prototype/risk dashboard that is being prepared for adoption within the Centre. In the Canadian experience, applying risk analysis is helpful for establishing a "resilient program" that is better prepared to effectively mitigate all hazards risk and identify priority S&T requirements for resource allocation.

P.93 Galloway, LD*; Bolus, KA; Bellamy, MB; Dolislager, FG; Walker, S; University of Tennessee; Ingenium Inc; Oak Ridge National Laboratory; Environmental Protection Agency; gallowayld@ornl.gov

Solving Complex Radioactive Decay Chains for Future Assessment and Cleanup Decisions

There is a need to understand how radionuclide activity changes with time as the activity measured in the past will be different from current and future levels. When a radionuclide decays, its activity decreases exponentially as a function of time transforming into a different atom - a decay product. The atoms keep transforming to new decay products until they reach a stable state and are no longer radioactive. The series of decay products created to reach this balance is called the decay chain. For radionuclide chains, the daughter products can have significant implications in dosimetry and remediation. Thus, risk assessors evaluating sites with radioactive contamination need to plan for future progeny ingrowth, in addition to sampled radionuclides. These are important considerations for risk quantification during the characterization and cleanup plans, particularly when sampling may have occurred years before the remediation cleanup work begins. If a radionuclide's half-life and current activity are known, then hand-calculating the future activity is straightforward. However, calculating the ingrowth of progeny quickly becomes cumbersome for longer chains such as the Thorium-232 decay series. For the more complex chains where many daughters are formed, possibly with multiple branches, this calculation involves solving a complex set of simultaneous differential equations known as the Bateman Equation. The Decay Chain Activity Projection Tool calculates the activity of radionuclides and their progeny as a function of time. This tool uses a combination of Python and Perl to automatically construct the radionuclide decay chains, solve the resulting Bateman Equation, and provide the user with tabular solution output and plots. The risk assessor can then use the data for exposure assessment and cleanup decisions without further costly sampling.

P.63 Gamo, M*; Honda, K; Yamamoto, K; Fukushima, S; Takebayashi, T; 1) 2) 3) National Institute of Advanced Industrial Science and Technology (AIST), 4) Japan Bioassay Research Center, 5) Keio University; *masashi-gamo@aist.go.jp*

Development of innovative methodology for safety assessment of industrial nanomaterials: Report of research project in Japan (FY2011-2015)

As breakthrough technologies in various fields, many industrial nanomaterials have been developed. There are a huge number of variations in terms of physicochemical properties such as size, shape, surface area, surface coating, and crystalline phase even within nanomaterials with the same composition. Although intensive researches on the health effects have been conducted, it has been found impractical to conduct a detailed assessment on each of a variety of nanomaterials. From this viewpoint, a five-year research project named "Development of Innovative Methodology for Safety Assessment of Industrial Nanomaterials" was launched in September 2011 by Ministry of Economy, Trade and Industry (METI) in Japan, and was completed in March 2016. The project consists of two themes; One is development of equivalence criteria of nanomaterials, which would contribute to reduction of the number of animal tests through categorization of variation of nanomaterials into a limited number of categories. For the purpose, using intratracheal administration tests, we compared the pulmonary toxicity of seven TiO₂, four NiO, and seven SiO₂ nanomaterials with different physicochemical properties. The sensitivity of the pulmonary toxicity to physicochemical properties was evaluated. Another is establishment of intratracheal administration method as a low-cost and convenient methods which enables us to screen nanomaterials from the viewpoint of pulmonary toxicity. We conducted inhalation exposure test and intratracheal administration test using same nanomaterials at comparable dose level, and discussed the difference/similarity of the results between the two tests. We also have developed a standardized protocol of the intratracheal administration test.) This work part of the research program "Development of innovative methodology for safety assessment of industrial nanomaterials" supported by Ministry of Economy, Trade and Industry (METI) of Japan.

P.193 Ganin, AA*; Kitsak, M; Eisenberg, DA; Alderson, DL; Linkov, I; US Army Engineer Research and Development Center and University of Virginia; Northeastern University; Arizona State University; Naval Postgraduate School; US Army Engineer Research and Development Center; *alexander_a_g@outlook.com*

Persistence and Stability of Large-Scale Command and Control Networks

In command and control (C2) systems comprised of social and communication networks, people and infrastructure provide diverse services to complete a shared mission. In difficult and time-sensitive decision-making situations, becoming isolated from the rest of the C2 network dramatically reduces both an individual's capacity to perform their role and the network's capacity to fulfill mission goals. Thus, the connectivity of these networks, and, in particular, the composition and the size of their largest connected components, must be studied to assess their robustness to unexpected losses. Well-known classical results for this form of robustness are based on percolation theory, where nodes and/or links are removed at random and the connectivity of the remaining sub-network is analyzed. Percolation theory establishes that the distribution of links among network nodes (degree distribution) is a key characteristic in determining network robustness. Still, percolation theory stops at identifying the persistence of network connectivity, and has yet to answer any questions regarding the types of nodes still connected to the network. In this work we develop a combined analysis of both the collective persistence of the connected component as well as individual node persistence. We show that networks characterized by heterogeneous degree distributions contain super-stable nodes, which typically are the part of the connected component. Our preliminary results indicate that it is not the mere number of links but rather the location of the node within the network that determines its individual persistence, which can be quantified as the likelihood the node belongs to the connected component. Where the number of links afforded to critical C2 nodes is limited via restricted social interactions and technological constraints, our results may be used for the optimal topological placement of critical nodes within C2 networks.

T4-F.2 Ganin, AA*; Kitsak, M; Linkov, I; US Army Engineer Research and Development Center and University of Virginia; Northeastern University; US Army Engineer Research and Development Center; *alexander_a_g@outlook.com*

Network resilience of urban transportation infrastructure

The transportation infrastructure of any major metropolitan area is a highly complex dynamic heterogeneous system prone to a number of adverse events, including inclement weather (snowstorms, floods), road repairs and traffic accidents. In our previous work, we stressed the importance of making such systems not only robust to natural and man-made disasters, but also resilient, and developed a methodology to quantify the resilience of complex networks based on the concept of critical functionality. We defined the critical functionality as a function of time representing the state of the system and proposed to quantify resilience as the integral of this function over a given time interval. Notably, transportation systems may naturally be represented as networks, giving an analyst access to a rich set of techniques developed in the fields of graph theory and network science. We focused on paved roads transportation infrastructure only and used its most obvious network representation, mapping road intersections to nodes and road segments between the intersections to links. To facilitate this mapping, we created an ad hoc plugin toolset for the ESRI ArcGIS software suite. With this toolset, we built transportation networks using the Open Street Map foundation geospatial datasets. In the presentation we compare the road structure of multiple major cities in the U.S.: Boston, Chicago, Washington, D.C., and others. We highlight the main questions and challenges in the resilience analysis of transportation systems and present results showing how the type and severity of adverse events interplay with the critical functionality and resilience of these systems. Finally, we discuss insights on how the road topology affects the respective transportation systems' resilience.

T3-B.3 Gardezi, M*; Arbuckle, JG; Iowa State University; *maaz@iastate.edu*

Upper Midwestern conventional farmers' perceived vulnerability to extreme precipitation event: a spatial analysis

Potential climate change-related impacts to agriculture in the Upper Midwest, pose serious economic and ecological risks to the U.S. and the global economy. Given the projected trend toward more extreme rainfall events in the Upper Midwest, it is important to note how such variation in rainfall can impact farm-level productivity and off-farm environmental sustainability. A vulnerability assessment is a commonly used tool by researchers and practitioners for representing the geographical distribution of vulnerability in response to global change. Most vulnerability assessments have measured objective vulnerability using secondary data collected by government agencies at different geographic scales and for specific sectors. In contrast, subjective assessments of vulnerability are associated with people's perception of changes in climate and extreme weather events and the extent to which they feel prepared to endure changes and take necessary steps to cope with them. This work presents a first attempt to implement a Simultaneous Autoregressive (SAR) model and a Conditional Autoregressive (CAR) model to estimate Upper Midwestern corn and soybean farmers' perceived vulnerability to climate change. The perceived vulnerability index produced in this paper can be useful to meet the information needs of a diversity of decision makers such as farmers, agricultural educators, agencies and policy makers.

M3-J.9 Gaspar, RF*; Silva, CM; Collins, EE; William James Center for Research, ISPA-Instituto Universitario; *rgaspar@ispa.pt*
Psychological Adaptation During Stress Inducing Social Events: The Case of the 2014-2015 Ebola Outbreak
 Adaptation processes that arise in face of demands posed to individuals by major life events and everyday stressors, have been studied extensively (Skinner et al, 2003). Less research has tried to understand these processes in face of demands posed to the social system by unexpected and extreme stress inducing social event(s). This is the case with worldwide events such as disease outbreaks and epidemics, which not only pose demands to individuals (health and wellbeing) but also to the various levels of a social system, including groups of individuals, organizations and society in general (e.g. healthcare systems). Hence, as events emerge and unfold, it is important to go beyond an individual level of analysis and consider the Human Adaptation System, i.e. how the social system evaluates and responds to demands, depending on available (personal and social) resources to cope. In this regard, social media platforms are a rich data source given that information is produced and exchanged across various levels of a social system and individual's expressions of coping on these are diagnostic of the social system (Gaspar, Barnett & Seibt, 2015; Skinner et al, 2003). To exemplify this, we present an analysis of messages produced on Twitter in the U.S.A. during the 2014-2015 Ebola outbreak. Among various ways of coping, results showed two as indicative of a disease-avoidance mechanism through which the social system was responding to events: 1) Opposition – identification of an “other” (e.g. Africans) in co-occurrence with the attribution of blame for the infection; and 2) Escape – cognitive and affective distancing from an “infected other”. This and other examples will be used to discuss the potential of social media data for developing evidence-based crisis communication. This will be particularly focused on how stress inducing social events may be evaluated by the social system – as a threat or challenge to cope with (Blascovich & Mendes, 2011).

M4-D.3 Gibb, HJ*; Devleeschauwer, B; Bellinger, D; Bolger, PM; Zang, J; Carrington, C; Cliff, J; Zeilmaker, M; Ezendam, J; Wu, F; Gibb Epidemiology Consulting LLC; *herman.gibb@gibbepi.com*
Global Perspectives on Foodborne Chemical Exposures
 Chemical exposures have been associated with a variety of health effects; however, little is known about the burden of disease from foodborne chemicals. Food is a major pathway for the general population's exposure to chemicals, and for some chemicals, it accounts for almost 100% of exposure. Groups of foodborne chemicals, both natural and anthropogenic, were evaluated for their ability to contribute to the burden of disease. The results of the analyses on eight chemicals are presented here - cyanide in cassava, peanut allergen, aflatoxin, dioxin, arsenic, lead, methyl mercury, and cadmium. Systematic reviews of the literature were conducted to develop age- and sex-specific disease incidence and mortality estimates due to these chemicals. From these estimates, the numbers of cases, deaths and disability adjusted life years (DALYs) were calculated. Chemicals in the food supply, as evidenced by the results for only eight chemicals, can have a significant impact on the global burden of disease. The case-fatality rates for these eight chemicals range from low (e.g., peanut allergen) to extremely high (aflatoxin and liver cancer). The effects associated with these four chemicals are neurologic (cyanide in cassava), cancer (aflatoxin and arsenic), allergic response (peanut allergen), endocrine (dioxin), reproductive (dioxin), intellectual disability (lead and methyl mercury), and kidney disease (cadmium).

T4-C.5 Gernand, JM*; Ramchandran, V; Penn State University; *jmgernand@psu.edu*
Testing the Validity of Proposed In Vitro Toxicity Forecasting Models for Predicting Pulmonary Responses in Rodents
 Several nanoparticle toxicity models have been proposed based on data obtained from high throughput in vitro experiments. These models rely on different descriptors or quantified properties of the nanoparticle materials to make their predictions, yet none have been tested against the more complex results of in vivo toxicity experiments. Do these predictive descriptors also differentiate between more and less severe toxic responses in complex organisms? This study makes use of publicly available pulmonary toxicity data in rodents for metal oxide nanomaterials and tests the predictive capability of each of the proposed in vivo model chemical descriptors in predicting the relative severity of toxic response in rodents following pulmonary exposure. We utilize three methods to evaluate the potential for these descriptors to also be used as descriptors in an as yet unpublished in vivo toxicity forecasting model for metal oxide nanoparticles. The first is a Random Forest model that uses the chemical descriptors in addition to a variety of experimental conditions to predict the specific response of a unique exposure group of animals in terms of their deviation from the control group. The second method is a hierarchical exponential regression model that tests the ability of the descriptors to accurately differentiate between more and less severe dose-response curves for each of the tested materials. The final method is a classification tree that uses the proposed descriptors to categorize more and less toxic materials into sets of 2, 3, or 5 bins. Strikingly, the descriptors that perform reasonably well for in vitro predictions, perform very poorly for in vivo toxicity forecasting. We discuss some of the possible chemical and mechanistic explanations for this disparity, as well as potential solutions both in terms of quantifying nanoparticle characteristics and developing useful pulmonary toxicity forecasting models that may resolve this challenge in the future.

M2-J.4 Gillespie-Marthaler, LL*; Nelson, KS; Vanderbilt University; *leslie.gillespie-marthaler@vanderbilt.edu*
An Integrative Framework for Assessing the Resilience of Complex Adaptive Systems Based on Present and Future Needs
 Resilience, vulnerability, and sustainability are widely used in assessing the quality or state of a variety of systems (social, ecological, engineered, and coupled social-ecological/human-environmental). There is increasing interest in understanding the relationship between resilience, vulnerability, and sustainability, and how these concepts can be combined to better assess system quality. Anthropocentrically speaking, the quality of a system is a measure of its ability to serve society. Although resilience, vulnerability, and sustainability assessments are typically used to assess different aspects of system quality (e.g., equity of impact distribution, ability to resist disruption, or expected lifetime of the current system state), they share many terms and attributes associated with a common foundation in risk assessment and mitigation. While approaches for combining aspects of resilience and vulnerability, or resilience and sustainability frameworks have been developed, to our knowledge a framework explicitly combining all three concepts has yet to be proposed. In this paper we present a critical evaluation of framework linkages and interdependencies based on classic definitions of each concept and a review of studies that demonstrate the conceptual frameworks in practice. We propose a new framework that integrates the concepts of resilience, vulnerability, and sustainability via a dynamic assessment and planning process. The proposed framework demands that resilience assessment include consideration of inequities and long-term resource availability, requiring that strategies developed to respond to system stressors maintain a balance across spatial and temporal scales and systems thresholds. We illustrate how the framework may be applied to a variety of complex systems and types of stressors with the goal of guiding decision-making processes of governing bodies and institutions towards more resilient, equitable, and sustainable system operations.

M3-D.3 Gilmore, EA*; Hegre, H; University of Maryland;
gilmore@umd.edu

Economic growth, armed conflict and the implications for climate change

Armed conflict and economic growth are inherently coupled; armed conflict can substantially reduce economic growth, while economic growth is a strongly correlated with a reduction the propensity of armed conflict. Similarly, economic growth and the associated greenhouse gas (GHG) emissions play a central role in evaluating the challenges for mitigation and adaptation to climate change. Here, we investigate these interactions by simulating the incidence of armed conflict and its effect on economic growth simultaneously along the economic pathways defined by the Shared Socioeconomic Pathways (SSPs). We then model the change in GHG emissions from the revised GDP pathways that account for the incidence of armed conflict using the Global Change Assessment Model (GCAM). We find that the more pessimistic SSPs have much higher incidences of armed conflict than predicted under an exogenously forecasted GDP with a more modest effect for scenarios with higher underlying economic growth rates. Further, there are strong regional patterns with countries with contemporaneous conflicts experiencing much higher conflict burdens and reduced economic growth by the end of century. The lower economic growth associated with armed conflict can sharply reduce overall GHG emissions, although regional mitigation efforts may be more challenging.

W3-F.2 Glasgow, G*; Smith, AE; NERA Economic Consulting;
garrett.glasgow@nera.com

Statistical and Model Uncertainty in the Estimated Risk of Lung Function Decrements Due to Ozone Exposure

In the most recent Health Risk and Exposure Assessment (HREA) for Ozone, the U.S. Environmental Protection Agency (EPA) used an exposure-response function estimated on clinical data to calculate the risk of lung function decrements in a series of population-level simulations. Although these risk estimates are subject to both statistical uncertainty (which arises because the exposure-response function was estimated on a sample of clinical observations) and model uncertainty (which arises because there are different plausible ways to model the relationship between ozone exposure and lung function decrement), neither type of uncertainty was provided in the HREA. We estimate statistical uncertainty in EPA's risk estimates through the method of simulated coefficients, also known as the parametric bootstrap. We find 95% confidence intervals on the risk estimates that in some cases include zero, suggesting that in some cases we cannot exclude the possibility of no health risk to lung function due to ozone exposure. We also identify two types of model uncertainty in these risk estimates: (1) plausible alternative exposure-response functions, and (2) the treatment of the exposure-response function error term when simulating individual risks over an entire ozone season. In both cases we find that changes in these assumptions lead to substantially different estimates of risk and of changes in risk from tighter ozone standards. Suggestions are made for research to improve this type of risk estimate.

W2-E.5 Goble, R*; Carr, ER; Downs, TJ; Clark University ;
rgoble@clarku.edu

Three risk conundrums in the design of development projects

More often than not, development projects around the world do not work as expected. Moreover, very often they produce substantial unanticipated outcomes, some harmful, some beneficial. Better project planning and design could help align expectations with outcomes. However, three conundrums make planning and design a challenge. These we label the Complexity conundrum, the Stakeholder Diversity conundrum, and the Varying Temporal/Spatial Scale conundrum. Conundrums such as these cannot be fully resolved; they reflect intrinsic conflicts and confusions in the settings in which they arise. They can, however, be approached as creative tensions. Thus while the conundrums are a challenge to risk assessment, risk management, and, ultimately, risk governance, we believe that risk analysis, broadly conceived, could also help in illuminating these settings. The question then arises: do we need to do risk analysis differently in development settings? If so, are the differences sufficient to encourage us to rethink some of our foundational precepts about risk? This presentation is intended to open a discussion of those two questions.

M3-H.1 Goble, R; Clark University; rgoble@clarku.edu
Opportunities and obstacles to more and better use of risk perspectives in development settings

This presentation will introduce the symposium participants and audience to the goals of the symposium. It will raise some key issues and pose some difficult questions relating to the application of risk perspectives in development settings. The issues and questions come from discussions and collaborative work with workers in the development field as well as practical experience with stakeholder engagement and with the use of scenarios as a tool in development project assessment. The presentation will be brief and is intended as an opening to a broad discussion that will help guide future efforts of the risk and development specialty group.

T3-E.1 Goerlandt, Floris; Aalto University; floris.goerlandt@aalto.fi
Finding fault with system safety risk analysis: a typology for criticism

Although risk analysis is used in many application areas, there is an increasing recognition in the risk analysis community that there is a need to focus on foundational issues to strengthen the platforms on which the discipline is built. One way to strengthen the scientific platform for risk analysis, while simultaneously supporting the improvement of risk analysis practices, is to better understand the various criticisms raised against risk analysis. Focusing on risk analysis in a system safety context, criticisms concerning (especially quantitative) risk analysis techniques have been ongoing since the inception of formal risk characterization. While advances have been made both on foundational issues and in terms of specific applications, many of these criticisms persist in scientific and policy contexts. A typology for the most common criticisms is created, and attempts to formulate rebuttals are made. A systemized understanding of the criticisms can be helpful for practitioners to address these when stakeholders related to their work raise them. It is also helpful to focus research to improve the knowledge base needed to make a convincing and coherent case to rebut these on scientific grounds. Rebuttals are formulated based on the author's understanding of the scientific risk literature. Acknowledging limitations in the author's knowledge, it is hoped that the typology can act as a catalyst for others to formulate additional and/or improved rebuttals. It is also hoped that this effort can lead to a useful repository of foundations-based arguments for practitioners to fall back on when challenged with criticisms in practical applications.

M4-D.4 Goldman, DP; US Department of Agriculture Food Safety and Inspection Service; david.goldman@fsis.usda.gov
Foodborne Illness Source Attribution: Providing Critical Information for Food Regulatory Authorities to Target their Efforts and Measure their Progress

Food safety regulatory authorities use information from foodborne illness source attribution both to target resources as well as to measure progress in limiting food contamination and in reducing foodborne illness. Specifically food safety authorities can use source attribution, among the data they gather, to identify food safety systems that may need more inspection, more lab surveillance or for which policy changes might lead to decreases in illnesses. There are a number of methods used by food safety authorities to estimate the relative contribution of specific food items to foodborne illness. Using information from ill persons provides a direct link from the food vehicle to illness, but linking sporadic cases of illness to specific food vehicles is difficult. Case control studies can be used to estimate the population attributable risk from particular food exposures, but are both difficult to conduct and resource intensive. The best data from foodborne illness cases comes from outbreak investigations in which a specific food vehicle is identified (and often linked microbiologically to ill persons). While outbreak data is limited, given outbreak associated cases represent a small percentage of all cases of foodborne illness caused by a specific pathogen, and in many instances the food vehicle is not definitively identified, it is the approach used by U.S. authorities at present. Other methods used to estimate attribution include expert elicitation, using recognized food safety experts, and blended approaches that combine data from both sporadic and outbreak-associated cases of illness. During this presentation, the approach to foodborne illness source attribution used currently in the U.S. will be described, as well as describing how one of the two U.S. food regulatory authorities has used attribution information to guide its policy development and to measure progress toward national health objectives.

P.4 Goerlandt, F*; Tabri, K; Aps, R; Höglund, A; Lensu, M; Rytönen, J; Aalto University; floris.goerlandt@aalto.fi
Enhancing operational risk management for wintertime oil spills with smart response services

While maritime transport is of vital economic importance to the Baltic Sea area, challenging winter navigation conditions pose a hazard to ships operating in these waters. To counteract the environmental risks posed by oil pollution from shipping accidents, adequate measures for accident prevention and spill mitigation are critically important. Operational oil spill risk management is facilitated by smart response services, encompassing several technological and scientific developments. When a ship collision or grounding has occurred, tools for predicting the amount of oil spilled and the spill duration provide critical information to response services about the necessary resources for mitigation actions. Likewise, projections about the fate of the oil in the moving ice fields are useful for operational planning purposes. Finally, linking this information to knowledge about the vulnerability of various ecosystem services of the sea area further assists in prioritizing actions to minimize the consequences of the spill. This work presents the overall rationale and selected results of the STORMWINDS project, which aims to advance the state-of-art in operational risk management for accidental spills in ice conditions, through the development of advanced tools and online services to assist oil spill response operations.

P.30 González-Ortega, J*; Ríos Insua, D; Cano, J; Instituto de Ciencias Matemáticas and Universidad Rey Juan Carlos; jorge.gonzalez@icmat.es
Adversarial hypothesis testing

Hypothesis testing is one of the standard problems in statistical inference. Though not exempt of debate, it is a thoroughly studied problem from a decision theoretical perspective, both from the frequentist and the Bayesian points of view, stemming from the seminal work of Wald (1950). Drawing on recent developments in cybersecurity, there has been an upsurge in applied areas which may be jointly denominated adversarial signal processing. This covers applications from online fraud detection to steganography, going through spam detection or watermarking, among many others. Several of the issues posed may be seen as hypothesis testing problems in which hostile adversaries somehow perturb the data observed by a decision maker as a way to confound him about the relevant hypothesis. However, attempts in this area have focused mostly on zero-sum game theoretic minimax approaches to hypothesis testing, which is not satisfactory since losses for various agents will be typically asymmetric. Moreover, the beliefs and preferences of the adversary will not be readily available, violating the common knowledge assumption from game theory. Thus, key assumptions for the proposed solution approaches would not hold. Using recent concepts from Adversarial Risk Analysis (ARA), we provide a novel approach to the Adversarial Hypothesis Testing (AHT) problem. We consider an agent, called Defender, which needs to ascertain which of several hypotheses holds, based on observations from a source that may be perturbed by another agent, which we designate Attacker. We study the AHT problem from the Defender's perspective. In doing this, we observe that the Defender needs to forecast the Attacker's decision, which we perform by simulating from the corresponding Attacker's decision making problem. Our approach is illustrated through a model for batch acceptance.

W4-D.4 Good, DH*; Krutilla, K; Indiana University;
good@indiana.edu

Evaluation of Bicyclist Morbidity and Mortality Mitigation with Crash Imminent Braking Technologies

On the pathway to self driving cars, several intermediate technologies are being developed and deployed that assist the driver, potentially providing improved safety. Crash imminent braking (CIB), is a technology that intervenes by applying near maximum braking when the driver fails to adequately react. In some cases, such as rear end collisions, these threats are easily identified. In other cases, such as pedestrians and bicyclists they are considerably more complex and subtle. More recent implementations of CIB are being marketed as offering some protection for these vulnerable road users. Some manufacturers plan to offer these systems as standard equipment on most of their 2018 model year. NHTSA is considering including pedestrian/cyclist CIB in their new car assessment program. In this paper we evaluate the performance of one manufacturer's most recent system for detecting and mitigating commonly occurring bicycle crashes. Because few equipped vehicles are on the road and bicycle crashes are rare, standard program evaluations techniques have insufficient statistical power. Instead, our alternative analysis has four components: 1) the development of scenarios for classifying cyclist crash geometries; 2) the construction of a realistic human bicyclist surrogate; 3) generating a sample of crash results with to build a model about how effective the system is under alternative scenarios; and 4) to develop a model predicting injuries under baseline and mitigated scenarios. Step 4 poses the largest challenge as there are no US data sources for predicting injuries for cyclists. Instead we synthesize available pedestrian and cyclist data from Europe, Japan and US. The developed models are considerably more detailed than typical, using information target motion, vehicle speed at impact, orientation and cyclist age as dominant variables. We find that these systems are of limited value in generating benefits for cyclists and offer some rationales for these limitations.

P.108 Gosen, DG*; Shelton, LM; Grenoble Ecole de Management;
dora.gosen@hotmail.com

Safety Culture and Return to Work: Does Perception Matter?

Work injuries are cumbersome and are blamed for time away from work. Financial burdens on both employee and employer resulting from employees missing days of work after an injury and the employee emotional pains initiated a debate for over two decades. Returning to work after an injury goes beyond physical disabilities to include social, psychological, and economic factors. Organizational policies and social environment are also known to determine employee's return. Many of the reviewed return to work studies focused on reactive measures dealing with bringing an employee back to work after an injury takes place and not on proactive safety measures like safety culture and its impact on employees' perception of their organization. We propose that safety culture enhances perceived organizational support and results in positive occupational outcomes. In particular, we propose that employees perceive their organization's safety culture as a form of care for their health and wellbeing where they reciprocate to such behavior by exhibiting favorable consequences. We suggest that safety culture is directly and indirectly responsible for improving critical aspects of organizational outcomes, i.e., number of days lost after an injury and number of litigated cases through the mediating effect of perceived organizational support. In addition, the proposed model examines the moderating effects of direct supervisors since employees view them as representatives of the organization where their favorable behaviors indicate organizational support. We also suggest that safety culture is directly responsible for accident prevention and the negative effects that accidents may have. This paper is unique since it explicitly discusses an additional, often overlooked benefit of a strong safety culture – its enhancement of perceived organizational support. By explicitly recognizing that improvements in safety culture can reduce injury related outcomes through the positive mediating influence of perceived organizational support as well as by directly improving safety performance.

T2-C.2 Gooding, RE*; Bradley, DR; DHS Chemical Security Analysis Center; rachel.gooding@ST.dhs.gov

Overview of the Explosives Terrorism Risk Assessment (ExTRA)

The Chemical Security Analysis Center of the DHS Science and Technology Directorate is developing a risk assessment to evaluate the public health risk from terrorist use of explosives based on a mature probabilistic risk assessment (PRA) methodology developed to evaluate the risk from an intentional release of a toxic chemical in the Chemical Terrorism Risk Assessment (CTRA). This end-to-end risk methodology considers a broad range of hazards incorporating emerging technologies, available countermeasures, security and mitigation strategies and input from the Intelligence and Law Enforcement communities (IC/LE) to evaluate the risk to human health from an explosive attack on the U.S. Homeland. The PRA generated output provides a mechanism to examine risk mitigation strategies, critical vulnerabilities, critical data/knowledge gaps and relative risk ranking of materials, devices, targets, and scenarios. This conference presentation will provide 1) an overview of the ExTRA methodology; 2) an analysis of the ability of existing consequence models to perform rapid, batch oriented calculations for millions of scenarios involving the interior and exterior placement of explosives to calculate the range of overpressure, fragmentation and thermal injuries; 3) prioritization of the explosive materials to be considered in the first full probabilistic risk assessment based on a risk management table incorporating material and information availability, historical use and impact and 4) development of scenarios and an event tree which form the basis of the probabilistic risk assessment.

W2-J.2 Goto, SG*; Sütterlin, B; Arvai, JL; 1 University of Michigan, Ann Arbor, Michigan 48109, USA; 2 ETH Zurich, Zurich CH 8092, Switzerland; 3 University of Michigan, Ann Arbor, Michigan 48109, USA; saragoto@umich.edu

How companies manage risks to their reputations: public perceptions of corporate behavior in response to controversies

Corporate social license is the extent to which corporations are constrained by societal pressures to act in a manner that is approved by society. Many studies evaluate the impact of social license on consumer behavior or market value, but few evaluate the variables that influence perceptions about companies seeking social license for their activities and business practices. Corporations seeking social license, often after controversy, do so through activities in the name of corporate social responsibility (CSR). CSR can be classified into two categories. Category A activities are central to the activity for which the company seeks social license. In contrast, category B activities are not central to the activity for which the company seeks social license, but are conducted in an effort to garner a positive halo effect for their objectives. Category B activities are frequently practiced and if successful can pose a risk to the environment. Environmental problems or concerns associated with the activity for which the company seeks social license will likely remain unaddressed due to difficulty if social license can be gained from, easier to achieve, category B activities. To explore the effectiveness of CSR activities on social license we conducted a 3x3 factorial experiment yielding 9 treatment scenarios. The factors included three classes of corporations (consumer electronics, oil and gas, and food and beverage) and three CSR scenarios (Category A, Category B, and no change). Category B activities were not viewed as legitimate, led to higher dissatisfaction with the company, and will not lead to the granting of social license. By comparison, category A activities were viewed more positively than category B activities and may lead to the granting of a social license. Although a frequent practice, these results indicate that Category B activities are unsuccessful in increasing social license, despite the fact that the activities themselves are seen as positive.

T3-H.1 Gould, F; North Carolina State University;
Fred_Gould@ncsu.edu

The biological basis of gene drive technologies: Beyond the hype
I will first give a brief explanation of how gene drive technologies are theoretically expected to work. I will then go over what has been done empirically toward achieving the goal of developing working gene drive systems in species that are targeted for alteration or suppression with gene drive. I will move on to examine some of the ecological and genetic attributes of species that are likely to make them more and less amenable to gene drive. Finally, I will discuss approaches for limiting the spread of gene drives in time and space.

W1-H.3 Gray, L*; MacDonald, C; Mackie, B; Paton, D; Baker, MG; Johnston, D; University of Otago, Wellington;
lesley.gray@otago.ac.nz

Community risk perception of flu vaccination campaigns in New Zealand
Whilst New Zealand represents a tiny population it has many and diverse communities, each with their own strategies around synthesising vaccination risk, management and prevention strategies. This presentation will look at qualitative data from community focus groups and discuss key issues for health promotion and health protection planners. Purposive population sampling methods were used to ensure the sample met criteria specified by the Ministry of Health. Vaccination beliefs and decisions varied between different communities, however responses from all groups endorsed the need for community based risk management including information dissemination. The importance of the differences identified is not the differences per se but highlights problems with a “one size fits all” approach. Participants contextualised their own vaccination decisions and risk assessment, balancing such decisions in relation to influenza between their perceived risk of influenza against the perceived risks associated with vaccines.

W3-F.4 Gray, G; Department of Environmental and Occupational Health, GWU Milken Institute School of Public Health;
gmgray@gwu.edu

Approaches to Characterizing Model Uncertainty
A challenge in risk assessment is characterizing model uncertainty in addition to stochastic uncertainty. This presentation will identify several approaches that have been taken in different fields to reflect uncertainty in the appropriateness of alternative models to predict risk. Ranging from qualitative to quantitative, the approaches use words, semi-quantitative approaches and fully probabilistic tools. Each has advantages and disadvantages. The strengths and weaknesses of each are discussed along with the challenges associated with communicating uncertainty to decision makers and the public.

W2-G.4 Greco, SL*; Young, S; MacIntyre, E; Kim, JH; Candido, E; Copes, R; Public Health Ontario, Cancer Care Ontario;
sue.greco@oahpp.ca

Quantifying the environmental burden of cancer in Ontario, Canada
Public Health Ontario (PHO) and Cancer Care Ontario (CCO) are agencies dedicated to protecting and promoting health as well as preventing disease in the Canadian province, Ontario (population approximately 13 million). PHO and CCO collaborated to estimate the environmental burden of cancer from carcinogens that Ontario residents might be exposed to on a daily basis, issuing the findings in a report released in the summer of 2016. The final list of carcinogens considered was developed starting with the International Agency for Research on Cancer (IARC) Group 1 and 2A carcinogens (carcinogenic or probably carcinogenic to humans), then excluding carcinogens where exposure was unlikely to occur via environmental pathways, not relevant to residents of Ontario, or unable to be quantified. We considered carcinogen exposure from the inhalation of indoor and outdoor air; the ingestion of food, drinking water and indoor dust; and exposure to sunlight. Characterizing variability and uncertainty in concentration and carcinogenic potency to the extent possible, we conducted a probabilistic analysis to estimate cancer risk from exposure to 23 carcinogens. We applied a risk assessment (RA) or a population attributable fraction (PAF) model, depending on the input data available. The estimated cancer burden (mean annual cases) in Ontario fell into several distinct categories: (1) between 1,300 and 2,500 for solar radiation and radon; (2) between 100 and 600 for fine particulate matter, arsenic, and acrylamide; (3) between 10 and 40 for asbestos, secondhand smoke, formaldehyde, dioxin, and chromium; and (4) less than 10 for the remainder of the examined carcinogen-exposure route combinations. This session will describe the approach, data sources, results, limitations, and policy implications resulting from this analysis. The results from applying the RA and PAF models for one carcinogen where this was possible will be compared.

P.74 Greene, CW; Minnesota Department of Health;
christopher.greene@state.mn.us

Prioritization of water contaminants using the USGS-EPA Water Quality Portal

The Water Quality Data Portal (WQP) is a data access system developed by the U.S. Geological Survey (USGS) and U.S. Environmental Protection Agency (EPA), and administered by the National Water Quality Monitoring Council. It contains over 270 million records from 2.2 million monitoring locations. The WQP includes the USGS National Water Information System (NWIS) data set, with data from 1.5 million U.S. sampling sites; EPA's Storage and Retrieval (STORET) database, containing data from over 400 partner agencies; and other, smaller data sets. Through a web-based interface, users can access data on sampling sites or analytical results by chemical, site, geographic region, or other parameter. Data can also be retrieved through a Web Services request in the form of an URL specifying the desired search parameters, returning a file in Extensible Markup Language (XML) or other convenient format. The WQP's shared Application Programming Interface (API) allows users to develop their own data analysis tools. The Minnesota Department of Health uses the WQP as a screening and evaluation tool for assessing Contaminants of Emerging Concern (CECs) in the state's surface water and groundwater. In addition to retrievals of environmental occurrence data for CECs, the WQP enables assessments of geographic water quality trends (such as changes in concentrations upstream and downstream of known emission sources or wastewater discharges) and temporal trends that may result from changes in chemical use and/or discharge. These analyses have enabled MDH to prioritize chemicals being considered for toxicological review and drinking water guidance development, and focus its efforts on those chemicals for which drinking water guidance would be most useful and effective.

T2-I.1 Guidotti, TL; O+EH&M; tee.guidotti@gmail.com

Overview

The language for risk concepts in occupational health and safety uses a similar vocabulary but with meanings often different from risk science in general (considered as "Red Book" risk language) and also often varies among the occupational health profession (hygiene, safety, medicine). For example, the concept called "risk assessment" in occupational health practice is closer to hazard identification or a hazard inventory than to risk analysis or risk characterization. This reflects usage and the origins of many risk concepts in occupational health from disciplines and traditions other than probabilistic risk assessment.

W4-H.1 Guibert, GP; City of Boulder, CO USA;
gpguibert@gmail.com

Resilient Boulder: Implementing the 100 Resilient Cities Global Network

100 Resilient Cities (100RC) is a global network pioneered by the Rockefeller Foundation to help cities around the world become more resilient to the physical, social, and economic challenges that are a growing part of the 21st century. Boulder joined the network as part of its first wave in 2013 and through its participation, is committed to demonstrating leadership in resilience as well as take advantage of the resources and opportunities it presents. 100RC supports the adoption and incorporation of a view of resilience that includes not just the shocks but also the stresses that weaken the fabric of a city on a day to day or cyclical basis, such as economic hardship or social inequality. By addressing both the shocks and the stresses in a holistic manner, a city becomes more able to respond to adverse events, and is better able to deliver basic functions in both good times and bad, to all populations. Boulder has a long history of planning today for the challenges of tomorrow, creating innovative solutions, and undertaking successful resilience-building activities and projects. Our natural hazards are tightly linked, necessitating a comprehensive and integrated approach to risk mitigation. Droughts stress our ecosystems, helping accelerate the damage of pests to our forests, thereby increasing the fuel for wildfires, and consequently denuding slopes and increasing flash flooding risk. But this cycle itself is not linear - each event builds on another and sets the stage for even more complex interactions. Therefore, to address these interlinked hazards, activities and programs must be well coordinated, using a systemic approach to reducing multiple risks at the same time and preparing communities to handle disruptions of any kind. The objective of the City Resilience Strategy is to provide a roadmap for building resilience in the city. The strategy will trigger action, investment, and support within city government and from outside groups.

T2-I.3 Guidotti, TL; O+EH&M; tee.guidotti@gmail.com

Occupational Medicine Perspective

Occupational medicine and occupational (industrial) hygiene shared a common history before about 1950 and both tend to provide qualitative risk estimates, even when hazard is quantified. Occupational physicians managing disease cases rarely have access to relevant exposure data other than through the history of the injured worker. Occupational medicine uses outcome-specific risk language rather than the language of systems safety, which tends to use terminology from engineering and failure analysis.

W2-A.2 Guikema, SD*; Reilly, A; University of Michigan;
sguikema@umich.edu

Agent Based Modeling of Repeated Hazards: Modeling to Enhance Interdisciplinary Collaboration

Interdisciplinary research is central to the Risk Analysis field, but is interpreted and implemented in substantially different ways by different groups and individuals. This talk discusses an effort to try to foster interdisciplinary integration through the use of a large-scale agent-based model. The context is a research project focused on better understanding the effects of repeated disasters on the evolution of regional vulnerability over time. The aim of the modeling effort is to help the team move beyond more the more superficial approach of different disciplines working in parallel to a deeper form of interdisciplinary integration. Preliminary insights and challenges will be provided based on the first half of a long-term project.

T4-G.1 Guiseppi-Elie, A*; Isaacs, K; Dionisio, K; Phillips, K; Wambaugh, J; Price, P; United States Environmental Protection Agency - Office of Research and Development;
guiseppi-elie.annette@epa.gov

Advancing Models and Data for Characterizing Exposures to Chemicals in Consumer Products

EPA's Office of Research and Development (ORD) is leading several efforts to develop methods for estimating chemical exposures related to the use of consumer products. These methods include mechanistic models for use in both high-throughput chemical screening/prioritization and higher-tier applications as well as new databases for parameterizing and evaluating these models. For prioritization, ORD developed the High-Throughput Stochastic Human Exposure and Dose Simulation Model (SHEDS-HT) which models aggregate population estimates of exposure based on 1) chemical concentrations in up to 200 consumer product categories and 2) population use patterns of these products. A higher-tier model, the Human Exposure Model (HEM), is being developed to consider additional factors impacting variability in aggregate exposures, including physiological variability and demographic and longitudinal patterns in product use. HEM will incorporate new agent-based models of product use. Both models will draw on new curated data sources for chemical, ingredient, and product use information, including 1) chemical ingredient weight fractions collected from Material Safety Data Sheets 2) weight fractions predicted from product ingredient lists, 3) product use patterns developed from purchasing data and 4) chemical function data collected from public sources. Also, functional use data is being used to develop chemical structure and/or property-based models for function and product weight fraction, which can aid in filling gaps in existing ingredient data. Finally, under ORD's Exposure Forecasting (ExpoCast) project, new HT analytical methods are being evaluated for characterizing the chemical composition of different products. These methods provide a potentially rich source of new data for modeling and evaluation. Taken together, these tools and data will improve the understanding and prediction of chemical exposures from consumer products in support of risk-based decision making.

W4-D.5 Gungor, A; U.S. Coast Guard; seniorgungor@gmail.com
How To Regulate For Black Swan Events? Capturing or Illustrating The Highly Unlikely In A Regulatory Context

Regulation is an intended set of government actions aimed at obtaining a socially desirable outcome. Sometimes a set of rules have the easily quantifiable goal of reducing or eliminating existing perilous risks—like making sure a commercial vessel engine meets mechanical adequacy. However, other rules' goals are far more difficult to quantify due to their abstract objective of say, reducing unforeseeable, yet potentially catastrophic outcomes, such as terrorist attacks or catastrophic oil spills like the Deepwater Horizon event. So, how does one analyze the highly unlikely when standard statistical methodologies seem inadequate, at best? Some insights may be garnered from the 'Black Swan Theory,' a paradigm guided by the notion that by their very nature, the highly unlikely is nearly impossible to mathematically predict. The U.S. Coast Guard must frequently estimate the risks of highly unlikely or low-probability, high-impact events, such as large oil spills or major vessel collisions in the process of developing regulations. By definition, these types of events are rare, and historical data is often limited. For some types of incident categories, a truly large event may never have occurred. Nonetheless, the Coast Guard still must design regulations and policies that account for the potential risks of these rare disasters. This presentation will provide an overview of various rulemaking projects and policies (such as Dynamic Positioning Systems, Hazardous Substance Spill Prevention, Implementation of Polar Code, and Frackwater Transportation in Inland Waterways) to help illustrate the challenges the Coast Guard faces in estimating highly unlikely events with potentially catastrophic impact. Specifically, it critically evaluates the status-quo practices of benefit estimation, provides an update on Coast Guard's efforts in addressing and modeling 'un-predictable' events, and ultimately explores the applicability of the 'Black Swan' paradigm in a regulatory context.

P.114 Gutiérrez, VV*; Toledo, MI; Universidad Diego Portales;
virna.gutierrez@udp.cl

Risk factors associated to cyberbullying in Chilean high school students

Bullying among young student is a well know phenomenon, however, much less ins know about cyberbullying. Cyberbullying has been described as harmful behavior that is: (1) intentional, (2) carried out "repeatedly and over time," and (3) takes place in an interpersonal relationship characterized by an imbalance of power using mobile phones and the internet (Olweus, 1999, p. 10; Smith et al., 2008, p. 376). Cyberbullying brings terrible consequences to those who suffer from it. Some research has shown that cybervictims can have low self-esteem, depressions, poor academic performance and on the extreme situations of suicidal thoughts and attempts. Nowadays, when technology is available to everyone and adolescents are using it in an unprecedented way, cyberbullying becomes a real concern to schools and policy makers. Little is known about risk factors that engage students in cyberbullying behavior. Some studies have found that traditional bullying might be a risk factor associated to cyberbullying, meaning that traditional victims would also be cybervictims. On the other hand, while popularity among peers is thought as a risk protector, time spent on-line, computer proficiency and usage of information technology are catalogue as risk factors. Many of the studies have been conducted in European and American student population, but a few, in Latino population. The aim of this study is to determine risk factors and risk protectors of cyberbullying, focusing on victims. We surveyed 749 students from high school, among 31 schools from the Metropolitan Region of Santiago, Chile. We asked students if they have been bullied in the last semester in different cyber contexts. We analyze frequency of cyberbullying with risk factors such as gender, age, self-esteem, popularity, traditional bullying, frequency and time spent on-line. Findings are discussed in terms of policy recommendations.

W1-B.1 Haas, CN*; Rycroft, T; Casson, L; Bibby, K; Drexel University and University of Pittsburgh; haas@drexel.edu

Risks from Ebolavirus Discharge from Hospitals to Sewer Workers
Current World Health Organization and Centers for Disease Control and Prevention guidance for the disposal of liquid waste from patients undergoing treatment for Ebola virus disease at hospitals in the United States is to manage patient excreta as ordinary wastewater without pretreatment. The potential for Ebolavirus transmission via liquid waste discharged into the wastewater environment is currently unknown, however. Possible worker inhalation exposure to Ebolavirus-contaminated aerosols in the sewer continues to be a concern within the wastewater treatment community. In this study, a quantitative microbial risk assessment was carried out to assess a sewer worker's potential risk of developing Ebola virus disease from inhalation exposure when performing standard occupational activities in a sewer line serving a hospital receiving Ebola patients. Risk projections were estimated for four scenarios that considered the infectivity of viral particles and the degree of worker compliance with personal protective equipment guidelines. Under the least favorable scenario, the median potential risk of developing Ebola virus disease from inhalation exposure to Ebolavirus-contaminated aerosols in the sewer is approximately $10^{-5.77}$ (with a 1st–3rd quartile range of $10^{-7.06}$ — $10^{-4.65}$), a value higher than many risk managers may be willing to accept. While further data gathering efforts are necessary to improve the precision of the risk projections presented here, the results suggest that the potential risk that sewer workers face when operating in a wastewater collection system downstream from a hospital receiving Ebola patients warrants further attention, and that current authoritative guidance for Ebolavirus liquid waste disposal – to dispose in the sanitary sewer without further treatment – may be insufficiently protective of sewer worker safety.

P.166 Hamilton, MC*; Speight, HA; Hunke, JA; Voyadgis, DE; Veeravalli, S; Becker, SJ; Lyon, SL; US Army Corps of Engineers Geospatial Research Laboratory; michelle.c.hamilton@usace.army.mil

Water stability index for risk identification within transboundary river basins

Stability tasks are conducted as part of United States military operations abroad in coordination with other instruments of national power to maintain or reestablish a safe and secure environment, and provide essential governmental services, emergency infrastructure reconstruction, and humanitarian relief. To do this the United States Army conducts primary stability tasks in order to achieve five end state conditions: a safe and secure environment, established rule of law, social well-being, stable governance, and sustainable economy. For stability tasks to be effective, it is critically important to understand and monitor the conditions that can lead to instability and target interventions accordingly. Water plays a vital role in underpinning stable and productive societies and the ecosystems on which they depend. In general, water security is defined as the reliable availability of an acceptable quantity and quality of water for health, livelihoods, and production. While several water security indices exist at the national scale, there are few indices that prioritize regions at a spatial scale that is informative for stability tasks. This research is developing a Water Stability Index (WSI) designed to inform the prioritization of where and what type of stability interventions at the river basin-country geospatial unit of analysis. The WSI focuses on water-related instability risk factors and includes concepts of ecological vulnerability, social vulnerability and adaptive capacity. The WSI is unique in that it aligns risk indicators under the five stability end states so that interventions can be targeted accordingly.

W4-E.5 HALL, I S; University of Northampton; ian.hall@sfcbusinessservices.co.uk

The use of scenarios to improve decision making through a better understanding of cognitive bias and mental models within a corporate environment

Risk analysis tools and techniques are continually evolving as decision makers seek to understand and quantify the risks faced by their business. The risk appetite of a corporate is increasingly being articulated through the use of quantitative measures to express the level of tolerance to risk that the business has. Against this, regulators seek to 'stop bad things happening' by de-risking the corporate environment, through reducing the volatility prevalent in a market, suggesting that risk is seen only as a negative factor. Individuals involved in the decision making process will often have conflicting objectives, and may also have a different tolerance to risk than their colleagues based on their individual mental models and cognitive biases created over the course of their life. In addition, the degree of power held and personal accountability for the outcome of the decision will also impact upon their willingness to accept risk. Within a Banking environment, there is a move away from 'Group' decision making towards personal accountability, and it is thus critical for decision makers to understand their own risk tolerance, and the aspects that influence this to ensure alignment with corporate strategy. This study used scenario based workshops to explore the decisions made by individuals with the aim of capturing mental models and the providing education to the decision maker about their biases with the aim to improving risk analysis and optimise decision making. The presentation will provide the findings from the study together with recommendations for organizational change.

T2-B.3 Hamilton, KA*; Haas, CN; Ahmed, WA; Drexel University; kh495@drexel.edu

Quantitative Microbial Risk Assessment of Legionella and Mycobacterium avium in harvested rainwater

Growing water scarcity has increased the need for development of decentralized and alternative water resources to conserve water and mitigate stormwater runoff. The harvest of rainwater from roof surfaces is common throughout the world and is relied upon to meet potable and non-potable water needs in water scarce regions such as Queensland, Australia. To assess the occurrence of opportunistic bacteria in roof-harvested rainwater tanks in the Southeast Queensland region, a study of seven opportunistic waterborne pathogens (*Acanthamoeba* spp., *Legionella* spp., *Legionella pneumophila*, *Legionella longbeachae*, *Pseudomonas aeruginosa*, *Mycobacterium avium* and *Mycobacterium intracellulare*) in 134 roof-harvested rainwater (RHRW) tanks was conducted using quantitative PCR (qPCR). All opportunistic pathogens were detected in rainwater tanks with the exception of *Legionella longbeachae*. Concentrations ranged up to 3.1×10^6 , 9.6×10^5 , 6.8×10^5 , 6.6×10^5 , 1.1×10^5 , and 9.8×10^3 gene copies per liter of rainwater for *Legionella* spp., *P. aeruginosa*, *M. intracellulare*, *Acanthamoeba* spp., *M. avium*, and *L. pneumophila*, respectively. A survey of 121 tank-owners provided data on rainwater end-uses. Using these exposure data, a quantitative microbial risk assessment was conducted for *Legionella pneumophila* and *Mycobacterium avium* complex (MAC) using a newly developed dose-response model for the most epidemiologically-relevant strains of MAC. These results can inform rainwater harvesting treatment and use practices.

W2-D.4 Hammitt, JK; Robinson, LA*; Harvard University (Center for Risk Analysis and Center for Health Decision Science); robinson@hsph.harvard.edu

Valuing Quality-Adjusted Life Years for Benefit-Cost Analysis

Benefit-cost analysis plays an important role in informing risk management decisions, by providing information on how those affected value the benefits they receive in comparison to the costs the policy imposes. However, the usefulness of these analyses is currently hindered by the lack of willingness to pay (WTP) estimates for nonfatal health conditions. As a result, analysts often rely on estimates of quality-adjusted life years (QALYs), valued using a constant WTP per QALY, as a rough proxy. However, both theory and empirical research suggest that this approach is inconsistent with individual preferences: the value per QALY is likely to vary depending on the severity and duration of the condition as well as other characteristics of the risk and the affected individuals. Several studies are now available that provide estimates of individual WTP per QALY for different health conditions. We combine the results of these studies to develop a function that can be used to estimate the value of a QALY, which may depend on the size of the gain. We find that this approach is promising, but yields uncertain estimates given the limitations of the available research. Our research has implications for the values used as cost-effectiveness thresholds as well as for benefit-cost analysis, suggesting that these thresholds should be varied for different types of health conditions.

T3-D.1 Hammitt, JK*; Hoffmann, S; Harvard University (Center for Risk Analysis); jkh@harvard.edu

The value of enhancing consumer confidence in the food supply

Conventional estimates of the value of risk reductions are based on the change in probability-weighted consequences. For example, conventional estimates of the value of enhanced food safety multiply the reductions in probability of illness or death by values per statistical case. This model implies the value of a small reduction in the probability of a specific harm is proportional to the change in probability. Moreover, it omits a number of factors that may influence an individual's valuation of a risk reduction. In the context of programs to enhance the safety of the food supply, we consider whether some of the omitted factors should be considered when evaluating policies, and if so how their magnitudes can be estimated. Examples of omitted factors include nonlinear probability weighting (as in prospect theory), certainty effects (reduction vs. elimination of a risk), ambiguity aversion, anxiety while bearing risk, cognitive dissonance and biasing of beliefs to reduce anxiety, decision costs, flexibility to try new foods, and reductions in precautionary behaviors (e.g., food preparation, avoiding unfamiliar foods). The analysis has implications for valuing risk reductions for other contexts, including other consumer products.

W3-G.1 Haney, JT; Texas Commission on Environmental Quality; joseph.haney@tceq.texas.gov

Development of an inhalation unit risk factor for cadmium

The inhalation unit risk factor (URF) for cadmium (Cd) on USEPA's Integrated Risk Information System has not been updated in three decades. Thus, it was important to conduct an updated carcinogenic assessment of Cd based on the latest scientific data to develop a URF to help ensure the most appropriate characterization of excess lifetime risk and protection of public health. Importantly, a more recent update (Park et al. 2012) was available for dose-response assessment of excess lung cancer mortality in the Thun et al. (1985) cohort of Cd smelter workers, the key epidemiological study cohort upon which USEPA's 1985 URF was based. Park et al. (2012) re-analyzed the Cd smelter worker population using more detailed work history information, a revised Cd exposure matrix, a detailed retrospective exposure assessment for arsenic (potential confounder), and updated mortality data through 2002 (an additional 24 years of follow-up). Grouped observed and expected number of lung cancer mortalities along with cumulative Cd exposures were used in the current study to obtain the maximum likelihood estimate and asymptotic variance of the slope (β) for the linear multiplicative relative risk model using Poisson regression modeling. Life-table analyses utilizing Texas and US background lung cancer mortality rates and survival probabilities were used to derive final URF values of $4.9E-04$ per mg Cd/m³ and $5.5E-04$ per mg Cd/m³, respectively. The corresponding lifetime air concentrations at the 1 in 100,000 no significant excess risk level are 0.020 mg Cd/m³ and 0.018 mg Cd/m³, respectively. These lifetime air concentrations can be used to protect the general public in Texas and the US against the potential carcinogenic effects from chronic exposure to Cd and Cd compounds. By comparison, annual averages at ambient air monitoring sites in Texas range from not detected to 0.003 mg Cd/m³ (based on speciated PM_{2.5} or PM₁₀), although nondetects drive the vast majority of annual site means.

P.112 Haney, JT; Texas Commission on Environmental Quality; joseph.haney@tceq.texas.gov

Regulatory risk assessor perspective on the historical drinking water contamination at Camp Lejeune, NC

Historical drinking water contamination at the U.S. Marine Corps Base at Camp Lejeune, NC is particularly notable because not only were the concentrations extraordinarily high, but an estimated 500,000 to 1 million people (e.g., civilian workers, military personnel and their families) may have been unknowingly exposed via water use (e.g., household, other drinking water and uses) over more than three decades. Although the former condition is not particularly rare in Superfund, large numbers of people (both military and civilian workers, adults and children) with substantial, long-term daily exposure (from years to perhaps decades, as opposed to a hypothetical exposure scenario) to highly contaminated water via drinking, food preparation, showering/bathing, and other pathways (e.g., baby formula preparation, in utero, workplace use) represents an approximate worst-case exposure scenario under which there is a greater than usual potential for adverse health effects. Historical trichloroethylene (TCE) and other chemical concentrations were sufficiently elevated to raise potential health concerns. For example, the 1952-1984 mean concentration (138 mg/L) exceeded the USEPA's current TCE maximum contaminant level by 28-fold, with the corresponding dose ($3.9E-03$ mg/kg-day) exceeding all three candidate USEPA reference doses (RfDs) by 8- to 11-fold. The mean dose also exceeds supporting RfD values based on toxic nephropathy and increased kidney weight, as well as the point of departure (POD) for toxic nephropathy. Furthermore, estimated doses for 29% of the monthly averages and 34% of the 9-month rolling averages exceed the POD for the highest RfD, which is based on fetal heart defects. The incidences of nephropathy and fetal heart defects should be thoroughly evaluated among those exposed. Long-term follow-up will be required to assess potential health effects for the 500,000 to 1 million who may have used the contaminated water at Camp Lejeune or were exposed in utero.

T4-J.3 Harthorn, BH*; Partridge, T; Enders, C; Thomas, M; Pidgeon, N; University of California Santa Barbara; harthorn@cns.ucsb.edu
Health risk perception, justice and bodily resilience in US and UK public perceptions of fracking

In the past five years, research on public perceptions of risks of shale oil and gas development (or 'fracking') in the US has focused primarily on environmental risk perception. Although some survey research to date has included health risk issues in addition to environmental risk, few studies have yet systematically explored health concerns using qualitative methods. Public surveys in areas of active extraction activities in the US have identified stress as one form of health hazard from fracking, and concerns about low birth weights and other adverse effects on both human and pet and livestock health have been reported, but deeper understandings of cultural constructs of health and bodily harm within a wider societal and political context associated with fracking are not yet well developed. This paper presents a cultural and risk analysis of health concerns of groups of diverse participants in US and UK deliberative workshops on shale oil and gas development convened in late 2014 in 'upstream' locations in both countries that were not yet experiencing such development but where future development was under discussion. This study reports on views workshop participants from differing social, geospatial, and geopolitical locations employed in considering fracking's potential effects on health, harm, safety, and bodily resilience and vulnerability in the face of water contamination, their foremost concern. The talk explores perceived boundaries between human, animal and environmental health, and their implications for trust, governance and risk communication. These ideas in turn are argued to reveal deeper reflections about embodied risk and its diverse health trajectories.

T2-B.1 Hartnett, E*; Wilson, M; Comer, N; Auld, H; Sparling, E; Smith, BA; Risk Sciences International; Public Health Agency of Canada; ehartnett@risksciences.com

Exploring Climate and Climate Change Impacts on the Risks from Drinking Water

We developed a quantitative risk assessment model for the assessment of risks from drinking water considering the impact of climate change in small communities across Canada (including First Nations). The impacts of drinking water quality on the population served by the drinking water source are estimated in terms of the burden of disease (DALYs) in the population from exposure to multiple microbial hazards in treated drinking water. The model is built to assess the impact of climate and climate change on human health and community water safety, as measured by shifts in projected DALYs across three time horizons: the present, the 2030s, and the 2050s. Components incorporated into the model include weather factors (projections of precipitation and temperature), wildlife, and infrastructure resiliency impacts on drinking water contamination and subsequent risk and burden.

W2-H.2 Hartley, KT; LSP Group LLC ; khartley@lspgrp.com
Molecular variability data streams are driving risk assessment changes for regulatory decisions on precision medicines and for personal injury lawsuits

New streams of molecular data increasingly reveal significant molecular variability within both populations and individuals, and are driving changes to risk assessment frameworks for both regulatory agencies and courts. The presentation will include a case study of drug agency decisions on requests for approvals of new "precision medicine" therapies and diagnostics. It will show that current and future requests increasingly are or will be based on "small n" sets of data that show the presence of an objectively observable molecular variable viewed as a proven or plausible part of a disease process or a treatment outcome. In response, agencies have implemented new classifications and frameworks for accelerated review based on results from studies of outcomes in cohorts selected for the presence or absence of particular (e.g. particular mutations). Often, approvals are conditional and require continuing development and evaluation of additional evidence. Thus, agency risk assessment methods have changed, and more changes are being requested by groups with relevant interests and expertise. Similarly, courts are receiving increasing requests for use of relatively small sets of molecular data as part of expert testimony and related legal arguments in personal injury lawsuits involving alleged "toxins." As a result, courts are receiving and acting on more requests for epigenetic and genetic testing or other investigations intended to investigate molecular variables that may render a particular person more susceptible to one or more types of disease, and/or may help to explain different outcomes observed in older cohort studies. Some requests also extend to information about family members other than the claimant. Moreover, researchers are increasingly identifying molecular "signatures" for pathways to disease, and often shed light on one or more "causes" of disease. These types of data drive requests for changes to legal frameworks for assessing diseases and causation.

P.33 Hatami, P*; Mitchell, J; Nejadhashemi, AP; Gibbs, C; Rivers, L; Michigan State University and North Carolina State University; pouyanhb@msu.edu

Developing a Predictive Model to Detect Mishandling in the Self-reported Water Discharge Data

The National Pollutant Discharge Elimination System (NPDES) regulates the level of pollutant discharges from point sources into the waters of the U.S. in order to protect public health and the environment. However, the NPDES program relies heavily on self-reported data without robust platforms to assess the integrity of that data, which could pose risks with adverse water quality impacts. Therefore, the need for data-driven methods to support regulatory enforcement is an important area of research. The goal of this study is to build a model capable of detecting fraudulent or mishandled data from wastewater treatment plants based on self-reported discharge data from one state environmental agency. Longitudinal data for water quality parameters like dissolved oxygen, nitrate, BOD, and phosphorus over several years were incorporated in a correlation analysis with precipitation and climate data. Based on the correlation analysis, causal statements were identified, which could subsequently be tested using stochastic regressors through regression analysis or structural models where appropriate mechanisms are well established. Hence, the final models will be able to estimate plausible probability distributions for dependent water quality parameters given a set of probability distributions for independent variables. Validation of the models is facilitated using methods of cross validation by splitting the time series across several years of self-reported data. Future work includes establishing thresholds for consistency with predicted distributions that can be used to support decisions about the veracity of future streams of self-reported data.

P.56 He, M*; Zhuang, J; University at Buffalo;
meilinhe@buffalo.edu

An Attacker-Defender Resource Allocation Game with Complementary or Substituting Effects

Many game-theoretic models have been developed to study the optimal government (defender) resource allocation strategies against the strategic adversaries (attacker). However, to our best knowledge, the complementary or substituting effects of the government's resource allocations have not been taken into consideration in the literature, especially facing with strategic attackers. This work fills the gap by developing a multi-stage game-theoretical model with a more realistic contest success function, which focuses on the optimal resource allocation to minimize the economic losses facing attacks by intelligent terrorists, taking into account the complementary or substituting effects. We study how the joint effectiveness of multiple security investments and the uncertainty of the interactions between different security programs influence the defender's strategy. In a sequential game model, we study the best response of the attacker for each potential defense allocation. Then we explore the dynamics between defender and attacker, and the corresponding expected payoffs. We provide analytical solutions to a single-target model and then provide numerical illustrations of a multiple-target model, using real data. We also compare the results of the models with and without consideration of the complementary or substituting effects. Our preliminary results show that the optimal resource allocation significantly depends on the joint effectiveness of security investment, and the defender would be worse off by not considering such effects. Finally, we study how the optimal strategies of each player and the corresponding probabilities of successful attack change when the parameters vary. This research provides some new insights into homeland security budget allocation through a multi-stage game model. Moreover, the impact of complementary or substituting effects on optimal budget allocations has emphasized the importance of developing a more realistic defense efforts model for use in homeland security budget allocation decisions.

T2-G.4 Henry, SH; Retired Food and Drug Admin.;
sarahalehenry10@yahoo.com

To Vape or not to Vape: Questions and Possible Answers

Many users of e-cigarettes have turned to these products in an effort to avoid the heart disease and cancer risks associated with use of smoking tobacco. But do e-cigarettes, which contain nicotine, help reduce use of tobacco products, or do they introduce new risks from flavoring ingredients or components of the vapor itself? The new (May 2016) Food and Drug Administration regulation bans the sale of e-cigarettes to anyone under the age of 18 and requires manufacturers to disclose their ingredients and submit the ingredients of their products to the government for approval. What will be the impact of this regulation? After some introductory remarks on the FDA regulation, the audience will be invited to ask questions and raise discussion points about the three preceding speakers.

M2-H.1 Heng, YK*; University of Tokyo, Japan and Visiting Fellow, University of St Andrews, UK; heng@pp.u-tokyo.ac.jp

Tools and Methods for Assessing Interconnected Risks

An ability to surmount and bridge different policy worlds and domains is especially important when assessing and managing interconnected risks such as infectious pandemics; climate change or cyber-security that can manifest and morph in different ways to impact upon societies. This paper first begins with a theoretical overview of attempts to better assess and understand complex interconnected risks. Drawing from the World Economic Forum's Global Risk Report 2015 'Interconnections Map'; the OECD Future Global Shocks report; Britain's Foresight Project and National Risk Register, and Singapore's Risk Assessment and Horizon Scanning programme, the paper highlights emerging methodologies and techniques such as crowd-sourcing and best practices for policymakers when dealing with complex interconnected risks. The paper concludes that a cross-sectoral response that blends cutting-edge futures analysis technologies with human cognitive responses best addresses the hazard-medium-consequence loop proposed in this panel.

W4-C.3 Henshel, DS*; Cains, MG; Alexeev, A; Hoffman, B; Indiana University and Army Research Laboratory; dhenshel@gmail.com

Modeling Cyber Security Risk Contributions From Human Factors

The current approach to cybersecurity risk assessment, as typified by the NIST guidance (2012, 2014), does not appropriately account for humans as risk factors. Human actors -- broadly represented as attackers, users, and defenders -- influence risk factors and characteristics as situations evolve, capable of effecting an increase in risk as well as mitigating it. For example, competent attackers introduce, and thus increase, risk to a cyber network through exploiting vulnerabilities and targeting associated systems. Competent defenders ostensibly mitigate, and thus decrease, risk in a cyber network. Incompetent defenders may mitigate or increase risk through applying ineffective measures to block threats or inappropriate steps to address intrusions. Competent (and security-aware) users may decrease risk to a cyber network, acting benignly with respect to the systems they use, while incompetent users may increase cybersecurity risk through introducing unintentional vulnerabilities or inadvertently providing an attacker with an avenue into the network. Insider threats, both from users and defenders, represent a much more purposeful and explicit cybersecurity risk to a network, yet defensive efforts don't usually plan for handling them. Over the past two years, we have developed a structured framework and ontology (Henshel et al, 2015, 2016; Oltramari et al, 2015) representing the human characteristics that contribute to humans increasing or decreasing risk in cyber networks. Using our framework for incorporating human factors into cybersecurity risk assessment, we present examples of models of different human factors contributing to and mitigating risk in cyber networks, detailing the potential impacts and effects of human actors on risk posture, strategy, and response. We propose a method to integrate these factors into a broader risk model in order to better assess and understand risk evaluation with respect to cybersecurity events.

P.46 Ho, WC*; Chou, YJ; Tsan, YT; Chan, WC; Lin, MH; Lin, YS; Chen, PC; China Medical University; whocmu@gmail.com
Impact of Temperature and Humidity on Stroke among Diabetes Mellitus Patients Using Statins

Cerebrovascular diseases have been the common cause of death globally during the past decade. Diabetes mellitus has been well-known risk factor of stroke. Person with diabetes mellitus tends to have increased risk for stroke. Statins are widely used medicine for their cholesterol-lowering effect in patients with hyperlipidemia to prevent vascular disease. However, among the noted pleiotropic effect of statins, anti-inflammation may reduce the risk of stroke. Previous studies reported that temperature and relative humidity are associated with stroke by changing blood viscosity or increasing plasma fibrinogen level that may lead to inflammation and contribute to stroke. The objective of this study is to investigate whether meteorological factor exposure and the statins use have the impact on stroke among diabetes mellitus population. This study used Longitudinal Health Insurance Database cohort applying for 2 million people with diabetes mellitus during the 1999- 2010 period. We collected and analyzed the incident of stroke in the diabetes mellitus cohort, and risk was measured by defined daily dose (eDDD) and diabetes mellitus severity. The meteorological factors including temperature and relative humidity data obtained from by the amount of 77 monitoring stations of Taiwan Environmental Protection Administration. The time stratified case cross-over approach was used to establish the groups of case, and controls 1:3 ratio. Conditional logistic regression model was used to estimate risks associated with average daily meteorological factors of daily air pollution and statin usage. Subgroup analyses by the level of statins intake were also further conducted. Finally, the potential interaction relationship of since the meteorological factor may trigger stroke, we will evaluate whether the statins interact with meteorological status in the risk of stroke. The expected impacts are preventive and therapeutic efficacy of statins that may modify the meteorological factor effects on stroke among the diabetes mellitus population.

WI-G.1 Hoang, M*; Gray, G; Department of Environmental and Occupational Health, GWU Milken Institute School of Public Health; gmgrey@gwu.edu

Understanding the Database Uncertainty Factor (UFD)

Regulatory agencies around the world develop human health non-cancer reference values (HHRVs) to guide decisions about health risks of specific chemicals. An HHRV is a numerical value indicating an exposure to a chemical that is unlikely to cause adverse effects. We have previously shown that different regulatory agencies, with the same toxicologic data available to them, derive different HHRVs for the same chemical with any two setting the same standard only 26% of the time with and more than 25% of the time values differ by more than an order of magnitude. Here we demonstrate that different uncertainty factors are among the key reasons for divergent HHRV values and most influential is the use of the database uncertainty factor UFD. We have found minimal guidance on the application of UFD so we undertook an empirical examination of its use by the US Environmental Protection Agency Integrated Risk Information System (IRIS). Specifically, for all chronic oral RfDs in the IRIS data base we identified the magnitude of UFD and the Agency's reported determination of their confidence in the critical study used in setting the RfD, the database for setting the value and the RfD itself. IRIS reports whether confidence in each of these factors is high, medium or low. We analyze the relationship between both the presence or absence of the UFD and confidence in the critical study, database and RfD and the magnitude of the UFD and confidence in the critical study, database and RfD with the hypothesis that lower values of UFD will be associated with higher levels of confidence in the specific study, database and RfD. We also examine application of the UFD over time. Preliminary results suggest that UFD use has been increasing over time in the IRIS program and is not tightly correlated to stated confidence in the critical study, database or RfD.

T3-J.2 Ho, SS*; Leong, XLAD; Looi, JM; Chen, L; Pang, N; Tandoc, E; Nanyang Technological University; tsyho@ntu.edu.sg
A Meta-Analytic Review of Factors Influencing Public Attitudes Toward Nuclear Energy

In comparison to fossil fuels that emit greenhouse gases, nuclear power plants are a cleaner energy source that could help to mitigate the problem of climate change. Despite this, the general public often associates nuclear energy with risks that include nuclear accidents, nuclear waste contamination, nuclear weapons proliferation, and many others. Media images of the 2011 Fukushima-Daichii nuclear accident have served to perpetuate a perception of nuclear energy as a risky technology. Furthermore, public perception of nuclear energy is shaped by a host of other factors such as trust in nuclear governing institutions, risk and benefit perceptions, knowledge, political inclinations, geographical proximity, and socio-demographic variables. Despite a proliferation of social scientific research that examine the social, cultural and psychological factors shaping public perceptions of nuclear energy in numerous countries, no meta-analytic studies have been conducted to examine the effect sizes/ strength of the relationships of each of these factors on public attitudes towards nuclear energy. In this study, we aim to review and compile a comprehensive list of factors and use meta-analytic tools to assess the relative effect sizes of each factor on public perceptions of nuclear energy and whether or not they are significantly related to the outcome variable. This analysis will flag out the strongest and weakest factors in predicting public opinion, and highlight the variation in the predictive power of the factors across Asia, Europe, and North America. Meta-analysis can systematically aggregate and compare findings from individual studies on a particular issue to examine the key hypotheses and central tendency of the outcomes. This method provides insight into the relative effect of independent variables and strength of variable relationships. The meta-analytic review will allow us to identify the limitations of existing studies, in which we can try to fill in the research gaps in future research.

M4-D.1 Hoffmann, S*; Aspinall, W; Cooke, R; DeDevelesschauer, B; Bhavelaar, A; Hald, T; USDA Economic Research Service; shoffmann@ers.usda.gov

WHO Global Burden of Foodborne Disease Estimates and Use of Expert Elicitation to Develop Global Foodborne Disease Source Attribution Estimates

The Global Burden of Foodborne Disease: Results and Lessons for Measurement and Management. Over the past 8 years, the WHO has been engaged in a collaborative scientific research effort to develop estimates of the global incidence and burden of foodborne disease for the first time in history. This talk presents the basic results from this effort and then focuses on the role expert elicitation played in estimating the probability that specific gastrointestinal diseases were foodborne and the likelihood that specific foodborne diseases were caused by specific food exposures. Without the emergence of the field of expert judgment under uncertainty led by leading scientists in SRA, this effort to assess the impact of foodborne disease on health globally would not have been possible. The study advances the field of expert elicitation by identifying and providing an initial treatment of problems that arise in applying current methods in large scale global studies.

W2-D.2 Hoffmann, S; USDA Economic Research Service;
shoffmann@ers.usda.gov

Application of Health-related Quality of Life Measures to Foodborne Risks

Use of Health-related Quality of Life Measures are growing in importance as part of analysis to support risk management in federal agencies. This talk looks at how HRQL estimates have been developed for foodborne illness risk in the U.S. It then looks at ways in which these measures could be used to address issues like prioritization of efforts to manage risks from very different hazards, such as chemical and microbial hazards in foods. It ends with an examination of lessons that should be considered in this effort based on a debate on the strengths and limitations of HRQL measures that is ongoing in the literature on health impact measurement.

P.122 Holley, JR; Cornell University; *jrh374@cornell.edu*

Risky discourses: framing as a function of accountability in climate change editorials

This study engages the social contingency model to examine the extent to which rhetorical elements of emphasis frames are engaged within newspaper editorials about climate change when authorship is known vs. not known (i.e., high accountability vs. low accountability). Five frames are examined across 304 articles from the Las Vegas Review-Journal and the New York Times: attribution of responsibility, human-interest, conflict, morality, and economic consequences frames. Accountability coping mechanisms and audience dispositions (i.e., conservative and homogenous; liberal and heterogeneous) are considered relative to the extent to which frame elements are used by authors. Findings reveal the general tendency for authors within disparate political environments to invoke the human-interest and morality frames when authorship is known vs. not known. For the Las Vegas Review-Journal, the conflict frame was used significantly more when authorship was not known. Findings suggest individuals may cope with accountability by extending impression management techniques to include discourse that may be considered socially or culturally favorable to audiences despite political dispositions.

W1-H.4 Holt, D*; Boudier, F; et al., ; Maastricht University;
f.bouder@maastrichtuniversity.nl

The patient voice in the 21st Century: are we listening?

Vaccination remains one of the most efficient tools for reducing the burden of infectious diseases and safeguarding health. However, public concerns about vaccine safety have been increasing, with negative impacts on vaccine acceptance. Vaccines are obligatory in many countries and recommended in others, thereby often managed in a "paternalistic" manner. Yet, it is not only the voice of the expert that is heard. Information can be disseminated via social media quickly and globally, with no checks on accuracy. Despite 20 years of research on vaccine risk perception and communication material written from the viewpoint of the patient or end-user is lacking or tends to be ignored or perceived as non-scientific, a misconception which is particularly damaging in the vaccine arena. The patient voice may be positive or negative, fragmented or complex. Therefore more attention to the patients' perceptions and behavior is becoming crucial in medical care and the 'voice of the patient', which includes healthy individuals receiving vaccines, needs to be heard, considered and addressed. The key to addressing any concerns could be to listen more and to develop a communication style that is trust-based and science-informed. Regulatory agencies are encouraging clinical and patient-reported outcomes research under the umbrella of personalized medicine, and this is an important step forward. This paper attempts to reflect the paradigm shift towards increasing attention to the patient voice in vaccination and vaccine safety.

W4-D.2 Homan, AC; U.S. Department of Transportation;
anthony.homan@dot.gov

Modelling the Risk from Railroad Tank Car Spills for Use in Policy Making

Increased transportation of oil in rail cars has increased the risk of derailments that result in spills. Most notably, the June 2013 derailment in Lac Mégantic resulted in substantial damages. Recent policy actions in response to this increased risk highlight the need for better tools to analyze the potential benefits of from these policy actions. In this paper, we model factors influencing both the annual number and severity of spills (spill size) resulting from derailments of railroad tank cars carrying crude and ethanol products (hazmat). We find that the annual number of hazmat tank cars was the most significant factor in modelling the annual number of spills. We also find that the number of hazmat cars in a train and train speed were significant factors in modelling the severity of the spill. Modelling these factors allows us to forecast both the annual count and the severity of spills based on different forecasts of the causal factors. This in turn allows us to estimate a range of future benefits from potential policy actions designed to mitigate derailments and spills. Doing so provides for a more rigorous discussion of the likely merits of any policy changes.

T3-H.4 Hosack, G*; Hayes, KR; CSIRO;
geoff.hosack@data61.csiro.au

Scientific risk assessment for synthetic gene drives: What does this mean and how do we achieve it?

Proposals for confined field trials of synthetic gene drives will likely require a scientific assessment of the ecological and human health risks associated with a deliberate or accidental release of the gene drive modified organism outside of the confines of the trial. This presentation discusses what it means for a risk assessment to be "scientific", and examines ways that ecological and human health risk assessment for gene drive modified organisms can achieve a high standard of scientific quality.

M2-I.4 Howard, J; National Institute for Occupational Safety and Health; jhoward1@cdc.gov

NIOSH activities in football epidemiology and safety

Professional football sports is an industry with risks to on-the-field players. NFL employee-players often suffer acute concussions, ligament damage, bone fractures, and chronic medical conditions such as obesity, cardiovascular disease, arthritis and serious neurodegenerative diseases like chronic traumatic encephalopathy (CTE). NIOSH published two reports showing that NFL players live longer than age-matched controls from the general population, but NIOSH observed higher death rates from other neurodegenerative diseases. The neurodegenerative mortality of this cohort is 3 times higher than that of the general US population; that for 2 of the major neurodegenerative subcategories is 4 times higher. NIOSH also showed that players who had a playing-time BMI of 30 or more had twice the risk of death from heart disease compared to other players. The study controlled for player size and position and determined that those factors are not the reason for this difference. Defensive linemen had a 42% higher risk of death from heart disease compared to men in the general population. The relationship between playing football, concussion, CTE and the connection to suicide continues to be a controversial topic in science and in the legal system. Those who support the connection refer to autopsy-based case reports that identified relatively large number of suicide cases among contact-sport athletes including football players. Among those who question the connection note that existing evidence in support of a relationship between CTE and suicide was rated very low in overall quality. In the 2012 NIOSH study of mortality, suicide in the cohort was significantly less than would be expected compared with the general US population. In 2016, NIOSH provided an update based on continued follow-up of the unique cohort of retired professional football players who played 5 or more year seasons. NIOSH reported that these players demonstrated no increased suicide risk.

W1-F.4 Howard, PM*; Arimoto, CA; ABS Group;
phoward@absconsulting.com

Strategic-level cybersecurity risk assessment for decision-makers

With the prevalence of information and cybersecurity breaches increasing, leadership can no longer turn a blind eye to the problem. Cyber risk once belonged only to the IT shop, but with a heightened awareness and increasing severity of incidents among industry and government organizations, senior leaderships can no longer avoid accountability. For these reasons, it is important for government leadership and the c-suite to understand the cyber risk present at their organization. A cybersecurity risk assessment that meets these needs will aggregate and prioritize risks, develop results that are comparable to other organizational risks, and communicate results in common language. This strategic-level assessment will enable senior leaders to prioritize risk management and strategic decisions across their portfolio. This project evaluated multiple appropriate assessment methodologies and ultimately selected a bow tie analysis as the most appropriate for a strategic-level assessment. Bow tie analyses are used to identify all of the potential methods, attacks, or initiators for an adverse event as well as all of the potential impacts that could occur following an event. During the presentation we will further discuss the applied methodology for conducting cybersecurity and other risk assessments, to include the assessment of threat, vulnerability, and consequence.

P.80 Hsing, HH*; Chuang, YC; Wu, KY; National Taiwan University; r03841029@ntu.edu.tw

Assessing the Health Risks of Gossypol from animal derived food in the Taiwanese population

In 2013, a food safety incidence occurred in some manufactures had illegally mixed cottonseed oil into other forms of cooking and edible oil. This event evoked public health concern of gossypol. As an anti-fertility agent, gossypol is a polyphenolic compound that occurs naturally in various parts of the cotton plant; highest concentration levels of this compound are in seeds. Cottonseeds are rich in protein, usually be used as livestock feed. There are several animal studies have investigated the tissue levels of gossypol in different species after feeding diets containing gossypol or cottonseed meal. This study aims to quantify concentrations of gossypol consumed by the general Taiwanese population through benchmark dose calculation, and the gossypol residues in edible tissues were established by using the Markov Chain Monte Carlo simulation (MCMC), and then assess the risk of gossypol to human health to general population. There is a clinical trial involving 151 men from various ethnic origins which is used to calculate the benchmark dose. The results of BMDL10 divided by uncertainty factors of human (10). The RfD were 1.96×10^{-5} mg/kg/day. There is a study of quantitative analysis of free gossypol in animal derived food in Sinkiang. The residual of gossypol in all kind of livestock tissues are estimate by MCMC simulation. The MCMC simulation would enable health risk assessment of general populations. The results show the average free gossypol residue level in chicken liver is 0.34 mg/kg and pig liver is 0.36 mg/kg. The Hazards Index for general population was greater than 1 and for young group were greater than 1 expect for one group; indicating that the residue of free gossypol in livestock tissues might pose adverse health effects. Though there are some limitations in this study, the exposure of gossypol through the consumption of food from livestock fed cottonseed products should be concerned in the future.

T-2A.4 Hu, X*; Surminski, S; Hall, J; Pant, R; University of Oxford; xi.hu@ouce.ox.ac.uk

Understanding the economic impacts of climate change in China and the implications on the Chinese infrastructure system: a case study of flooding

China is historically prone to flooding. In particular, its infrastructure system is often hard hit by these events. Climate change and the rapid rate of infrastructure development over the past few decades are expected to increase the vulnerability of the system to the impacts of these hazards. Understanding the nature of this vulnerability in the context of climate change is crucial for adaptation decision-making. Moreover, it is of global interest given the central role of Chinese manufacturing in global supply chains. The objective of this research is to understand the economic impacts of flooding on the Chinese economy and what the implications are for its infrastructure. Our research is based on empirical work, conducting a regression analysis of Chinese flooding data and 162,830 manufacturing companies in China. We use panel data between 2003-2010 with fixed effects to control for unobserved variables that, (a), vary across firms but not over time (here defined as firm-fixed effects), (b), and/or vary over time but not across firms (time-fixed effects). We find that flooding reduces output of Chinese manufacturing companies by 3.6% on average. This gives us an indication of direct economic impact of flooding on one of the most important sectors – manufacturing – in the Chinese economy. The empirical loss of output of the manufacturing sector from flooding is then used in an economic input-output framework to calculate the indirect economic impact on the rest of the Chinese economic sectors. Economic losses to infrastructure sectors such as energy, transport, water, waste and ICT are highlighted.

P.129 Huang, S-K; Jon, I; Lindell, MK*; University of Washington; mlindell@uw.edu

Tornado risk perceptions in response to warning polygons

The National Weather Service (NWS) has replaced county-wide warnings with smaller warning polygons to provide people with more specific information about tornado threats. Previous studies of strike probability (ps) judgments in response to tornado warning polygons have found that people infer ps is highest at the polygon's centroid, lower just inside the polygon edges, still lower just outside the polygon edges, and lowest (but not zero) in locations beyond that. However, it is unclear if a warning polygon together with additional information such as radar images of storm cells, would affect ps ratings. Thus, 167 participants were presented 23 hypothetical warning polygons in 3 different scenarios. In the first scenario (warning polygon only), the distribution of ps ratings replicated findings from previous studies. In the second scenario (warning polygon plus radar image of a major storm cell with a hook echo), ps was highest at both the polygon centroid ($M = 4.3$ on a 1-5 scale) and the polygon edge closest to the storm cell ($M = 4.4$, $t_{214} = .40$, ns), lower just inside the other polygon edges ($M = 3.5$, $t_{322} = 5.87$, $p < .001$), still lower just outside the polygon edges ($M = 2.7$, $t_{700} = 10.76$, $p < .001$), and lowest beyond that ($M = 2.3$, $t_{700} = 6.26$, $p < .001$). The results in the third scenario (warning polygon, major storm cell with hook echo, and two minor storm cells adjacent to the main storm cell) were similar to those in the second scenario. Overall, these data suggest people judge their risk more accurately by seeing a warning polygon in the context of a radar image of the storm cell on which the polygon is based. They also confirm that, contrary to NWS guidance, people perceive they are at risk of a tornado strike even if they are outside a tornado warning polygon. This information can help meteorologists to better understand how people interpret the uncertainty associated with warning polygons and, thus, improve tornado warnings.

M2-F.1 Huang, J*; Yang, ZJ; State University of New York at Buffalo; jialingh@buffalo.edu

Beyond "Under the Dome": Amplified risk perception increases knowledge and public engagement about air pollution in China

Air pollution is a major environmental issue in China, and it poses serious risks to public health. Based on the social amplification of risk framework (SARF; Kaspersen et al., 1988), the current study examines whether media, in particular, a documentary Under the Dome (UG), can amplify public risk perception about air pollution. Our ultimate goal is to see whether the amplified risk perception could subsequently predict the Chinese public's knowledge about air pollution, information seeking, policy support and mitigation behaviors. A random sample generated from a panel of Chinese residents maintained by Qualtrics was surveyed from May 5 to May 20, 2016. The sample ($N = 504$) was nationally representative on age, fairly representative on household income and geographic regions as compared to the 2010 Chinese census data. Major findings include: a) household income and education were positively related to participants' exposure to UG; b) participants' evaluation of UG fully mediated the effect of exposure on risk perception about air pollution, thus confirming the amplifying effect of media on risk perception; c) risk perception were positively related to information seeking, policy support and mitigation behaviors; d) information seeking was positively related to participants' knowledge about air pollution. These results suggest that UG indeed contributed to public risk perception about air pollution and has the potential to motivate the Chinese public to support mitigation policies and engage in mitigation behaviors. Our study can fill the gap in the current literature about media effect on risk perception that overlooks the role of the evaluation of media content in the amplification process (Renn, 1991). Also, it extends the application of SARF to air pollution, a prominent environmental issue in China and elsewhere. Finally, it provides practical implications for communication experts in China to encourage greater public engagement related to air pollution.

WI-B.2 Huang, Y*; Bui-Klimke, T; Gregori, L; Asher, DM; Forshee, RA; Anderson, SA; Yang, H; Food and Drug Administration; Yin.Huang@fda.hhs.gov

Geographic risk assessment of variant Creutzfeldt-Jakob disease and evaluation of blood donor deferral and risk mitigation options

To mitigate the risk of transfusion-transmitted variant Creutzfeldt-Jakob disease (TtvCJD), the FDA has, since 1999, recommended deferring certain blood donors in the US who traveled to Western European countries and may have been exposed to the bovine spongiform encephalopathy (BSE) agent, which causes human vCJD. Those recommendations warrant re-evaluation because the annual reported numbers of BSE and vCJD cases have abated markedly. We previously used an algorithm to rank geographic vCJD risk based on the country-specific vCJD case rate and the person-years of exposure of US blood donors in the country. The model showed that the UK, Ireland, and France have the greatest vCJD risk, contributing approximately 95% of total risk worldwide. We then estimated resulting risk reduction and donor loss should the criteria for donor deferrals be narrowed. We further estimated the additional effect of leukocyte reduction (LR) of red blood cells in reducing TtvCJD risk. We compared the risk reductions between two deferral policies: 1) Current donor deferral policy (cumulative duration of stay in UK ≥ 3 months, 1980-1996; most other countries in Europe ≥ 5 years, 1980-present); 2) Modified donor deferral policy (UK ≥ 3 months, 1980-1996; France and Ireland: ≥ 5 years, 1980-2001). The model estimated that deferring US donors who spent extended periods of time in the UK, Ireland, and France, combined with voluntarily implemented LR (currently 95%), would reduce vCJD risk by 89.3%, a reduction similar to that achieved under current policy (89.8%) but allowing potential addition annually of about 100,000 currently deferred donors. Our analysis suggests that a geographic deferral option focusing on three highest-risk countries would achieve a level of blood safety similar to that of the current policy.

P.98 Huang, T; Department of Urban Planning, National Cheng Kung University; tailinhuang@mail.ncku.edu.tw
Realizing Disaster Causation: Critical Realism as an Underpinning Philosophy for Disaster Risk Analysis

Disasters are increasing in terms of frequency and intensity. People seek to go beyond addressing merely the symptoms of disasters, but rather a treatment for underlying causes in order to prevent future disasters occurring in the same manner as before. Although common understanding exists that disaster and its risk are influenced by various factors and processes, there is still limited knowledge regarding the causation of those factors and processes. A disaster is often defined as a natural or man-made hazard resulting in "an event" of significant physical damage or destruction, loss of life or drastic change to the environment. The perception of disaster as an event implies that it has a point of beginning and an end. Therefore, we analyze the disaster with reference to the occurrence of the event, that is, before, during and after its onset. As illustrated in the critical realist framework of causation, the unsafe conditions of our societal system as a whole emerge out of the workings of the underlying structures. Given the unsafe conditions, the onset of a disaster is contingent on triggering hazards, be it natural or man-made. The unfolding process of disaster starts from problematic structures of the system leading to internal functional disorder, or dynamic pressures; that in turn manifest as symptoms or warning signs, which jointly determine the system's conditions at the time. Hazards, by definition, are things that can cause risk or danger; in critical realist term, hazards are the "other mechanisms" that triggers the escalation of the already unsafe conditions into a state of crisis or emergency. Hazards are not necessarily extrinsic. Depends on the coping actions, the outcomes of the crisis and emergency events eventually impact on the structures creating further underlying causes of the disaster. That, in turn, deteriorates the system structure and starts another disaster cycle.

P.81 Inoue, K*; Higashino, H; National Institute of Advanced Industrial Science and Technology; kazuya-inoue@aist.go.jp
Modeling study on the areal variation of the sensitivity of photochemical ozone concentrations and associated health impacts to VOC emission reduction in Japan.

For the purpose of reduction of photochemical ozone concentrations in Japan, measures to reduce 30 percent of the VOC emissions of point evaporation sources have been undertaken uniformly nationwide since 2006. However, the resultant effect of VOC emission reduction on ozone concentrations in 2010, the time of the target year, varied greatly according to different areas such as Kanto, Tokai, and Kinki area. This was likely because the sensitivity of ozone concentrations to VOC emissions varied with locations in which emission reduction was conducted. By using a chemical transport model, we quantitatively estimated the sensitivity of the regional average ozone concentration and associated health impacts (e.g. premature mortality) to reducing VOC emissions in different locations. Two indexes, called "ozone concentration reduction efficiency (= decrease in regional average ozone concentration / the amount of VOC reduction)" and "ozone health impact reduction efficiency (= decrease in regional total health impacts associated with ozone exposure / the amount of VOC reduction)", were calculated, by repeating the simulations with VOC emissions reduced in each specific place. The results show both indexes varied widely with different places in which emission reduction was conducted. In particular, "ozone health impact reduction efficiency" over coastal areas was over 10 times higher than that over inland areas. This means that we can get more than 10-fold higher health benefits with the same amount of VOC emission reduction by carefully choosing the locations in which we will reduce the emission. It was also found that the variation of the index of "ozone concentration reduction efficiency" among areas (such as Kanto, Tokai, and Kinki area) was consistent to that of the observed decrease in average ozone concentrations among such areas, implying the calculated areal variation of the effects of VOC emission reduction possibly occurs in the real world.

T4-E.4 Hudson, DW; Johns Hopkins University; dhudson6@jhu.edu
Probabilistic consequence analyses for concurrent accidental releases of radiological materials from multiple reactor units at a shared nuclear power plant site: safety goal policy implications

The US Nuclear Regulatory Commission (NRC) safety goal policy broadly defines an acceptable level of radiological risk to the public from potential accidental releases of radiological materials from commercial nuclear power plants (NPPs). This risk management policy addresses the question "how safe is safe enough?" in NRC evaluations of proposed regulatory actions that impose additional safety enhancements beyond those needed to ensure adequate protection. Two issues with respect to this policy have emerged in the wake of the 2011 Fukushima nuclear accident: (1) NRC applies the policy only to individual operating reactor units, even for the majority of NPP sites that include multiple collocated reactor units; and (2) quantitative health objectives used to evaluate NPP probabilistic risk assessment results to determine whether safety goals have been met are limited to average individual risk metrics for radiological health effects. Thus, there are no objectives that limit the residual public risk with respect to: (1) concurrent accidents involving multiple collocated reactor units; (2) measures of the total radiological detriment to society; or (3) measures of the non-radiological health and safety detriment to society from taking protective actions to reduce radiological dose. Probabilistic consequence analyses are used to advance of the state of knowledge about the spectrum of public health and safety consequences due to potential radiological releases from severe reactor accidents at NPPs by: (1) expanding the analysis scope to include potential concurrent releases involving multiple collocated reactor units; and (2) characterizing a broader scope of public health and safety consequences that include measures of total radiological detriment and non-radiological health and safety detriment to society. The implications of considering these additional contributions to residual public risk from NPP operations within the NRC safety goal policy framework are evaluated.

P.19 Janickova, M; Paris Dauphine University ; marketa.janickova@dauphine.eu
Enterprise Risk Management Implementation after Organizational Crisis: Opportunity to build a resilient structure in a multinational company

In Multinational Companies (MNCs) major challenges and crises often dramatically impact their organizational systems. This is largely due to risk management systems that are ineffective in anticipating uncontrolled events. The starting point of our research is the literature on MNC Structural Change (Chandler, 1962, and Mintzberg, 1979) followed by the more recent integrated approach called Enterprise Risk Management (Bromiley, 2015; Power, 2009, 2007; Mikes, 2014, 2011, 2009). Indeed our literature review highlights that the new topic area in research literature that is Enterprise Risk Management (ERM) needs further empirical shaping. Moreover, we identify in the previous literature a lack of consensus on ERM building in practice which reveals an unexplored gap between key concepts in organizational studies; especially between the dynamic of the organizational crisis, structural change and system of actors. To fill this gap we propose an Integrated Risk Management System Framework. We present a revelatory (Yin, 2003) one case study that allows us to examine the change in the organizational structure by involving ERM. Than our embedded approach is appropriate to examine risk structure and change in detail. We collect and triangulate data from multiple sources such as observations, semi-directed interviews and documentation. The data analysis supports our conceptual framework that leads to our main results. Our findings contribute to the development of Risk Management theory within Organizational Studies. We conclude with a discussion on effective ERM practices and conditions that could be further examined by future research.

T3-I.2 Jardine, CG; University of Alberta;
cindy.jardine@ualberta.ca

Perspectives of a Risk Communication Specialist

Risk communicators have long recognized that confusion around language and concepts is a major source of misunderstandings and 'mixed messages' in conveying and understanding risk information. Harmonizing terminologies will definitely help mitigate this problem. However, there is still potential for different understandings of basic terminologies (e.g. the many different interpretations of the word 'risk' itself) and of derived concepts related to risk assessment and management (e.g. association versus causation), both between various types of risk professionals and with other interested and affected parties. It is therefore important that we continue to remember the importance of the risk communication precepts of 'know your audience' and 'two-way exchange of information'. Taking the time to fully understand different perspectives of risk and understanding of terms will greatly reduce potential misunderstandings and facilitate productive dialogue on risks. If the ability to engage with various parties is limited, at the very least risk information and messages should be pre-tested to identify unrecognized areas of potential misunderstanding or confusion. It is incumbent upon all of us to constantly reflect upon our use of language and terminology to ensure we are all 'on the same page' as a primary means of facilitating better communication on risks.

T2-G.2 Jaspers, I; University of North Carolina at Chapel Hill;
ilona_jaspers@med.unc.edu

Effects of E-cigarettes on Respiratory Mucosal Immune Responses

E-cigs have rapidly gained popularity, particularly among young adults, yet little is known regarding their health effects. Although the FDA has classified many flavorings commonly used in e-liquids as "Generally Recognized as Safe" (GRAS) for oral consumption, most flavoring additives have not been evaluated for inhalational toxicity. While cigarette smoking is known to impair innate host defense responses, whether and how vaping e-cigs modifies respiratory immune responses is completely unknown. Using non-invasive sampling of the nasal mucosa, ex vivo analyses, as well as in vitro experiments our studies are designed to determine how vaping e-cigs affects respiratory host defense responses. Specifically, tissue samples obtained by superficially scraping the epithelial layer covering the inferior turbinates from non-smokers, cigarette smokers, and e-cig users were analyzed for changes in the expression of almost 600 immune genes. Our data confirm that smoking cigarettes causes suppression of several key immune genes in the nasal mucosa. E-cig users showed the same changes in immune genes as cigarette smokers as well as demonstrated suppression of several additional immune genes, suggesting even broader suppressive effects on respiratory mucosal immune responses as compared to cigarette smokers. In separate in vitro experiments, we examined the effects of flavored e-cigs on respiratory mucosal immune responses, specifically focusing on cinnamon-flavored e-cigarettes containing the flavoring agent cinnamaldehyde. Our data indicate that cinnamaldehyde-containing e-liquids have a significant negative effect on innate immune cell function. In addition, additional of cinnamaldehyde alone recapitulated the adverse effects on immune cell function in a dose-dependent manner. In summary, using translational human in vitro and in vivo approaches, our studies examined whether exposure to e-cigs has an immune suppressive effect on the respiratory mucosa and whether specific flavoring agents induce dose-dependent effects in mucosal immune cells.

W4-J.2 Jardine, CG*; Boudier, F; Driedger, SM; Turner, N; Gray, L; Heywood, A; Rath, B; University of Alberta;
cindy.jardine@ualberta.ca

Developing an International Strategy for Determining the Immunization Risk Communication Needs of Immigrant Populations

Recent international outbreaks of vaccine preventable diseases have been primarily linked to under-vaccinated communities. These outbreaks have emphasized the need to increase immunization rates internationally to improve disease control and reach herd immunity targets. Concurrently, many countries are experiencing increased immigration because of accelerated population mobility and displacement of populations. New immigrants and refugees are often particularly susceptible to vaccine preventable diseases because they may lack adequate immunization, may not have acquired immunity and/or may be more susceptible to disease because of poverty and underlying health conditions. An international team of risk communication and immunization experts has been assembled to develop a transnational research strategy to improve immunization rates of recent immigrants through more effective risk communication, and to identify collaboration opportunities for advancement of knowledge in this area. The objectives of the strategy and collaboration are to: (1) understand the knowledge level and perceptions of immigrant populations on infectious disease immunity and vaccines; (2) understand the reasons behind immunization decisions made by immigrant populations for themselves and their families; (3) determine the effect of different cultural perspectives on immunization decisions; and (4) use this information to develop innovative and targeted risk communication strategies that promote informed decision making. Research projects are being developed in specific countries under the auspices of this international and integrated strategy. However, addressing a risk communication issue from an international perspective presents unique considerations. Challenges include funding, different country contexts and priorities, varying degrees of baseline information and coordinating collaboration activities across different geographies. The process of developing this transnational strategy and collaboration, and addressing obstacles, will be discussed.

T3-E.4 Jensen, A*; Aven, T; University of Stavanger;
anders.jensen@uis.no

Reflections on hazard / threat identification in complex systems: inductive versus deductive approaches

Complex systems are characterized by non-linear cause and effect relationships, making it challenging to model and predict future hazards and threats. In this presentation we make some reflections on how to best identify hazards and threats for such systems. What are the approaches and methods available? How good are they? Where can improvements be made? Special attention is placed on deductive and anticipatory approaches combined with adaptive thinking and implementation of appropriate barriers.

W1-D.4 Jessup, A; Sertkaya, A*; Wong, H; HHS Office of the Assistant Secretary for Planning and Evaluation and Eastern Research Group, Inc.; aylin.sertkaya@erg.com
Calculating the Expected Net Present Value (ENPV) for the Development of a Rapid Point-of-Care Diagnostic (POC) Device for *C. Difficile* and Carbapenem-resistant enterobacteriaceae (CRE)

The problem of antimicrobial resistance is a serious threat to global health. Although development of new antibacterial drugs will help with this problem, resistance can develop easily if the drug is overused or misused. Rapid point-of-care (POC) diagnostic tests can play an important role in guiding appropriate antibacterial drug treatment as they allow clinicians to identify patients who need antibacterial drugs, and if so, which drugs might be appropriate. Additionally, rapid POC diagnostic tests can also be used to identify patients who have a resistant bacterial cause for their disease and allow for appropriate therapy and proper actions to prevent transmission to other patients. However, the potential of these rapid POC diagnostic tests to foster appropriate use has not been fully realized. Given the potential public health impact of rapid POC diagnostic tests, it is important to understand the factors that may lead to the success of a new test so that proper incentives may be put in place to spur innovation. We develop a decision-tree model to estimate the private and social returns to developing a rapid POC diagnostic test for detecting *C. Difficile* and Carbapenem-resistant Enterobacteriaceae (CRE), two bacteria of major public health significance. Using the model, we then examine the level of public sector incentives needed to stimulate the development of a rapid POC diagnostic test for detecting *C. Difficile* and another for detecting Carbapenem-resistant Enterobacteriaceae (CRE).

M4-C.2 John, R S; Univ of Southern California; richardj@usc.edu
Modeling the Value of Deterrence

I will present a decision analytic framework for quantifying the value of deterrence (VoD) for one or more adaptive adversaries. This framework allows us to partition the cost-effectiveness of particular countermeasures in terms of both decreasing vulnerability and decreasing threat. Vulnerability cost-effectiveness is decomposed to account for both increases in interdiction probability before an attack is executed and increases in resiliency following an attack. Deterrence cost-effectiveness is also decomposed to account for both threat reduction and threat shifting. Both vulnerability reduction and deterrence are conceptualized in terms of differences in Expected Utility for the Defender. The value of both vulnerability reduction and deterrence can be thought of as a special case of the value of partial control (VoPC). I will highlight the distinction between threat reduction without substitution effects and threat shifting. Quantifying the cost-effectiveness of countermeasures requires expert assessments of the likely behavior of adaptive adversaries in response to the countermeasures. The fidelity of my proposed value of deterrence analysis depends critically on knowing more about the psychology of deterrence.

M3-A.2 Johansson, J; Div. of Risk Management and Societal Safety, Lund University; jonas.johansson@risk.lth.se

Societal Consequences of Multi-Infrastructure Disruptions: Exploring Swedish National Critical Infrastructures

The society is highly dependent on services that critical infrastructures (CI) provide, especially those constituting the backbone of society - critical technical infrastructures. As past major events, such as Hurricane Sandy in 2012, the tsunami in Japan in 2011, and power outage in Europe in 2006, have revealed, extensive disruptions of the services CIs provide often entails large scale societal consequences and also clearly indicates the complexities involved. Hence, necessitating the need for holistic risk and vulnerability methods that address these system-of-systems and increase our understanding of their inherent limits towards failures and effect on society. Here the focus is on technical infrastructure disruptions and exploration of societal consequences from a modelling and simulation perspective. Three different Swedish infrastructures are modelled; a full-scale model of the transmission system, one of the most vital critical infrastructures, a full-scale model of the national railway infrastructure, and a representative model of the Swedish air traffic system. The functional dependencies of railway and airports upon the power system are explicitly modelled. To enable the exploration of societal consequences, two different proxies are used; an economic input-output model populated with Swedish national economic account data, and Swedish population census data to explore the number of persons at risk. Combining infrastructure and societal models enables the exploration of CI's risk and vulnerabilities, and in the end better guidance towards holistic mitigation decisions. Different perspectives towards this end is exemplified, concluding that it is of utmost importance to take a more holistic perspective on critical infrastructures risk and vulnerabilities, including the importance of explicitly addressing infrastructure interdependencies and including different measures of societal consequences.

M2-C.2 John, R S*; Cui, J; Nguyen, K; Rosoff, H R; University of Southern California; richardj@usc.edu

The Influence of Causal Attributions on Responses to Near-Miss Terrorist Events

We report two experiments investigating the role of causal attributions in determining responses to near-miss events. In the first experiment (N=528 students) involving a video news report of a commercial aviation IED attack scenario in the US, we manipulated the implied vulnerability (low, medium, high) and the causal attribution (internal, ambiguous, external) for why the (near miss) attack is not ultimately successful. Causal attribution for avoiding disaster directly influenced respondents' positive and negative affect. Furthermore, causal attribution moderated the impact of implied vulnerability of the near miss attack on respondents' perception of future vulnerability. Intentions to fly immediately after the attack were negatively affected by the implied vulnerability of the near miss attack, independent of the causal attribution for halting the near miss attack. A second experiment (N=773 mTurkers) was conducted involving causal attributions for both the initiation and the halting of a near-miss event at a nuclear reactor facility in the US. Three video scenarios varied in the causal attribution for a loss of coolant accident (LOCA) (system failure, natural disaster, terror attack), the causal attribution for halting the LOCA disaster (internal, ambiguous, external), and the level of uncertainty following the LOCA (low vs. high). Participants reported more negative affect, perceived risk, and avoidance behavior when the causal attribution for the LOCA was an earthquake or a terrorist cyber-attack than a computer system failure. Participants reported greater intention to evacuate if the accident was halted by an external or ambiguous cause than by an internal cause. Also, high uncertainty about the consequences of the LOCA resulted in greater negative affect, perception of risk, and intention to avoid nuclear power plants. Longitudinal structural equation modeling (SEM) is used to demonstrate the influence of causal near-miss attributions over time.

W2-J.1 Johnson, BB*; DeGarmo, DS; Decision Research; University of Oregon; branden@decisionresearch.org

Institutional stereotypes in the context of trust in, and cooperation with, organizations facing hazard management decisions.

The Trust, Confidence and Cooperation model of Earle and Siegrist is used here for two purposes. First, we assess its efficacy for understanding trust, confidence and cooperation (e.g., willingness to buy processed food; intention to adopt stricter food handling practices at home) when a hypothetical agency, corporation, or advocacy group is faced with a decision on whether to further reduce microbial contamination of processed foods, while also manipulating information valence (positive, negative, neutral) and familiarity with the organization. Second, we use the TCC model as a foundation for assessing whether stereotypes of societal institutions—e.g., of government agencies, corporations, and nonprofit advocacy groups that try to affect policy—significantly explain any added variance in these outcomes when TCC variables are controlled. Results indicate whether stereotypes are most influential on trust, if at all, when situational information is neutral/absent and/or when the organization is unfamiliar.

P.139 Johnson, BB; Decision Research; University of Oregon; branden@decisionresearch.org

Public cues to relative credibility of disputing scientists.

When large groups of scientists disagree over the causes or consequences of a phenomenon, public certainty, trust in science, or cooperation with expert advice can suffer. One little-examined issue in understanding public interpretations of and reactions to such disputes is the nature of cues laypeople might use to decide which position in the dispute is more likely to be correct (e.g., nanotechnology is on balance beneficial or risky; dietary salt intake should be reduced for those at risk or for everyone). Cues might include such categories as use of scientific method, credentials, values, experience, and the proportion of scientists on each side. Controlling for other variables that might critically affect public responses to a two-sided debate (e.g., ideology; prior position on the issue; understanding of scientific reasoning; science mistrust), this paper reports survey and experiment results that explore the effects of varied cues manipulated in mock news articles about real scientific disputes. Dependent variables include choices of the “correct position,” trust in the dueling scientists, and support for research funding, among others.

M2-A.2 Jones, KA*; Nozick, LK; Sandia National Laboratories; Cornell University; kajones@sandia.gov

Multi-hazard risk mitigation for electric power systems using investment optimization

Infrastructure owners faced with the difficult challenge of preparing for, withstanding, and recovering from both attacks and natural disasters must balance differing threats, vulnerabilities, and potential consequences to develop a single investment strategy. Metrics used to evaluate possible investment alternatives are often qualitative, and the degree to which each proposed mitigation investment will reduce risk from each threat can be uncertain. We develop a mathematical model to optimize investments in hardening measures against multiple threats. We integrate subjective elements of the problem into the optimization model using the Analytic Hierarchy Process (AHP). A case study focused on an electric power system is described. The case study illustrates a mechanism to integrate 1) downstream impacts on other infrastructures, 2) recovery over time, using repair stages, and 3) cost of investments and repairs into the analysis.

P.173 Joo, J; Mayeda, A*; Chakrabarti, K; Wang, T; Song, X; Hmielowshi, J; Boyd, A; Washington State University; amanda.boyd@wsu.edu

Factors that Influence Public Perspectives of Energy Development in Canada: Results of a National Survey on Climate Change and Energy Systems

Energy production is a critical component of the Canadian economy. Canada is not only the fifth-largest energy producer in the world; it is also one of the highest per-capita consumers of energy. This high production and consumption of energy results in high levels of greenhouse gas (GHG) emissions in Canada. There is an increasing concern about these GHG emissions and recognition that low carbon energy systems need to be developed and sited. The publics' opinions about energy systems can impact the development of these technologies. A survey was administered to examine public views on and understanding of key issues surrounding energy systems, climate change and government regulation. The survey was administered via Internet and phone to a representative sample of 1,479 Canadians. Results indicate that multiple factors influence public opinion about the development of energy systems. The majority of participants indicated that impact to human health and the environment were the most important factors when thinking about energy sources. Fewer responded that reliability of energy supplies or independence from other countries' fuels was the most important factor in their perspectives on energy. Trust in government to regulate technology and perceptions of industries ability to safely develop energy systems were shown to be important factors in the publics' attitudes towards these developments. We conclude by discussing the policy challenges associated with the energy systems development and provide directions for future risk perception research on climate change and energy systems.

M2-E.2 Jore, S.H.; University of Stavanger; sissel.h.jore@uis.no
Conceptualizing security risk – A discussion of the Value, Threat, Vulnerability definition of security risk

In Norway, several reports, guidelines and standards have been published where security risk is described as a combination of threat, value, and vulnerability. Security is understood as situations involving the potential occurrence of intentional, malicious events, such as terrorism. This perspective to security risk differs from well-recognized approaches to risk, which often describe risk as a combination of probabilities with associated consequences or consequences and uncertainties. However, the value, threat, vulnerability perspective to risk is problematic because of multiple factors. First, the perspective proposes a perspective to risk that varies from international risk standards. A myriad of different national perspectives may hamper international mitigation of global threats. Second, knowledge foundation and uncertainty associated with risk assessments are not included in this risk perspective. Third, excluding probability assessments do not solve the problem of mitigation of low-probability – high-consequence incidents. Frequency and expected likelihood could be important factors that in many cases should be visible to decision-makers. Last, according to this perspective the starting point of a risk analysis is to describe values. However, what a value is in the light of a security risk, such as terrorism, is much more challenging to describe than for safety risks. Symbolic values are often more important than economic or material values in such settings and this is not sufficient taken into account in this perspective. Additionally, values are not a straightforward parameter, but a factor that is depended on possible threats.

W3-J.1 Jovanovic, AS*; Renn, O; Linkov, I; Steinbeis Adv. Risk Technologies; jovanovic@risk-technologies.com
Use of indicators in the assessment of the resilience of critical infrastructures

The paper presents a new concept of using indicators in the resilience assessment of critical infrastructures (transportation, energy, water supply...). This concept has been developed as part of the new European project SmartResilience that started in 2016. The project focusses on "smart infrastructures", assuming that the modern critical infrastructures are becoming increasingly "smarter" and considering their interactions within a case study "smart city" in Germany. By means of conventional indicators and the indicators derive from the "big data" and "open data", the project will provide an answer to the fundamental question: does making infrastructures "smarter" increases their resilience? The indicators-based concept includes the following main steps. (A) Identification of existing indicators suitable for assessing resilience of SCIs. (B) Identification of new "smart" resilience indicators (RIs) – including those derived from Big Data. (C) Development of a new advanced resilience assessment methodology based on smart resilience indicators ("resilience indicators cube", including the resilience matrix). (D) Development of the interactive "Resilience Dashboard" tool. (E) Application of the methodology/tools in six case studies, integrated under one virtual case study, involving energy, transportation, health, water and others, are all integrated as a "virtual smart city". This indicator-based approach will allow benchmarking best-practice solutions for improving resilience of smart critical infrastructures against new threats and cascading ripple effects. The benefits will also be assessed from the point of view of insurance/reinsurance side. The consortium involves seven leading end-users/industries in the area, seven leading research organizations, and is coordinated by a dedicated European organization. Highly reputable external experts from all over the world will be included in the international advisory board.

P.167 Jore, S.H.; University of Stavanger; sissel.h.jore@uis.no
The security risk management regulation regime applied in the Norwegian context

In today's fight against terrorism, national security concerns cannot be reduced to external threats and handled exclusively by military means. Current counterterrorism strategies are based on building resilience through the involvement of civil society, including private and public organizations. In Norway, several regulations, standards and reports propose a risk-management regulation regime for mitigating against terrorism and other security threats. A risk-management regulation regime builds on the assumption that organizations have the necessary competence for knowing what type of risks the organization might face in the future, and know the appropriate means for how these threats should be met. This presentation aims to describe and discuss challenges and advantages with applying a risk management regulation regime within the area of security, which is protection from terrorism or other intentional, malicious crimes, in contrast to safety which implies protection from non-intentional acts. We identify challenges organizations face when applying the security risk regulation regime. The application of a risk management regulation regime is discussed in light of three Norwegian case studies; 1) the current aviation security regime 2) the rebuilding of the Government complex in Oslo after the bombing on July 22 2011, and 3) the implementation of security risk management in the Norwegian petroleum sector. We conclude that several aspects of a risk-management regulation regime are challenging from an organizational perspective, including the risk analytical methodology currently available to organizations.

P.64 Jovanovic, AS*; Quintero, FQ; Klimek, P; Markovic, N; Steinbeis Advanced Risk Technologies, Stuttgart, Germany; jovanovic@risk-technologies.com
Technology "Risk Radars": An example in the area of nanotechnology

The paper presents the development of the RiskRadar in the large EU project caLIBRAte ("Performance testing, calibration and implementation of a next generation system-of-systems Risk Governance Framework for nanomaterials"). The objective of the caLIBRAte project is to establish a state-of-the-art versatile Risk Governance framework for assessment and management of human and environmental risks of MN and MN-enabled products. After reviewing the "risk radar like" initiatives worldwide (e.g. in insurance industry), the paper will present the development of the caLIBRAte Risk Radar that is being largely based on the method developed in the iNTeg-Risk project (www.integrisk.eu-vri.eu). It helps identifying and monitoring emerging risks in the area of nanotechnology by considering the environmental, health/safety, socio-political, economic/financial, regulatory/legal and technological aspects. The indications about the possible risks are collected from different sources, such as Expert level: Platform for including experts, opinions and warnings; Scientific publications level (bibliometric analysis), Public and stakeholders' perception level (conventional sources; reports on surveys, focus groups and similar) as well as the social media/ networks. A special technique for automatic identification of new risks in the internet-based sources, developed for insurance industry and measuring singularity and ubiquity of new information, has been developed and deployed. The results of the identification and monitoring process will be used also for the predictive part based on the agent-based models (previously calibrated on the monitoring results).

T3-B.1 Junod, AN*; Jacquet, JB; The Ohio State University; anne.junod@gmail.com

Perceptions of environmental and social-psychological risk on the periphery of the Bakken Shale

Amid the rapid expansion of renewable and non-renewable energy development around the world, social scientists have become interested in how individuals and communities perceive of and react to various risks of development. Of recent interest has been how the perceived risk of disruption to closely-held social and environmental meanings and identities may influence attitudes and perceptions toward future energy development; less examined in this context are communities on the periphery of such development, where perceived and actual risks to social and environmental amenities are more nuanced. For this study, twenty-eight long-time residents from three Bakken periphery communities were interviewed to evaluate perceptions of environmental and social risk from drilling activities. Findings suggest many residents view their proximal location to the Bakken region as a social and economic "Goldilocks Zone," close enough to oil development activities to benefit from positive spillover economic impacts, yet far enough away to avoid long-term negative social impacts. Furthermore, participant responses suggest oil development activities in the Bakken region do not pose a threat to social or environmental perceptions in periphery communities, but instead may be compatible with existing place meanings and place-based identities. This research extends understanding of perceptions of risk in periphery communities where future energy development activities may occur.

M4-B.3 Kashuba, RO*; Morrison, AM; Palmquist, KR; Menzie, CA; Exponent, Inc.; rkashuba@exponent.com
Framework for Environmental Causal Analysis that Accounts for Uncertainty in Data Quality

In a world where data is more available than ever, there is an emerging imperative to develop a framework for evaluating the quality of different data sources and incorporating their relative certainty into decision-making. Types of data potentially useful for answering questions about environmental causality may include geo-spatial information, remote-sensed satellite reflectance, in situ measurements, laboratory tests, surveys or interviews, professional opinions and expert knowledge, citizen science or crowd-sourced information, and model simulations. However, each type of data is not necessarily equally informative for a particular causal question. Additionally, a retrospective causal analysis typically relies on data not collected specifically for that purpose. For example, environmental monitoring efforts may collect samples across different time and space scales, in different ways, depending on the goals of the monitoring program. This may involve using fixed station or random stratified sampling, different time intervals (e.g., 15-minute continuous monitoring versus once daily or monthly grab samples), and different kinds of sampling equipment (e.g., nets with smaller or larger size mesh), each with its own specifications and caveats. Different conclusions may result solely as a function of how data were collected. Therefore, an important, often overlooked, element of incorporating, comparing, and combining different types of data sources as part of the weight of evidence in causal analysis, is determining the relevance and reliability of each data source. We discuss a framework for context-based causal analysis that emphasizes (1) clearly defining your causal question(s), (2) determining what type of data would ideally answer your question(s) and (3) characterizing the quality and certainty of your data based on the difference between ideal and available data properties.

P.11 Kabir, E*; Guikema, SD; University of Michigan; ekabir@umich.edu

Comparison and validation of statistical methods for predicting the failure probability of trees

This paper examines disparate statistical methods for predicting the failure likelihood of trees in the face of storms and also comparing their accuracies. Being able to make accurate predictions plays a key role in helping arborists to do preventive measures with the aim of decreasing the chance of failure or even cutting down the hazard trees. The data used consists of four factor variables including the location of each tree, the tree species, whether the tree was pruned and whether there are any removed trees around the tree, and also two continuous variables including diameter at breast height (DBH) and height. Different data mining methods are used to predict the failure probability of trees. They include logistic regression, random forest regression, classification and regression trees (CART), multivariate adaptive regression splines (MARS), artificial neural network (ANN), Naïve-Bayes regression and an ensemble model. These models are validated through one hundred holdouts and the best ones in terms of accuracy are chosen for further analysis. Our results indicate that logistic regression, random forest and ensemble model of these two models predict the failure rate better than others.

M2-J.3 Kato, T*; Koriyama, K; Ito, S; Aso, H; Taninobu, M; University of Kitakyushu; tkato@kitakyu-u.ac.jp

Quantitative evaluation of organized disaster response capacity through functional exercises

Good cooperation and coordination among multiple organizations are key features of successful emergency management. Functional exercises are considered a tool for testing emergency plans and creating a basis for cooperation and coordination. However, the results of conventional functional exercises were not easy to evaluate quantitatively and there was some difficulty in determining the specific problems of coordination and cooperation. Our functional exercise solves this problem through four procedural steps: predetermination of an information processing and decision-making network that spans multiple organizations, specification of expected responses by each section of the decision-making network to various types of emergency incidents (exercise injects), measurement of response time for each expected response in a functional exercise, and analysis of response time records. We practiced this exercise method to test the emergency medical plan in Kitakyushu, Japan. The plan intends to create an orchestrated activity for hospitals, doctors, pharmacists, and government sections by organizing around 50 representatives from these organizations into five functional groups at the headquarters. The functional exercise was conducted in October and November, 2015. Thirty types of exercise injects were sent to the exercise room and response times of 43 expected responses by the groups were measured. Most exercise injects and participants were the same between the two exercises. It was revealed that misunderstanding of job responsibilities and obsolete email lists caused longer processing times in the first exercise but these problems were solved in the second exercise. The results showed that in the second exercise the participants gave a greater priority to finishing ongoing tasks rather than working on other tasks such as reporting task completion to other groups. This new exercise method succeeded in recording detailed information processing and decision-making activities.

W3-D.4 KAUSE, JR; Food Safety and Inspection Service-USDA; janell.kause@fsis.usda.gov

Evolution of QMRAs in food safety decision-making: 20 years after the Hazard Analysis and Critical Control Point rule

The U.S. Department of Agriculture, Food Safety and Inspection Service (FSIS) increasingly relies on the conduct and use of quantitative microbial risk assessments (QMRAs) to inform federal food safety policy. In 1996, FSIS implemented the Hazard Analysis and Critical Control Point rule to provide industry flexibility in meeting federal food safety standards with a focus on a systems approach to preventing the introduction of foodborne pathogen during processing. To supplement this regulatory shift, FSIS began conducting QMRAs to guide the establishment of industry performance standards to achieve national food safety goals. Over the past 20 years, the conduct and application of QMRAs process has evolved. QMRAs have become more tailored to meet risk manager and stakeholder needs, moved beyond being calibrated to being validated, become more transparent and user friendly with models and data publicly available, and are incorporating near time field data and information. Today, with the modernization of science and collection of whole genome sequencing data, there is also exploration of the value of omics information to further enhance QMRAs. The availability of FDA-iRisk, Combase, and consumption data have enhanced to potential for technology transfer and use of QMRAs to guide food safety decisions by the private sector. Also discussed, is the elevation and integration of FSIS's risk analysis process into the broader enterprise governance process to align better align organizational resources as part of the agency's multi-criteria decision-making approach to food safety. Other advancements include the successful engagement of stakeholders in the conduct of QMRAs, resulting in enhanced data sharing and collection, acceptance of regulatory risk assessment predictions, and use of these findings to motivate industry changes. This presentation explores the rapid evolution and future of QMRAs and the risk analysis process in regulatory food safety decision-making.

P.20 Kawasaki (Aiba), R*; Hiromatsu, T; Institute of Information Security; ritsuko@shihtzu.jp

Evaluation of a Model which Supports Decision-Making on Information Security Risk Treatment Using Statistical Data

This research aims to evaluate the effectiveness of a model proposed by Kawasaki (Aiba) and Hiromatsu (2014), which supports decision-making by top management on information security risk treatment. The model provides one of a suitable set of risk measures and the costs needed for the measures under the constraints of the total budget and the target level of information security risks of an organization. By using this model, top management can avoid to make a decision depending only on his/her experiences and intuition. On the other hand, the model has a difficult problem on evaluating its effectiveness. Although the evaluation needs the actual outcome of information security risk assessment and information security risk treatment, such information generally does not disclose because of security reasons. Therefore, this research focuses on using statistical data. First, how to apply statistical data to the model and the results of application are shown. Then, consider the effectiveness of the model by referring the results.

M4-A.1 Kavicky, JA*; Portante, EC; Petit, FD; Clifford, MC; Argonne National Laboratory; kavicky@anl.gov

Modeling Electric Power and Natural Gas Systems

Interdependencies: Application to Climate Change and Natural Hazards

Resilience is generally defined as the ability to adapt to changing conditions and withstand and rebound from the impacts of disasters and incidents caused by various hazards and threats. Argonne National Laboratory proposes a Resilient Infrastructure Initiative to leverage basic and applied science and technology to develop next-generation infrastructure resilience assessment models. One of the primary goals of the initiative is to develop an infrastructure impact analysis tool that integrates and automates the interactions of existing infrastructure modeling tools for anticipating both intra and inter-systems cascading and escalating failures. A unique approach is adopted to integrate existing and proven infrastructure models used for impact assessment analyses to foster and enhance the design of resilient energy systems. This process permits a cyclic and progressive expansion of analytical capabilities all framed under an overarching environment capable of representing an all-hazards scenario development approach. The integrated modeling approach employs a generalized framework that facilitates the integration of multiple disparate models into one virtual model without introducing major modifications to the original standalone models. Significant benefits of this approach are that the generalized framework permits the integration and automation of the entire resilience assessment process including threat and hazard identification and data acquisition, impact zone projection, simulation of the initial effects on the initiating infrastructure, evaluation of propagating effects within each infrastructure, and simulation of the influence of cascading effects of the disruption on interdependent infrastructure. The presentation will provide an overview of the Resilience Infrastructure Initiative, the framework methodology, and case study results that illustrate the combination of energy models using the proposed framework.

W2-I.2 Keller, C; ETH Zurich ; ckeller@ethz.ch

Communicating complex risk information to high and low numerates: The role of visual attention on relevant information and good instruction

Aiming at increasing risk comprehension, graphs are commonly used to convey complex risk information to lay people, in particular to low numerates. However, previous research indicates that high numerates better comprehend complex graphical representations than low numerates. The questions arise of why high numerates have better graph comprehension than low numerates and whether graph comprehension can be taught. Combining Shah and Freedman's (2011) theoretical approach to graph comprehension with Lipkus and Peters' (2009) information processing approach to numeracy we examined whether high numerates' graph comprehension might be explained by a relatively higher attention to graphical elements from which they expect to obtain the numerical information they need to understand the graph. An eye-tracker experiment was conducted (N=110). In the control group, participants received no instruction about how to read the graph (instead they received another text). In the training group, participants received written instructions on how to read the graph. The mediation model was significant: the higher the objective numeracy the higher the visual attention on relevant numerical and graphical elements in the graph and in turn, the higher the graph comprehension. The indirect effect of numeracy on graph comprehension through visual attention on relevant information was significant and did not differ between the control and the training group. However, condition had a significant main effect on visual attention and on graph comprehension, indicating that the training was successful. Results suggest high numerates have better graph comprehension due to greater attention to relevant numerical and graphical elements required to understand the graph than low numerates. However, this graph processing efficiency and the resulting good level of graph comprehension can be trained in high and in low numerates by means of good instruction. Practical implications will be discussed.

T3-C.1 Kennedy, AJ; Diamond, SA; Poda, AR; Weiss, CA; Brame, J; Torres Cancel, K; Melby, N; Lackey, T; Harrison D, Moser, RD; Rycroft, T*; Army Engineer Research and Development Center; Alan.J.Kennedy@usace.army.mil

Tiered Testing of Nano-TiO₂ Release Potential from Self-cleaning Concrete Under a Modeled Scenario

Testing methods and frameworks are needed to streamline environmental, health, and safety (EHS) testing of nano-enabled products. Screening “nano-unique” properties and toxicological effects has been elusive in research and problematic for regulatory science. NanoGRID is developed as an adaptive, tiered approach for generating relevant data to feed risk assessment and the process may terminate once sufficient information is collected. Nano-enabled product case studies from different structural categories are used to demonstrate the process. For example, TiO₂ in self-cleaning concrete provides a relevant in-use release scenario. The UV-photoreactivity of TiO₂ is purported to “depollute” concrete surfaces. TiO₂ may enter the environment during concrete production, transport, use, and weathering. The release scenarios included construction runoff, in addition to abrasion and weathering of cured concrete in a solar simulator. Weathered (UV exposed) and abraded particles were collected from cured concrete to determine potential releases from finished concrete infrastructure. Imaging of the abraded self-cleaning concrete revealed nano to micron sized TiO₂ occurring as isolated aggregates embedded in cementitious particles. Photocatalytic degradation of fluorescent dyes demonstrated that the abraded self-cleaning concrete retained phototoxicity. The toxicity of P25 to *Ceriodaphnia dubia* increased 70-fold under UV illumination. However, the 2% TiO₂ content of the self-cleaning concrete did not result in substantially greater phototoxicity relative to Portland Cement. To estimate environmentally-relevant exposure, a construction scenario (4,000 lbs concrete/yr; 5% waste) near Cleveland Harbor was used to populate the Army Corps Particle Tracking Model (PTM). Future work will improve TiO₂ phototoxicity dose response relationships and calibrate PTM for nanoparticles (agglomeration, attachment, etc.).

P.117 Khan, KJ; Vienna University; kghan01.kjk@gmail.com

Nuclear Risk Communication

This paper is based on the forethought that the lack of communication between the scientific community and the general public can possibly be bridged through an intervention by the development evaluation professionals who dare to enter in any critical situation to make an assessment on behalf of key stakeholders to provide as accurate an account as possible of the causes and effects given the circumstances. Development evaluators also act as ‘Change Agents’ who propose and lead to a new direction, particularly in the aftermath of a disaster to save the day. Independent evaluators enjoy the trust of the public vis a vis the government and the multinational corporations. Evaluators’ hub of activities lies mostly in the non-profit sector and their work touches the life of people at every level. Their code of conduct shields them from hypocrisy and gives them the courage to speak out in the best interest of people. Thus the idea to initiate a dialogue between the scientific community and evaluators for disseminating information and building knowledge basis for public use on issues like the nuclear risk is born. The paper deals with the vocabulary used in communicating and perceiving the risk associated with nuclear power plant in the aftermath of Fukushima Daiichi accident resulting from a massive earthquake and tsunami in Japan in 2011. Two brief activities have been undertaken: a review of news and articles in the selected newspapers issued on 11 March 2016 commemorating the five years of Fukushima Daiichi Nuclear Power Plant accident, and a brief survey with a group of development evaluators recalling the day of accident and their interaction with scientific community during the past five years. The learning from the ‘content analysis’ of these two activities is captured in the paper to be orally presented.

M3-D.2 Kenney, MA*; Gerst, MD; Wolfinger, JF; University of Maryland; kenney@umd.edu

Using Visualization Science To Diagnose And Improve Global Change Indicator Understandability

Indicators are variables that stakeholders believe summarize relevant trends. They have become an increasingly important part of continuous assessment of global environmental change. For indicators to be effective, they need to be understood by diverse audiences. Using visualization science, we have diagnosed and redesigned a set of global change indicators, showing how simple visual changes can lead to large improvements in understandability.

P.184 Kim, B*; Schuldt, JP; Cornell University; bk483@cornell.edu
Quantity Neglect in Judgments of the Ecological Impact of “Green” Consumer Goods

Over the decades, limiting consumption has been emphasized as a means to reduce environmental impacts and mitigate global risks from climate change. In this vein, consumption of pro-environment or “green” consumer goods is widely considered to be highly desirable, with research suggesting that it gives rise to a halo effect in judgment. However, little is known about the role of quantity in people’s judgments about the ecological impact of pro-environmental goods, an important omission given that it takes more resources to produce more goods—even “green” goods. To address this gap, we report on an experiment in which participants (n = 274) judged the total carbon footprint of a fictional family that was depicted as owning and driving either one Toyota Prius (a widely recognized hybrid-electric vehicle) or two Toyota Prius, depending on randomly assigned condition. In addition, we measured individual differences variables shown to predict the emergence of “green” halo effects in past research, including participants’ level of pro-environmental values (using the New Ecological Paradigm scale; Dunlap et al., 2000). Results revealed that whereas participants with stronger pro-environmental values (M + 1SD) rated the family’s total household carbon footprint as significantly greater in the two Prius condition than in the one Prius condition (thus accurately accounting for the quantity in their ecological impact judgments), participants with weaker pro-environmental values (M – 1SD) rated the family’s carbon footprint similarly regardless of the number of vehicles owned—demonstrating what we are calling “quantity neglect.” A follow-up study is currently underway that attempts to replicate and more systematically examine the utility of alternative theoretical accounts for this effect, including the greater likelihood of cognitive elaboration among pro-environmental individuals for whom the experimental scenario may have been deemed more personally relevant.

M2-H.2 Kishimoto, A; The University of Tokyo;
kishimoto@pp.u-tokyo.ac.jp

Interaction between extreme natural events and technological changes

While similar natural hazards occur repetitively, the expected damage will vary from event to event since the society changes continually. The concept of Natech (natural hazard triggering technological accidents) was created in this context. It follows that the unexpected damages naturally arise in each event, unless systematic risk assessment considering interconnectedness explicitly is carried out periodically. The Great East Japan Earthquake, as a "once a millennium" event, reminded the Japanese people of living in the long history of the Earth. We have never experienced the combination of tsunami and nuclear power plant or chemical complex until 2011. In a similar way, we have never experienced the combination of volcanic ash and modern-urban. This research focuses on large scale natural hazards, such as catastrophic volcanic eruptions, solar (super)flares, and asteroid impacts, and investigate how they are governed in Japan and in the global community. It will be observed whether these extreme natural hazards are recognized as possible hazards, their probabilities of occurrence are assessed, the possible damages are estimated and they are regarded as public policy issues in the global, national and important facility level. In this research, we deal with nuclear facilities in Japan as an important facility case study. The nuclear accident in Fukushima triggered an update of regulatory requirements to commercial nuclear power reactors, which covers volcanic eruptions, tornadoes, and terrorist attacks for the first time in addition to earthquakes and tsunamis. Although it is true that we cannot assume every possible extreme hazards, the question about how rare is rare enough to ignore still remains unclear in the public policy domain

M4-E.2 Klinke, A; Memorial University of Newfoundland;
aklinke@grenfell.mun.ca

Global governance on systemic risks as dynamic multilevel governance

An increasing challenge in world politics is to cope with human-induced systemic risks that are closely coupled and cross-linked with various functional areas and which cause-effect-relationships are stochastic and non-linear. They transcend national boundaries and are often underestimated in public discourses. However, they have the potential to destroy the anthroposphere. No nation-state is capable to handle alone the corresponding issues because the capacity of domestic politics and regulations is too weak to achieve eligible political outcomes that can guide and structure the global challenges. Current global risk governance institutions are largely incapable tackling such systemic risks because interactions between domestic and international structures and institutions are insufficient. My governance model is a departure from the domestic analogy to supranational multilevel governance, from a realist tradition in international relations, which focus on states as the primary actors, and from the concept of a centralized international structure headed by world organizations. In this light, I argue for dynamic multilevel governance that has the capability and power to reform and transfigure institutions, structure and agency, hierarchies, cultural fabrics, socio-technical systems, and infrastructures towards new social and political orders. I define this governance as a flexible and pluralistic form which constitutes itself as a network configuration of variable, multilayered and polycentric geometry. It conceives processes and institutions as distributed mechanisms of self-governing of exchanges among interests that is driven by individual and collective actors who consent to a plural and polyarchic network structure of authority and decision making in order to produce shared norms and rules. I conceptualize three major governance framework conditions, namely inclusiveness, adaptiveness, and distributed and differentiated deliberation. These capabilities produce reflexive authority with transformative and structuring power.

T2-J.4 Klima, K*; Bruine de Bruine, W; Dessai, S; Lefevre, C; Taylor, A; Carnegie Mellon University, University of Leeds, University College London; kelly.klima@gmail.com

Climate change concerns, weather expectations, and willingness to adapt

Adaptation will become necessary as climate change causes more extreme weather worldwide. People with lower climate change concerns may be less willing to act. Yet, people who dismiss climate change may still perceive that extreme weather events are becoming more frequent or more intense. It is possible that weather perceptions and change concerns are partially independent constructs, even if they do inform each other. In this research, we ask: 1) How likely do people think that wet, windy, and hot weather events will become worse by 2050? 2) How willing are people to implement climate change adaptation? and 3) Is willingness to adapt to climate change motivated by perceptions of extreme weather, independent of concerns about climate change? To answer these questions, we surveyed two areas with different political views on climate change and extreme weather events, the United States (474 participants) and the United Kingdom (607 participants). We find expectations for extreme weather and willingness to adapt vary between countries; US residents expect hot weather to worsen the most, and for UK residents the least. Willingness to adapt varies as well. Yet, for each type of weather, weather expectations and climate change concerns independently predict willingness to adapt, in the US and the UK. Our findings have implications for communications about climate change adaptation. Willingness to prepare for extreme weather may be higher among individuals with low climate change concerns if the term 'climate change' is omitted from communications.

WJ-J.3 Knoblauch, T.A.K.*; Stauffacher, M.; Trutnevyte, E.; ETH Zurich; theresa.knoblauch@usys.ethz.ch

Communicating induced seismicity risk including low-probability high-consequence events and expert confidence: the cases of deep geothermal energy and shale gas

Induced seismicity is associated with both, enhanced geothermal systems (EGS) and shale gas production. This risk includes low-probability high-consequence (LPHC) events that are rare and difficult to anticipate. Due to unpredictable reactions in the subsoil, experts can disagree about exact risk estimates. To inform deliberations about EGS and shale gas, such risk estimates and the related degree of expert confidence need to be communicated. In literature there is, however, limited empirical evidence on how to best communicate it. In our study we investigate how the broad public perceives various ways of communicating three facets of induced seismicity risk: risk in general, LPHC events in particular, and expert confidence. Our hypothesis is that different communication formats, such as quantitative or qualitative, lead to differences in the reader's reactions with respect to understandability, concern, and trust. We study whether different communication formats influence the respondents' risk perception of induced seismicity. We control how this relationship is influenced by numeracy, acceptance of the technology, and prior experience with earthquakes. We conduct an online survey with N=500 respondents. We use a full-factorial survey design in 12 groups, where each respondent receives one of 12 risk communication materials for both EGS and shale gas. Our findings provide the first empirical test of risk communication for induced seismicity. We expect our results to inform a transparent discourse about risks when discussing, implementing, and operating EGS and shale gas projects. Nevertheless, a successful risk communication depends on more than the exact wording. For this reason, our future research will extend towards stakeholder engagement and the design of the siting process.

P.199 Kobayashi, N; Tanaka, S; Ikarashi, Y; Hirose, A*; National Institute of Health Sciences; norihiro.kobayashi@nihs.go.jp
Developmental toxicity assessment of various sizes of multi-wall carbon nanotubes in mice after repeated intratracheal instillation to initiate grouping and read across

Grouping and read across are necessary and appropriate tools for filling data gaps in the hazard assessment of manufactured nanomaterials. Some studies have reported that maternal exposure to nanomaterials, including carbon nanotubes, may induce teratogenicity. In order to initiate grouping and read across for filling data gaps in the developmental toxicity including the teratogenicity of multi-wall carbon nanotubes (MWCNTs) via airway exposure, we conducted repeated intratracheal instillation studies of various sizes of MWCNTs in pregnant mice. Four types of MWCNT dispersions were repeatedly administered to pregnant Crlj:CD1(ICR) mice on gestational days 6, 9, 12, and 15 at dosages of 4.0 mg/kg/day. Ten pregnant mice per group were dissected on gestational day 17, and then developmental toxicity was evaluated.

T3-B.4 Kokotovich, AE*; Andow, DA; University of Minnesota; koko0013@umn.edu

Improving invasive species management using risk analysis: the case of Asian carp

Contemporary invasive species issues are increasingly characterized by complexity, uncertainty, and conflict, and, as a result, they are well situated to be addressed using risk analysis. Case studies are needed that explore how to integrate risk assessment, risk communication, and risk management to address the challenges posed by invasive species. Here we present the findings from a two-year project to improve the management of invasive Asian carp in Minnesota using risk analysis. First, we conducted in-depth, semi-structured interviews with 16 state and federal agency officials, stakeholders, and researchers to examine the tensions and conflicts hampering Asian carp management. Key areas of conflict and tension that emerged included: 1) scientific uncertainty concerning the impacts of Asian carp in Minnesota and the efficacy and non-target effects of possible management actions; and 2) social uncertainty concerning both the lack of societal agreement on how to respond to Asian carp and the need to avoid acting from apathy and/or fear. Second, to help reduce the uncertainty concerning the impacts of Asian carp, we conducted a risk assessment for the two most important species of Asian carp in Minnesota. We conducted 5 focus groups with state agency officials and stakeholders to garner a list of potential adverse effects, and then we held a two-day meeting with 22 state and national experts on Asian carp and Minnesota's waterways. Risk assessment participants characterized the likelihood that Asian carp would establish in select watersheds, their resulting abundance, and the consequence of potential adverse effects. Third, we conducted a risk communication meeting to share the results from the assessment and discuss their implications with a broad set of decision makers and stakeholders. We conclude our presentation by reflecting on the implications of this work for using risk analysis to address invasive species.

P.161 Kojima, N*; Tokai, A; Machimura, T; Xue, M; Zhou, L; Todoroki, A; Ebisudani, M; Osaka University; kojima_n@see.eng.osaka-u.ac.jp

Risk Governance through the Cooperation of a Risk Evaluation Technology and the Institutional System: attention to chemical stock in product

WSSD 2020 target requires higher level of chemical risk management in the world. To do so, much effort has been doing in the world. We try to build methodology to support this target through integrating risk evaluation and institutional options. Japanese chemical risk management have been carrying out through PRTR and Law Concerning the Examination and Regulation of Manufacture, etc. of Chemical Substances. These institutional systems mainly look at chemical flows management and in this research project, concept of stock management is introduced and the possible extension of the coverage of chemicals risk management will be discussed. We employ a couple of representative chemicals and manufactured good as examples and perform case studies. Point of arguments are stock management and its contribution to the risk governance. For estimating the annual flow and stock, we collected the in-flow of both the chemical and products, chemical emission from products, the wastage rate based on the life-time of products. The combination of chemical and products was based on the real situation in Japan. And for the pilot case studies below described, we chose the representative combination from the social issue. From the 3 case studies: sick-building syndrome by the adhesives from the plywood at home, ozone-depletion and global warming by the refrigerants from home appliance, and water contamination by the detergent from home and business facilities, we evaluated the human health risk or environment impact caused by the chemicals on the in-flow/out-flow and stock with each products since 2001 when started PRTR. From these results, we quantitatively clarified that the reduction of risks from the chemical stocks would be delayed for several years after the counter-measures for in-flow. This research was supported by the Environment Research Technology Development Fund (1-1501) of the Ministry of Environment, Japan.

P.95 Kokotovich, AE; University of Minnesota; koko0013@umn.edu
Delimiting the study of risk: risk assessment guidelines and values-based judgments

How values-based judgments are recognized and addressed has and continues to be an important topic within risk assessment. While values-based judgments are often seen as belonging only to the realm of problem formulation, there has been acknowledgment, going back to the "Red Book", of the role of values-based judgments – known as "risk assessment policy" – throughout the steps of risk assessment. Risk assessment guidelines are proposed as a way to rigorously deal with the unavoidable judgments in risk assessment, yet there has been a lack of scholarship reflecting on how values-based judgments within guidelines shape risk assessment. The work presented here begins by developing a conceptual model of risk assessment guidelines, scientific studies, and the conducting of individual risk assessments that acknowledges the role of values-based judgments throughout. I then present a case study of conflicting genetically modified organism ecological risk assessment guidelines to examine the implications of values-based judgments within guidelines. Specifically, I examine the differences between two competing risk assessment guidelines for assessing the potential impacts from insect-resistant genetically modified plants on non-target organisms. Utilizing document analysis and in-depth interviews, I found that judgments (e.g., concerning hazard identification, substantial equivalence testing, species selection, and indirect effects) delimit how each set of guidelines examines the risks from genetically modified plants and influence which scientific studies are called for. I conclude by arguing that inclusive, transparent, and deliberative scrutiny of risk assessment guidelines is needed to ensure that consequential judgments are realized and reflected upon. This is especially true when regulatory bodies decide upon guidelines for new stressors, such as plants with novel traits from new gene-editing techniques like CRISPR.

T2-B.2 Kopeck, K; Weir, MH*; Division of Environmental Health Sciences, College of Public Health, The Ohio State University; weirmarkh@gmail.com

Development of a Combined Growth and Persistence Model for Legionella pneumophila in Biofilms in Drinking Water for QMRA Models

Legionella pneumophila (*L. pneumophila*) has been a consistent water health hazard since its discovery. The lesser of the two symptomologies can present with flu-like characteristics and is typically termed Pontiac Fever. *L. pneumophila* can also present as a pneumonia, which accounts for the greater number of mortalities between the two symptomologies. Due to the ability for it to harm public health from both diseases *L. pneumophila* is considered a significant public health hazard. With the recent developments in Flint, MI it can also be observed that with deteriorating drinking water infrastructure risks of exposure to *L. pneumophila* may increase. It has been known that *L. pneumophila* can grow and persist in drinking water and other biofilms. Interacting with the biofilms' microbial ecology and surviving disinfectant residuals makes system-wide *L. pneumophila* control strategies challenging. The ability to model the growth and persistence of *L. pneumophila* in drinking water biofilms would be invaluable to quantitative microbial risk assessment (QMRA) models for drinking water systems. We present a model that has been developed specific to drinking water biofilms that accounts for persistence of *L. pneumophila* with respect to time and growth of *L. pneumophila* with respect to iron concentration and temperature. The model was developed as a non-linear multiple regression with interaction that is incorporated into a 2-dimensional (2D) simulation. The 2D simulation is an integral part of the model so as to remove the limitations of data resulting from experimental trials and allow for the modeling of real world conditions. Since this model is intended for use in QMRA models the use of a 2D simulation method is not a limiting factor rather can be considered a valuable addition to its structure. Development and examples of the use of this model will be presented.

T2-I.2 Kovacs, DK*; Austin, LC; Thorne, S; Evans, N; Moody, J; Decision Partners; Electrical Safety Authority; dkovacs@decisionpartners.com

Understanding Influences on Electricians' Decision making: Mental modeling for OH&S

Electric current is a leading cause of occupational fatality in North America, especially among electricians. In Ontario, for each fatal electrical occupational injury there are about 5 critical and 18 non-critical injuries. Analyses suggest that unsafe work practices and human error play a role in about 70% of fatal electrical occupational injuries, with most injuries to electricians happening while working on energized systems. To understand the cause of unsafe work practices and develop appropriate risk mitigation strategies, we used a mental modeling research approach to understand influences on safe work practice decision making and behaviour. We developed an expert model of these influences based upon relevant literature and an expert elicitation workshop with 19 domain experts. The expert model informed design of a semi-structured interview protocol deployed with 60 Ontario electricians to understand their mental models of influences on safe work behaviours and especially of the decision to "work energized." Results show that most electricians have chosen to work energized, many have, on occasion, unknowingly worked energized, and decisions leading to these two states take place in cognitively complex environments. Key influences on whether electricians knowingly or unknowingly work energized include: electricians' training, knowledge and experience; the quality of a hazard assessment (if done at all); their understanding of the task and the type, quality and condition of the equipment being worked on; and, the decisions and behaviours of others such as supervisors, customers and other trades at the work site. This study is the first to use a decision analytic mental models approach to understand influences on electricians' decision making and safety behaviours. Resulting insights are informing development of behaviour-focused risk management and risk communications interventions to reduce injury and death.

P.105 Korchevskiy, A; Chemistry & Industrial Hygiene, Inc.; akorchevskiy@c-ih.com

Asbestos risk assessment modeling: what are the keys to "Carolinas' mystery"?

Asbestos health risk assessment modeling significantly progressed during the last two decades, with several approaches proposed and validated (Hodgson, Darnton, 2000, Berman, Crump, 2008, Berman, 2011, 2013). However, all risk assessment models face an outlier problem with asbestos textile cohorts of South and North Carolina asbestos textile factories. For example, according to Darnton (2011), mesothelioma potency factor for South Carolina asbestos textile cohort was 17 times higher than for Quebec chrysotile miners; for North Carolina cohort, this ratio was equal to 10. We attempted to model mesothelioma potency factors for different types of fibrous minerals using log-log regression shape and various characteristics of fibers as independent variables. It was demonstrated that silicon oxide, magnesium oxide and iron oxides (mostly ferric iron) content of fibers along with their median aspect ratio were strong predictors of a mesothelioma potency level (measured based on Hodgson, Darnton method), with $R=0.98$, P

W4-G.1 Kratchman, J*; Wang, B; Gray, G; George Washington University, School of Public Health and Health Services; jkratch@gwu.edu

Toxicity Testing: Are Species and Genders Equally Sensitive?

As a convention, toxicity testing that informs human health risk assessments generally exposes multiple species and both sexes under identical conditions in evaluating a chemical. By defining the point of departure (POD) of a chemical as the lowest POD cross groups the apparent, but usually unstated, assumption is that any one of these groups might be more sensitive to the chemical than the others, and therefore testing different species and sexes would increase the sensitivity of the test. Across a large number of chemical toxicity tests, this common thought amongst scientists leads to the implied assumption that the sensitivity of test animals would be uniformly distributed. To examine if the sex/species groups are similarly sensitive we used a unique database constructed from data extracted from National Toxicology Program's (NTP) short and long-term technical reports for 41 chemicals. We computed PODs for all non-neoplastic lesions identified as pathologically significant in the NTP reports, final body weight and organ weight in the groups of male and female mice, and male and female rats exposed to the same chemical under identical conditions. For each endpoint or lesion associated with each chemical, best-fit benchmark dose lower limits (BMDLs) were modeled using the U.S. Environmental Protection Agency's Benchmark Dose Software, which resulted in over 3,000 final endpoints characterized by chemical, species, gender, and health effect. To evaluate the distribution of sensitivity, the species/sex of the animals showing the minimum best-fit BMDL was identified for each chemical. The most sensitive species/gender combinations were analyzed to determine if they are uniformly distributed amongst the chemicals sampled or whether a specific species or sex is most sensitive (i.e. has the lowest BMDL for a chemical) more often than expected. The results demonstrate that sensitivity is not uniformly distributed. This could have implications for toxicity testing and for risk assessment.

M3-F.4 Krewski, D; Ottawa University, Ontario, Canada;
cphra@uottawa.ca

Modelling U-shaped exposure response curves

Essential elements such as copper and manganese may demonstrate U-shaped exposure-response relationships due to toxic responses occurring as a result of both excess and deficiency. Categorical regression methods are introduced for simultaneously fitting excess and deficiency data in the form of a single U-shaped exposure-response curve, the minimum of which occurs at the exposure level that minimizes the probability of an adverse outcome due to either excess or deficiency. The use of a severity scoring system to place diverse toxic responses on a common severity scale permits the analysis of all available exposure-response data from multiple studies expressing multiple endpoints due to both excess and deficiency. The application of these new methods is illustrated using categorical regression databases developed for both copper and manganese.

T4-H.3 Kuiken, T; North Carolina State University;
tkuiken@ncsu.edu

CRISPR without Walls: Myths and realities about the democratization of genetic technologies

There is a revolution happening by “makers in biology.” This nascent innovation ecosystem thrives in community bio labs, which allow people of all ages to engage with biology and genomics in non-traditional settings, building on increasingly distributed and inexpensive biotechnologies. Meanwhile, one of the top science stories of 2012 was the furor about the wisdom of enhancing the transmissibility of the H5N1 influenza virus and whether do-it-yourself (DIY) biologists would cook up their own versions of the virus using information published in the academic press. Now, journalists and others are again pointing to the citizen science community amid fears about the nascent gene-editing technology CRISPR-Cas9. The DIYbio community developed codes of conduct in the summer of 2011. This culture of responsibility, the collaborative style of working, and the fact community labs are open spaces where everyone can see what’s going on reduce, if not eliminate, doomsday scenarios. This proactive culture of responsibility is an advance on the post-hoc scrambling that has often occurred within the scientific establishment. For instance, the US National Academy of Sciences began to seriously discuss the risks associated with gene drives only after experiments demonstrating the concept had been published. New governance models will be needed to establish appropriate norms for government funding and regulatory agencies, for researchers within and outside traditional laboratory settings, and for crowdfunding platforms. The DIYbio community, as stakeholders already addressing many of these questions, should play a role in a robust public dialogue about CRISPR-Cas9 and how new governance models can ensure safe, responsible scientific research. We are at a tipping point. We could help ensure safe and responsible research and build new innovation models or we could drive these emerging communities underground or out of existence.

T3-C.3 Kuempel, ED; National Institute for Occupational Safety and Health; ekuempel@cdc.gov

Evaluating the Current Evidence for Hazard- and Risk-Based OEL Categories of Nanomaterials

The goal of recent risk assessments of nanomaterials is to develop predictive models for occupational health decision-making based on hazard categories. Data needed for these analyses include quantitative dose and response endpoints across various types of nanomaterials, as well as physicochemical factors that may influence the toxicity (e.g., size, shape, chemical composition, solubility, surface reactivity). An ongoing NIOSH risk assessment strategy for nanomaterials involves the systematic review and development of datasets from studies in humans, animals and cell systems following exposure to nanoscale and microscale particles. Comparative potency analyses of nanomaterials to benchmark particles in tiered assays (in vitro, in vivo acute, in vivo subchronic/chronic) provide a framework for examination of endpoints of relevance to workers, including pulmonary inflammation and fibrosis, and the utilization of a broad array of experimental evidence. Challenges in these meta-analyses includes heterogeneity due to experimental design differences, limited reporting of quantitative dose-response data (especially for chronic health endpoints), few dose groups, and missing data for key parameters. Results of analyses of rodent data on acute pulmonary inflammation response to various types of nanoscale titanium dioxide, zinc oxide, and multi-walled carbon nanotubes included the identification of three nanomaterial hazard groups, which were approximately four to 200 times more potent (based on mass lung dose) than a fourth group with a microscale reference particle. Derived occupation exposure limits (OELs) based on such hazard groups may be useful for making initial exposure control decisions for nanomaterials without individual OELs. Disclaimer – The findings and conclusions in this abstract have not been formally disseminated by the National Institute for Occupational Safety and Health and should not be construed to represent any agency determination or policy.

WI-C.3 Kusumastuti, SA*; Rosoff, F; John, RS; University of Southern California; kusumast@usc.edu

An Interactive Real-time Behavioral Game For Cyber Security

This study describes an experiment in the form of a cyber security game with three players: attacker, defender, and user. Attacker is given 3 choices: attack the defender, attack the user or not attack anyone. The defender and user are given 2 choices, to defend either with standard or enhanced security. The outcome of the game depends on the combination of the three player’s choice of action. The likelihood of successfully defending from attacks for the defender and user may be enhanced by cooperating in making their security decisions, therefore there is an incentive to adjust one’s choices according to the other. In this game we observe whether the capability for the defender to see the user’s choice or vice versa would affect their own choice of security level. In addition, we observe if the attacker is sensitive to the level of coordination between attacker and user choices, particularly their likelihood to be deterred from making an attack. This experiment is implemented in o-tree, an online behavioral game platform that allows simultaneous interactive multiplayer games and uses online participants from Amazon Mechanical Turk.

W4-C.5 Kuypers, MA; Stanford University;
Marshallkuypers@gmail.com

Cyber Risk: Malicious Email Attacks at a Large Organization

Cyber security is a major concern to many organizations. Data breaches are frequently in the news and can pose serious monetary consequences to companies. Despite this, very little research has been conducted on quantitative methods for assessing risk in cyber systems. Organizations often resort to using imprecise heat maps or other qualitative decision support tools that can lead to suboptimal decision making. In this talk, we present a case study that assesses cyber risk with respect to the threat of malicious emails to a large organization. The model uses probabilistic risk analysis, real world data from a large organization, and newly developed cost models to quantify the losses stemming from reputation damage, business interruption, and other consequences in dollar terms. Further, the cost-effectiveness of several safeguards is analyzed, including email filtering and two-factor authentication to guard against credential theft. We find that the decision to implement email filtering is sensitive to many variables, while two-factor authentication is generally a good investment.

T4-H.5 Kuzma, J; NC State University; jkuzma@ncsu.edu
Systems-thinking about gene drives and risk governance: findings from a deliberative workshop

Scientists have proposed several reasons to use gene drives to engineer populations in the environment. For example, engineered drives could spread killer-genes to destroy unwanted pest populations, invasive species, or disease-carrying organisms. The Genetic Engineering and Society center at NC State, with partners from Arizona State and MIT, hosted a NSF-funded workshop "A Roadmap for Gene Drives" in 2016 that brought together over 70 stakeholders and experts to identify research, policy, and engagement needs for responsible risk governance. The workshop was unique in some important ways: 1) the group was larger and more diverse than previous workshops on gene drives, with participants coming from multiple sectors, over 10 different countries, and almost equally from the natural sciences, social sciences, and humanities; 2) it focused on the development of frameworks that could be helpful for unpacking the ethical, policy, and ecological risk issues surrounding different kinds of gene drives and pointing to key areas of uncertainty; and 3) it employed collaborative-mapping for incorporating considerations about risk governance into broader thinking about socio-ecological systems. This talk will present key frameworks and risk-governance needs identified at the workshop, as well as reflect on the workshop as form of anticipation and participation to inform the future oversight of gene drives.

M3-B.2 LaBarre, DD*; Ebel, EB; Williams, MS; Disney, WT;
Catlin, MC; Food Safety and Inspection Service;
davi.labarre@fsis.usda.gov

The Prevalence Risk Model as an Alternative to Traditional QMRA: Application to Estimating Human Foodborne Salmonella Illness Reduction after Implementing New Slaughter Inspection

Before instituting a new slaughter inspection system in poultry and market hog establishments inspected by the USDA Food Safety and Inspection Service, the risk to public health due to foodborne Salmonella from poultry or pork products was evaluated using FSIS and CDC data. The prevalence risk model developed by Ebel, Williams, and Vose was used to estimate the number of human Salmonella illnesses avoided if FSIS implemented a new inspection system. This model does not use a dose-response relationship because it relies solely on prevalence when the numbers of Salmonella are uniformly low across samples. This was confirmed by quantifying Salmonella for each sample using MPN analysis. A multivariate distribution for the production-volume weighted logistic regression model component provided the regression coefficients. Those coefficients were input into a model's Monte Carlo stage which included all the individual establishment data for Salmonella contamination and inspection procedures performed on each sample day, giving the prevalence estimate for each establishment day. The decrease in the prevalence distribution from baseline was represented by the ratio of the prevalence distribution with inspection components targeted for increase by incorporating individual Pert functions with parameters set to fit the expected increase from establishments currently implementing the new inspection system, divided by the baseline prevalence distribution as a function correlated with the numerator of the ratio. The number of illnesses remaining after implementing the new inspection system was found by multiplying the respective species ratio by the Salmonella annual illness distribution in humans from the same species food products. The expected number of illnesses avoided due to the new inspection system was found by subtraction of the resulting distribution from the original illness distribution.

M3-B.1 Lambertini, E*; Kowalczyk, BB; Thomas, EM; Ruzante, J;
RTI International; elambertini@rti.org

Comparing health risk impacts of qualitative and semi-quantitative microbiological criteria for Salmonella in poultry

Contamination of poultry products by bacterial pathogens has been responsible for numerous foodborne illness outbreaks and recalls. Despite several initiatives to improve the safety of poultry products, progress has stalled and public health agencies have reported little to no improvement in recent years. In 2015 the USDA-FSIS (Food Safety and Inspection Service) proposed new performance standards for not-ready-to-eat poultry to reduce the risk of consumer exposure to Salmonella and Campylobacter. However, these criteria are qualitative and based only on presence/absence, ignoring levels of contamination and dose-response relationships. Implementing a quantitative (level of contamination) performance standard may be more effective in identifying system failures, but public health benefits of this approach compared to qualitative standards have not been assessed. A risk assessment model was developed to: 1) evaluate the public health impacts of implementing semi-quantitative microbiological criteria for Salmonella in poultry, 2) compare public health impacts of performance standards of increasing degrees of quantitation and process coverage, in particular presence/absence tests vs. pathogen enumeration, at different points in the production chain, and 3) assess factors affecting estimate variability and uncertainty. The risk model, based on a Monte Carlo probabilistic framework, describes the U.S. poultry production chain from slaughter to consumer, including primary and secondary processing as well as consumer behavior. Distributions of input variables and model parameters were derived from microbiological surveys, validation studies, and published literature. Model outcomes were expressed in terms of both product contamination and disease burden. This study provides a comprehensive model to compare public health impacts of two different microbial performance standards for Salmonella in poultry. Outcomes will inform industry practices and provide a basis for future standard updates.

W2-B.4 Landis, WG*; Sawyer, K; (Author 1) Western Washington University (Author 2) The National Academies of Sciences, Engineering, Medicine, ; wayne.landis@wwu.edu
Requirements and schemes for the ecological risk assessment and adaptive management of gene drive organisms.

Within the next several years, governments and other authorities will likely need to decide whether to test and release gene-drive modified organisms into the environment. Gene drives are systems of biased inheritance in which select genetic elements are preferentially passed from parent to offspring, often at rates greater than the expected Mendelian frequency. The development of gene-drive modified organisms in the laboratory has been facilitated by the specificity of gene editing tools such as CRISPR/Cas9. Proposed uses of gene-drive modified organisms include the reduction (or control?) of host populations for a variety of diseases, the reduction and elimination (or control?) of nonindigenous species, and the adaptation of rare and susceptible populations to climate change risks due to such uses of gene drives have not been quantitatively evaluated as of this date. The NEPA process has been used to evaluate the release of genetically modified organisms for a variety of uses, notably disease reduction and to control pest species. However the NEPA process is not inherently quantitative. For gene-drive modified organisms released to the environment we propose that an ecological risk assessment design be used that incorporates clear cause-effect relationships including clear statements of probabilities and an assessment of uncertainties. As examples we will present a case study for disease control and another for the reduction of an invasive species on an island. The risk frameworks are based on the Bayesian network relative risk model for nonindigenous species although others may be applicable. Finally we will demonstrate how the ecological risk assessment can be part of a broader adaptive management process that incorporates governance, stakeholder engagement and the inclusion of alternative management scenarios.

P.180 Lange, SL*; Jones, L; Haney, JT; McCant, D; Schaefer, HR; Phillips, T; Honeycutt, ME; Texas Commission on Environmental Quality; sabine.lange@tceq.texas.gov
Analysis of the Corpus Christi Refinery Row Public Health Assessment

The US EPA, the Texas Commission on Environmental Quality, and the citizens and industry in Corpus Christi have spent decades working together to improve air quality, particularly in the area called Refinery Row. In August of 2016, the Agency for Toxic Substances and Disease Registry (ATSDR) released a draft public health assessment (PHA) for the Corpus Christi Refinery Row area in Texas. ATSDR analyzed 1980 – 2010 air monitoring data from the area, and provided conclusions about the public health risk to monitored chemical concentrations. Those conclusions comprised concerns about public health risk from exposure to a number of chemicals, including benzene, chromium, and particulate matter, among others; as well as discussions of increased cancer risk and birth defect prevalence. The objective of our analysis of the PHA was to compare standard toxicological and risk assessment methods with those used by ATSDR to determine the validity of their public health risk conclusions. We found significant differences between standard risk assessment and toxicological practice and the methods in the PHA, including using chemical concentrations measured on industrial sites for a public health exposure analysis; not considering sampling duration and exposure duration when calculating risk; using highest yearly mean concentrations for lifetime cancer risk calculations instead of data from the entire sampling period; and not appropriately communicating uncertainties of the birth defect and cancer risk analyses. Our own analysis of current monitoring data shows that there are no monitored concentrations of chemicals in this area that are above toxicity comparison values, so levels would not be expected to cause health concerns. A public health assessment that uses inappropriate risk assessment methods and improperly communicates uncertainties in the analysis can cause undue alarm in the population, and can damage hard-won relationships between the public and regulatory agencies.

P.34 Landquist, H*; Rosén, L; Lindhe, A; Hassellöv, I-M; Chalmers University of Technology; hanna.landquist@chalmers.se
VRAKA – a method for environmental risk assessment of potentially polluting shipwrecks

Shipwrecks around the world containing unknown amounts of hazardous substances pose an increasing risk of polluting the marine environment. Many dwell far below the sea surface and the amount of hazardous substances contained might be uncertain or not known. Mitigation operations of these shipwrecks are costly and therefore risk assessment and decision support for prioritization is needed. A holistic method for risk assessment of shipwrecks should encompass both the probability of a discharge and the consequences thereof. The aim of this study was therefore to develop VRAKA (short for shipwreck risk assessment in Swedish), a comprehensive method for probabilistic risk assessment of shipwrecks. The method consists of two parts: (1) is a tool to estimate the probability of a release of hazardous substances from a wreck. The tool is based on a fault tree model combining site- and wreck specific information with activities that might cause damage to the shipwreck. Input information to the fault tree has been derived by expert elicitation. The second part, (2) can be applied to estimate the consequences of a discharge and can be performed in three tiers depending on available resources. An initial approach is to combine the probability of release with the potential amount of hazardous substances contained. The next tier involves an environmental sensitivity matrix while the third tier combines an advanced oil spill trajectory tool with coastal sensitivity estimations. The probabilistic approach of VRAKA facilitated by the fault tree model enables a distribution of probable outcomes rather than a point value. Thus facilitating incorporation of the uncertainties involved in shipwreck risk assessment. VRAKA can deliver decision support regarding risk mitigation of potentially polluting shipwrecks taking uncertainties into account. It offers a comprehensive approach facilitating prioritization of shipwrecks for risk reduction measures enabling efficient resource use.

P.159 Larson, DB; Virginia Polytechnic Institute and State University; dlarso12@vt.edu
Health Outcomes and Congressional Control of Consumer Safety Regulations

In 2007, the U.S. was racked by a series of massive recalls of children's products. A year later, Congress responded by passing the Consumer Product Safety Improvement Act of 2008 (CPSIA). Though the name indicated a broad overhaul of consumer safety, most of the provisions focused on the regulation of children's products that had recently proven so hazardous. The federal agency charged with regulating these products, the Consumer Product Safety Commission (CPSC), was directed to issue new standards for a handful of products aimed at children, such as cribs, strollers, and bouncers, and given additional authority to implement them. Since the passage of CPSIA, CPSC has issued 18 mandatory product standards for children's products, marking significant progress toward the fulfillment of Congress' mandate. At the same time, three standards have been issued for non-CPSIA products, including those product categories CPSC leadership designated as priorities. This raises questions as to who should be setting these priorities: Congress as the representative of the people or CPSC as the specialists in product safety. The democracy versus expertise quandary is a longstanding one in public administration, but the standards issued, and not issued, by CPSC since the passage of CPSIA offer an opportunity to assess the current balance. To assess the impact of congressional mandates on consumer health outcomes, we will utilize injury data available through the National Electronic Injury Surveillance System, maintained by CPSC. We will examine the injury rates associated with each product category for which a standard has been issued as a result of CPSIA and assess whether they have declined since the enactment of the new federal standard. Additionally, we will compare the prevalence of injuries in these product categories to those categories CPSC has designated as priorities. This will provide an additional comparative opportunity between expert and congressional prioritization.

W2-C.3 Lathrop, JF; Decision Strategies, LLC;
jlathrop@innovatedecisions.com

Nuclear Autumn, Deterrence, Crisis Stability and Adversary Models, Tying Them Together To Address A Global Catastrophic Risk

We take a decision aiding approach to global catastrophic risks (GCRs). That is, we describe an approach to aiding decisions to address a GCR, as opposed to other approaches that focus on assessing, describing or understanding a GCR. We do that by identifying the strategically significant links in the probabilistic causal network from initiation, observables and risk-addressing decisions, to consequences. We model that causal network with what in some cases may be a very approximate, conceptual probabilistic risk assessment (PRA). We exercise that model to achieve three goals: 1.) Develop insights into the problems of deciding among risk-addressing actions; 2.) Make the problem and linkages from decisions to events to consequences more vivid and salient, to encourage action; 3.) Guide and encourage further research and development of processes to address that GCR. A key theme in this work: Epistemological Modesty, i.e. to be explicitly aware of what we don't know and can't know, and the consequences of that lack of knowledge for addressing that GCR. A key example: We have no way of knowing initiation rates for wars or terrorist actions, so aiding risk-addressing decisions in those cases must account for that lack of knowledge. We describe that framework by applying it to the specific GCR of inter-hegemon nuclear exchange causing a global catastrophe termed a "Nuclear Autumn," that is, a partial but still extremely devastating version of the Nuclear Winter projected as a consequence of a superpower nuclear exchange. That example will combine concepts of deterrence, crisis stability and adversary models to model the network from initiation, observables and risk-addressing decisions, to consequences. We then use that example as a basis for a discussion of concepts for a strategically coherent approach to addressing the risks of the several GCRs we face, e.g. inter-hegemon nuclear exchanges, pandemics, unbounded bio WMD terrorist attacks, and climate change.

T3-H.3 Leitschuh, CL; North Carolina State University and Genetic Engineering and Society Center at NCSU; caro.leit@gmail.com
Contrasting ecological risks and benefits of genetic biocontrol for invasive rodents

Despite making up only 5% of Earth's land mass, islands are home to 20% of bird, reptile, and plant species. Unfortunately, they are also the site of 80% of animal extinctions and 40% of endangered animal species, with invasive species responsible for 80% of island extinctions. Invasive rats and mice are present on 90% of islands worldwide and are implicated in most island extinctions. The only current effective technology for eradicating rodents from islands is the widespread and systemic use of toxicants. While they are lethal with the consumption of only a few grams and relatively easily dispensed, they are expensive and can have high failure rates. Additionally, toxicants pose a risk to other animal species on the island, including humans, pets, and livestock, making them challenging to use safely on islands with human populations. Gene drives, or genetic biocontrol, are an alternative being explored for invasive rodent eradication. Genetic biocontrol of rodents is species specific, more humane, and biologically safe to use around humans. Current technologies being developed use natural meiotic drive or CRISPR to influence the development of developing rodents so that all offspring are phenotypically male, creating a population that eventually cannot reproduce and dies off naturally. Implementing this technology would involve releasing laboratory-developed engineered mice into wild populations. While areas of ecological risk have been identified, a formal risk analysis has not yet been conducted in the potential implementation genetic biocontrol for invasive rodents. Some areas of concern, such as how any behavioral differences of the engineered rodents might impact the local ecosystem, are being examined in the lab. Other areas, such as implementing gene drive technologies in vertebrates and assessing the potential risks for the accidental or deliberate release of this technology into mainland mouse populations, still need to be addressed.

T2-A.1 Lei, X*; MacKenzie, C; Iowa State University and IMSE;
xlei@iastate.edu

Estimating Mean Time to Failure Based on Survey Data: Application to Hybrid Vehicles

Transportation infrastructure consists of mass transit systems, airports and seaways, and roadways. Estimating the reliability and vulnerability of these infrastructure components, especially for new technology, can pose challenges in part because of a lack of data. This talk will present a Bayesian method for estimating the mean time to failure (MTTF) of engineering components based on consumer survey data. The specific application is the hybrid vehicle battery in the 2004 Toyota Prius. Due to the combination of mechanical power and electric power that increases the complexity of the hybrid system, the risk of failure needs to be identified and mitigated. The reliability of the hybrid system is modeled using a fault tree for different operation modes, and the MTTFs of the main components are estimated. Bayesian analysis, based on a Markov Chain Monte Carlo simulation, is used to calculate the MTTF of the hybrid vehicle battery based on survey data. The methods presented in this talk can be applied to assess the reliability of other infrastructure systems.

M4-I.3 Lentz, TJ*; National Institute for Occupational Safety and Health; TLentz@cdc.gov

Drivers for Occupationally-Focused Cumulative Risk Assessments

Ongoing and future efforts to assess risk due to aggregate exposures and cumulative risks may lead to more inclusive and better defined representations of conditions that affect the health of workers. Identifying and characterizing the realities of mixed exposures to physical, chemical, biological, and psychosocial stressors which impact workers and the occupational environment will inform better understanding of disease determinants and allow for better risk management decisions. Cumulative risk assessment considerations are increasingly useful due to a number of factors including advances in surveillance systems to link multiple exposure measurements with health metrics, improved engineering controls to reduce or eliminate hazardous exposures, and societal and policy-focused health initiatives. Community-based initiatives for the cumulative assessment of chemical and nonchemical stressors in the environmental context may represent a class of approaches with the potential to extend to the evaluation of risk in the workplace. The concept of integrating the health impact of all stressors from occupational and non-occupational sources is consistent with the National Institute for Occupational Safety and Health Total Worker Health™ Program and Environmental Protection Agency initiatives relating to environmental justice. These and other drivers will be discussed in the context of their impact on occupational and environmental public health risk assessment.

WI-D.3 Lew, N*; Lavaty, R; Wolff, C; Peckham, J; Wood, D; Muth, M; Karns, S; Brophy, J; U.S. Food and Drug Administration; nellie.lew@fda.hhs.gov

Behavioral Responses to Health Information and Warnings

One of the most common risk-reduction strategies used by the Food and Drug Administration (FDA) to achieve its public health mission is to ensure that relevant health information and warnings about FDA-regulated products be disclosed to consumers and healthcare providers. Informational approaches, such as warning labels and nutrition labeling, are often used as a more flexible regulatory alternative to “command-and-control” approaches for addressing risks. From a social welfare perspective, informational strategies may be more efficient than “command-and-control” approaches in reducing risk because they reduce information asymmetry and allow individuals to decide for themselves how to best proceed. While informational approaches have the potential to be effective in promoting public health goals, compared with bans and other more restrictive types of regulatory approaches, their effects on actual behavior and consumption decisions are inherently more difficult to predict and to quantify ex-ante. We develop and apply a theoretical model of consumer response to predict the behavioral change brought about by healthcare information and warnings. In this model, we first estimate the effect of new health information about a product on consumers’ willingness to pay for that product. We then estimate the change in the equilibrium price and quantity demanded for the product. The model takes into account consumers’ absorption of new risk information, the change in perceived health cost or benefit of consuming a product, and spillovers to consumers who are not the target of the health information treatment. Disclaimer: The findings, interpretations, and conclusions expressed in this presentation are those of the authors in their private capacities, and they do not represent the views of the Food and Drug Administration or RTI.

P.21 Lewis, LP*; Petit, FD; Berry, MS; Argonne National Laboratory; plewis@anl.gov

1 Going further than Physical and Cyber Connections: Consideration of Logical Interdependencies

Infrastructure interdependencies are fundamental considerations when assessing regional resilience. Most assessments focus solely on physical, cyber, and geographic interdependencies existing between infrastructure systems. Although a fourth class of connections, the logical interdependencies, has been identified in scholarship, it has yet to be integrated in resilience and risk assessment methodologies; the term logical dependencies is widely used but it has suffered from little further refinement beyond its identification. The lack of deeper inquiry into the human interests and activities that define these logical dependencies, such as business continuity principles, economic market forces, societal aspirations, equal access, and distributive justice, is a significant deficiency in the holistic understanding of community resilience we seek to build. A multidisciplinary or “socio-technical” point of view is needed to fully elucidate the extensive range of influences acting upon infrastructure, from the individual asset to the sector level. Refining the concept of logical dependency and defining the elements characterizing this type of critical infrastructure relationship are essential steps in order to draw connections between infrastructure and its management, from the operator to the policy-maker. Novel assessments are being developed that incorporate the social, behavioral, economic, political, and legal forces that influence and are impacted by the strategic management of critical infrastructure. Developing this capability will enable policy-makers, economic actors, infrastructure operators, and community planners to draw more meaningful and actionable conclusions about the fundamental relationship between critical infrastructure sectors and their impact on community resilience. The objectives of this presentation are to define the concepts and propose a framework for identifying and characterizing system logical dependencies to enhance regional resilience.

M4-F.2 Lewandowski, TA; Gradient;

tlewandowski@gradientcorp.com

A Toxicologist’s View of Alternatives Assessment: Challenges and Opportunities

This talk will provide the toxicologist’s perspective on the focus alternatives assessments puts on inherent chemical hazard (as opposed to risk) and how hazard and risk assessment each can play a role in product stewardship. The speaker will also discuss the challenges of performing alternatives assessments in a number of topic areas including: Challenges in obtaining good quality data, challenges in evaluating data (e.g., using weight of evidence versus relying on worst case data), the potential role of high-throughput data and structure activity relationship (SAR) evaluations, defining the scope of the assessment, and making trade-offs among different concerns (e.g., among different human health concerns or between human health versus environmental concerns). Existing frameworks for conducting alternatives assessment will also be compared and contrasted, focusing particularly on the data and analysis requirements. Finally, the types of skills (beyond toxicology) that are often required in order to complete an alternatives assessment under regulatory programs such as that now being implemented by the State of California will be discussed. These various points will be illustrated with case examples of previously completed alternatives assessments.

P.82 Lewis, RC*; Singhal, A; Gauthier, A; Kalmes, R; Sheehan, P; Exponent, Inc.; rlewis@exponent.com

Proposed methods for characterizing dermal exposure to BPA for purposes of Proposition 65

Bisphenol A (BPA), a synthetic monomer that is widely used in polycarbonate plastics and epoxy resins, was recently recognized by the State of California as a reproductive toxicant under Proposition 65. The State has proposed for BPA a Maximum Allowable Dose Level (MADL) of 3 ug/day specifically for dermal contact with solid materials. This regulatory development affects a large number of industries that sell relevant products in California and, consequently, there has been much interest in understanding exposures via this route to evaluate compliance with Proposition 65. However, there is no standardized approach for estimating dermal exposure to BPA. Although previous approaches have been applied to phthalates, a group of chemicals that are also used in consumer applications and regulated under Proposition 65, those approaches may not be appropriate because BPA and phthalates have somewhat different chemical properties. Therefore, we evaluate various methods to characterize dermal exposure to BPA through use of different dermal wiping methods that simulate the amount of BPA that may be dislodged during specific product handling scenarios. We compare both wet and dry media as well as direct wiping and washing methods of skin after contact with products. Based on experimental studies involving several different consumer goods that contain BPA, our preliminary results suggest that a reasonable characterization can be made to assess dermal exposure. Because BPA is water soluble, the approaches used to simulate skin perspiration are expected to provide an upper bound estimate of dermal exposure. Results from the various approaches are used to determine a range of dermal uptake values and are compared to the Proposition 65 MADL of 3 ug/day.

P.179 Li, J; University of Science and Technology of China;
laj2336@mail.ustc.edu.cn

Modeling Growth Models of Media Attention and Public Attention during Disasters

Understanding the growth models of media attention and public attention during disasters is a key issue for disaster communication. Based on Gaussian Function, this study constructed three respective growth models to estimate the media attention and public attention growth model, and then we used the data from 41,016 news stories about 185 disasters that occurred in China from 2003-2012 to test the growth models. The factors that influence the likelihood of media attention include newsworthiness and disaster severity, and newsworthiness, disaster severity and GDP per capita of affected area can affect the likelihood of public attention. We also compare the strength of media attention with public attention, and results show that causation, newsworthiness, frequency can influence these differences.

M4-A.2 Li, B; Sansavini, G*; Reliability and Risk Engineering Laboratory, ETH Zurich, Leonhardstr. 21, 8092 ZÃ¼rich, Switzerland; sansavig@ethz.ch

Energy markets impact on the risk of cascading outages in power systems

Wide-area cascading events happened suggest that the power system is operating with reduced safety margins. The generation dispatches provided by current energy markets may increase the risk of cascading outages. This paper aims at estimating the risk of cascading outages associated with diverse dispatch solutions by integrating market-based power dispatch models and a cascading outages simulation. Two alternatives of the pool-based market-clearing model are considered: the decentralized dispatch and the centralized dispatch. In the decentralized dispatch, (i) the energy auction matches demand and supply, (ii) the achieved schedule is adjusted according to security constraints, and (iii) the market for ancillary services satisfies reliability criteria. The paper models the optimal bidding strategy for competitive suppliers, simulates the market clearing process, and manages the congestion through an AC optimal power flow which minimizes the re-dispatch of generation units. In the centralized dispatch, the energy auction and the ancillary services auction are conducted simultaneously with security-constrained AC optimal power flow. The risk of cascading outages stemming from diverse dispatches is estimated by cascading failure analysis model, which captures power system operations, protections, automatic regulations, and remedial action and represents combinations of several types of failures and interactions in blackouts. The model is validated through WECC blackout statistics. Computational experiments are performed on the WECC network. The results in terms of DNS illustrate that in high loading conditions, the centralized dispatch is associated with lower risks of load shedding. The effects of future system are assessed by increasing the generation capacity. In these conditions, the centralized dispatch can lead to more severe consequences with larger probability. The results provide insights on how the interplay between the infrastructure and the market structures impact the risk of cascading outages under different operating conditions.

P.178 Li, Y*; Odame, E; Zheng, S; Silver, K; East Tennessee State University; liy005@etsu.edu

Comparing Urban and Rural Vulnerability to Heat-Related Mortality: A Systematic Review and Meta-analysis

Studies of the adverse impacts of high temperature on human health have been primarily focusing on urban areas, due in part to the facts that urban centers generally have higher population density and are often significantly warmer than its surrounding rural areas (Heat Island Effect), and thus urban areas are considered to be more vulnerable to summer heat. However, heat vulnerability can also be affected by other population characteristics such as age, education, income and social isolation, which are likely to mark greater vulnerability among rural population. Here we explore the vulnerability to heat-related mortality in rural areas through a systematic review and meta-analysis of existing evidence. We searched studies that examined the association between high ambient temperature and mortality in rural areas published in English between 2000 and 2016. Heat-mortality effect estimates from selected studies are grouped into two: (1) Rural effect estimates (RR_{rural}) and their corresponding urban effect estimates (RR_{urban}), from studies that reported risk estimates for both urban and their surrounding rural areas (7 studies included); (2) Rural effect estimates only (12 studies included). For Group 1, we performed a meta-analysis of the ratio of the rural estimate to the urban estimate in order to compare the magnitude of effects in rural versus urban areas. For Group 2, we performed a meta-analysis of the effect estimates in rural areas only. The pooled ratio estimate (RR_{rural}/RR_{urban}) for Group 1 is 1.051 (95% CI: 0.954, 1.160), which indicates the rural relative risk is about 5% larger than the urban relative risk. The pooled estimate for Group 2 is 1.191 (95% CI: 1.13, 1.251). Our preliminary results suggest that vulnerability to heat in rural areas may be similar to or even higher than urban areas, indicating that more studies are needed to understand rural vulnerability to heat-related hazards.

WI-A.3 Lindhe, A*; Rosen, L; Johansson, PO; Norberg, T; Chalmers University of Technology; lars.rosen@chalmers.se

Probabilistic Modeling of Water Supply Safety Measures in Drinking Water Systems in Arid Areas

The arid and semi-arid climate of Botswana brings low rainfall and high rates of potential evapotranspiration, with limited surface runoff and recharge to groundwater aquifers. A continuously increasing water demand in this environment leads to a water stressed situation. Managed Aquifer Recharge (MAR) is considered, among other measures, to increase available water quantities for water supply and to improve water quality. To evaluate the potential for MAR in Botswana a probabilistic and dynamic water supply safety model was developed. The model uses statistically generated time series of source water availability, transient storages in dams and aquifers, and predicted water demands to simulate the magnitude and probability of water supply shortages. The model is capable of modeling future supply scenarios, taking into account transient water availability and demand in the North-South Carrier (NSC) water supply and distribution system in eastern Botswana. The NSC supplies major towns and cities in eastern Botswana, including the capital Gaborone. The model simulates the system and its components, including dams, aquifers, water treatment facilities, and transfer pipelines, for the period 2013 to 2035 (23 years), using one-month time steps. Several possible future MAR scenarios have been defined, with well-injection of treated surface water to groundwater aquifers. Major results of the study are: (1) severe water shortage is likely to occur already early in the simulated period if no measures are taken to increase water supply safety in the NCS; (2) implementation of MAR scenarios may be of significant importance in improving supply safety in the NSC; and (3) the demand forecast is the most sensitive parameter for assessing the probabilities of water shortage, especially for the years 10 and onwards during the 23-year simulation period. The water supply safety model provides important support to strategic decisions at the Department of Water Affairs (DWA) in Botswana.

M2-J.10 Linkov, I; ilinkov@yahoo.com

Risk and Resilience: Summary of the 2016 NATO Workshop

As society relies more upon integrated cyber-physical systems, the importance of the security of these systems increases. As new safeguards are developed and implemented, adversaries continue to develop novel ways to breach and disrupt critical infrastructure. While significant advances in the field of risk assessment have been achieved, risk-based solutions tend to focus on assessing and hardening individual component of complex systems under specific threat scenarios. Realization of the inability to predict threats resulted in significant interest in resilience-based management. In June 2016, a North Atlantic Treaty Organization (NATO) workshop was held in the Azores Islands on the subject of resilience analysis and thinking; the workshop was also supported by SRA. The workshop focused on ways in which military commanders and civilian decision makers could utilize resilience management in operations. Military and Civilian applications of resilience concepts are concerned with similar threats and need to be harmonized. Methods and tools that are able to reconcile conflicting information, as well as the complex context of the decision making environment will be discussed. Workshop participants were organized into four working groups, which addressed risk and resilience based management in (1) infrastructure, (2) cyber systems, and (3) social domains and (4) methodological tools for cross-domain integration. "State of the Science and Practice" reviews by these working groups along with other materials discussed during the meeting will serve as material for an upcoming book to be published by Springer. This session will present summaries from the working group and discuss lessons learned from this NATO Workshop, where such conclusions are equally relevant to SRA members for improved resilience thinking and management practices.

W1-G.3 Lipscomb, JC*; Garrahan, K; Nichols, T; U.S.

Environmental Protection Agency; Lipscomb.john@epa.gov

Choosing Effects and Points of Departure for Provisional Advisory Levels (PALs)

In 2002, the US Environmental Protection Agency (EPA) established the National Homeland Security Research Center (NHSRC) to provide science that supports EPA's Homeland Security responsibilities including rapid response to accidental and intentional releases of toxic industrial chemicals and chemical warfare agents. Because of the lack of exposure guidelines between 24 hours and the subchronic duration (90 days), NHSRC began to develop Provisional Advisory Level (PAL) values to provide such guidelines for air or drinking water exposures. While PAL values are quantified and presented as point values, they are neither promulgated nor regulatory. Rather, PAL values are to be used by incident managers to protect human health during evacuation, reentry and reuse activities. The PALs Standing Operating Procedure (SOP) borrows from the SOP for EPA's Acute Emergency Guideline Level program. PALs are established for durations of 24 hours, 30 days, 90 days and two years and for three tiers ranging from no adverse effect to potential lethality. PAL 1 values are intended to protect against adverse effects, even reversible ones; above PAL 1 values, the likelihood of progressively adverse health effects increases. PAL 3 values are intended to protect against lethality; above PAL 3 values, the likelihood of lethality increases. PAL 2 values are more nuanced. PAL 2 values are intended to protect against serious, irreversible or escape-impaired effects; above PAL 2 values, the likelihood of these effects increases. For PAL 2 value development, the choice of effect and point of departure can be complex, especially when studies from multiple applicable durations indicate several candidate effects with differing dose-response functions. This presentation will review the principle components of the PALs SOP and will focus on the selection of critical effects and points of departure for PAL 2 values for acrylonitrile, hydrogen sulfide and phosgene.

M4-H.1 Linkov, I*; Fox-Lent, C; Florin, MV; US Army Engineer R&D Center; ilinkov@yahoo.com

International Risk Governance Council Resource Guide on Resilience: Metrics and Approaches for Quantification

Resilience as a concept has been adopted by a variety of professional fields—, including psychology, engineering, medicine, and other social and physical sciences—and has also served as a tool to address risks in or related to cyber security supply chains, infrastructure, and climate change, among others. 2016 IRGC Resource Guide on Resilience (2016) is a collection of authored pieces to the topic of metrics and indicators for assessing and measuring resilience. This paper will review approaches to quantify resilience reported in the IRGC Resource Guide. The focus of the review will be on quantifying resilience at appropriate and operational scales, incorporating complexity and ultimately creating actionable recommendations to enhance resilience that are fundamental for improved decision-making and risk reduction policies. Individual metrics of resilience as well as approaches for their integration in indices, scorecard, matrices and decision models will be discussed. Advanced modeling approaches, including network science based models will be presented. Finally, we will introduce a tired approach to operationalize resilience in agencies that are responsible for disaster risk reduction from natural hazards with regard to property damage, diminished ecosystem services, and loss of life. The structure of the analysis consists of discrete tiers by which users can scale a resilience assessment and management action (simple to complex) relative to the scope and urgency of the risk and the capacity of resource managers (i.e. adequate funding and understanding) to improve system resilience and reduce risk.

P.200 Liu, XL*; Goodman, T; Fort Valley State University;

liux@fvsu.edu

Risk Choices of Farms under the 2014 Farm Bill

The enacted 2014 Farm Bill represented a fundamental shift of the U.S. agricultural policy. Traditional direct and counter-cyclical payments were replaced by three new support programs: Agriculture Risk Coverage (ARC), Price Loss Coverage (PLC), and Supplemental Coverage Option (SCO). These "shallow loss" programs and the other Pre-existing Federal Crop Insurance programs built a risk management safety net, affordable and universally available to farmers. The new Farm Bill had tremendous effect on the risk management choices of U.S. farms. The heavily subsidized crop insurance programs became a dominant force in risk management planning. About 90 percent of crop land was enrolled in these programs and higher levels of coverage were usually purchased. In contrast, traditional production risk tools such as diversification and shared leases, and marketing risk tools such as spreading sales and contract sales were crowded out to some extent. Other risk-sharing vehicles like Community Supported Agriculture (CSA) farm and Food Hubs did not rise to expected prominence, although they are effective both in mitigating risk and promoting the development of local communities. Based on USDA data and our observations, we examined the various risk management choices of farms, weigh the pros and cons of the heavily subsidized programs, and identified CSA farm, food hubs, organic farming as effective alternatives for farms, specifically for small-scale farms. In the long run, the federal farm subsidy programs should be designed to benefit the large number of small-scale farms; and the CSA, food hubs, and organic farming should receive more attention of the government for their key functions on risk mitigation and rural community development.

M3-E.2 Livingston, O*; Shabat, M; Cheesebrough, T; Department of Homeland Security; olga.livingston@hq.dhs.gov

Cost of Cyber Incidents

The DHS Office of Cybersecurity and Communications (CS&C) and the Office of the Chief Economist (OCE) within the DHS National Protection and Programs Directorate (NPPD) are researching the various costs of cyber incidents, in part to better understand the value of cybersecurity investments. To inform the analysis, NPPD is examining everything from the cost of containing malware to re-imaging a hard drive to the cost of data and functions lost in a breach to the cumulative impacts to the national economy. This presentation will describe NPPD's methodology for quantifying the losses from cyber incidents in an activity-based cost framework. The initial focus is on the cost of response and recovery at the level of various defensive measures, depending on the combination of method, target, and impacted assets. The activity-based cost framework is focused on associating specific response and recovery activities with the phases of intrusion, the relevant tactics, techniques and procedures, and the corresponding costs and required level of effort for response and recovery.

M2-I.5 Lobel, O; University of San Diego; lobel@sandiego.edu
Political and legal issues surrounding federal, state, or private governance of NFL risks

What can Congress, the states, professional associations, and others do to improve the health of NFL players? What would the political and legal impediments be to this? Beyond the conventional command-and-control model of regulation, lawmakers have been experimenting with new governance approaches, including more collaborative partnerships between private and public actors toward improved health and safety standards. These collaborative partnerships aim to involve employers, industry associations, employees, and employee representatives, as well as other stakeholders, for example, the medical community. In particular, the framework of enforceable partnership, in which the regulated writes its own code of practice and agree to follow it as the application of OSHA's General Duty Clause, may prove a useful model in the context of NFL health and safety. The goal is not to displace the judgment of the regulated entity but rather to support their decision making processes and responsible behavior. In general, the NFL is in a better position to determine the particular processes and standards needed for the safety and health of the players, but a requirement of disclosure and continuous improvement through enforceable partnerships could be a path for better safety and health. A new governance approach could also draw on the Players Association to aid monitoring and enforcement, building on the model of worker safety committees.

W1-E.2 Lofstedt, R; Kings College London; ragnar.lofstedt@kcl.ac.uk

Evidence based uncertainty analysis: What should Europe do?

In the summer of 2015 the European Food Safety Authority (EFSA) put forward a guidance document on uncertainty analysis for public commentary. The stated aim of the Agency is that once the guidance document is approved that: "...uncertainty analysis will be unconditional for EFSA panels and staff and must be embedded into scientific assessment in all areas of EFSA's work." (EFSA 2015a, p.1). The guidance document provides a rigorous overview of both how to understand uncertainty as well as how to integrate it with scientific advice as robustly as possible. In March 2016 EFSA published a refined version of this guidance and at the present time it is testing it with regard to a number of scientific opinions. In this presentation I discuss what EFSA should do now going forward, highlighting a number of key recommendations that were initially tabled in the European Parliament in May 2016.

W2-A.1 Logan, T*; Guikema, SD; Zaitchik, B; O'Meara, K; Liberman, K; Zou, C; Nichols, R; University of Michigan; tomlogan@umich.edu

Beat the Heat: A Statistical Analysis of the Urban Heat Island

Surface temperature is projected to rise under all of the Intergovernmental Panel on Climate Change's assessed emission scenarios in the Fifth Assessment Report. Heat waves are very likely to be longer and more frequent. Heat waves are the deadliest of the natural disasters, so high urban temperatures urgently need to be addressed. This study aims to contribute rigorous statistical methods, based on readily available data, to how policy makers and planners identify and predict at-risk areas within a city. Identifying which neighborhoods need attention will ensure appropriate distribution of resources. The initial city of interest is Baltimore, Maryland. We use geospatial data from demographic databases, infrastructure plans, and satellite imagery. The aim of is to predict satellite derived land surface temperature as a function of (a) biophysical parameters and (b) socio-economic parameters. As well as test hypothesis the effects of green space, water bodies, and impervious surfaces on land surface temperature, and whether there is a relationship between wealth and land surface temperature of a neighborhood. The models will then be tested on other cities to analyze their general applicability.

P.70 Lokhandwala, M*; Shevade, P; Nateghi, R; Purdue University; mlokhand@purdue.edu

Cooling Energy Analysis of Commercial Buildings in the U.S.

Over the past decade there has been considerable improvement in technology related to indoor climate control applied to commercial buildings in the United States. The focus of innovation in this area has been mostly to reduce energy consumption costs and associated CO₂ emissions, in order to regulate the temperature inside the built environment. Energy Usage Intensity (Energy consumed per square foot area) is a common bench-marking parameter used to compare the energy efficiency of buildings in the United States. We developed predictive models for cooling energy usage intensity of commercial buildings using the Commercial Buildings Energy Consumption Survey (CBECS) data to identify the main contributors to cooling energy loads. With the number of Cooling Degree Days projected to increase in the coming years, the results of this study can help in devising energy usage policies and also have great implications for future innovations in the field of cooling technology.

P.153 Lu, H*; Schuldt, JP; Cornell University; hl896@cornell.edu
When are climate victim portrayals persuasive? The interplay of perspective taking and social-identity cues

Findings from communication and psychology suggest that encouraging audiences to adopt a more empathic versus objective perspective while processing messages about victims may prove a useful persuasive strategy, by promoting an emotional connection between audiences and victims that motivates helping behaviors. At the same time, research in climate change communication reports differential effects of victim portrayals across political partisans in the U.S., where the issue remains highly politicized. Drawing on these findings, we explored the conditions under which taking an objective perspective regarding a climate change victim may prove more persuasive among a key audience: political conservatives and moderates. N = 502 U.S. participants read a modified news article about an expectant mother living in Puerto Rico who is worried about Zika virus—a vector-borne disease linked to climate change. Depending on condition, participants were instructed to adopt an empathic or objective perspective while reading the article, which furthermore, referred to Puerto Rico as a “U.S. territory” or not—a social-identity cue intended to prime ingroup versus outgroup thinking (a control condition received no perspective-taking instructions). Immediately after, participants reported their support for climate change mitigation policy and other climate beliefs. Results revealed a two-way interaction between perspective taking and social-identity cue, such that the objective perspective condition increased policy support, but only when the ingroup cue was present—an effect driven by political conservatives and moderates. Further analysis revealed beliefs about the origins and consequences of climate change as key mediators. Our findings complement prior work on the politics-contingent effects of climate victim portrayals, while offering practical insights for risk communicators and environmental advocates seeking to communicate about climate-related emerging and zoonotic diseases.

P.83 Lu, EH*; Wu, KY; National Taiwan University; shren199322@gmail.com

Probabilistic Risk Assessment of Fipronil Residue in Tea in Taiwan

Tea leaves used in chain tea shops have been found to contain multiple insecticides, including fipronil, ametryn, fenprothrin and DDT. Fipronil, banned to use in tea trees, is an insecticide commonly used in corn and rice in Taiwan. Previous studies showed that fipronil may lead to neurological toxicity and thyroid cancer. The objective of this study is to establish a probabilistic risk assessment of fipronil in tea consumption in Taiwan. The established reference dose (RfD) was derived from NOEL. Thus, this study used Benchmark Dose Software (BMDS 2.6.0.1) to calculate the corresponding benchmark dose level, BMDL10, based on existing animal study. Lifetime Average Daily Dose (LADD) was using on Bayesian Statistics with Markov Chain Monte Carlo simulation (BSMCMC). Tea consumption data was obtained from the National Food Consumption Database of Taiwan. Three target populations were 12-16, 16-18 and 19-65 years old. The factors of transfer rate and infusion process were added when conducting exposure assessment. This study reveals that LADD are 3.85×10^{-5} , 4.1×10^{-5} and 5.8×10^{-5} mg/kg/day in 12-16, 16-18 and 19-65 years old, respectively. Hazard Index (HI) of fipronil in three age groups are 0.085, 0.091 and 0.129. Although the HI shows that consumers aren't subject to the potential adverse health effects, the risk of fipronil shouldn't be ignored. Farmers often spray multiple insecticides at the same time. Consumers may expose to multiple insecticides when drinking tea. Although the result of residual model is below MRL, residues of fipronil on FDA tea report still exceeds than MRL. Some imported tea leaves with high possibility containing excessive insecticides are still used in tea shops. It's still necessary listing insecticide in tea leaves as inspection target. It's essential for experts and government to cooperate together to improve the policy of insecticides.

W4-F.3 Lu, Y*; Izurieta, H; Wernecke, M; Kelman, J; Wong, S; Worrall, C; Lash, T; Fox, M; Forshee, R; Food and Drug Administration, Acumen LLC, Centers for Medicare & Medicaid Services, Emory University, and Boston University; Yun.Lu@fda.hhs.gov

Quantitative Bias Analysis for Herpes Zoster Vaccine Effectiveness Study in the Medicare Population Ages 65 Years and older

As a result of the Food and Drug Administration (FDA) Amendments Act and FDA Safety and Innovation Act, FDA has increased the number of post-market active surveillance studies using health claims databases. Bias is an important concern in observational studies, the Office of Biostatistics and Epidemiology (OBE) at FDA Center for Biologics Evaluation and Research (CBER) has developed a quantitative bias analysis tool (QBAT) to estimate the direction, magnitude, and uncertainty associated with the biases in safety and effectiveness studies. This presentation uses Herpes Zoster Vaccine effectiveness study in the Medicare Population ages 65 years and older as an example to illustrate approaches used to quantify bias using QBAT. Herpes Zoster is most common in people 50 years and older, and its risk increases with age. Herpes Zoster and its complications could affect tens of millions of seniors, and live-attenuated Herpes Zoster Vaccine reduces the risk of Herpes Zoster. Medicare claims for beneficiaries ages ≥65 years were used to evaluate Herpes Zoster Vaccine effectiveness. Because Herpes Zoster vaccinated and unvaccinated cohorts may have different health seeking behavior, and there may be outcome misclassification bias, QBAT was used to quantify bias in the Herpes Zoster Vaccine effectiveness estimates attributable to these bias sources. Exploring the potential impact of bias sources with QBAT will support decision-making and improve clear and transparent communication with all stakeholders.

P.43 Luk, SY; Mumpower, JL*; Texas A&M University;
 jmumpower@tamu.edu

Siting High-Level Radioactive Waste Disposal Facilities: 50 Years of Failure

According to The Blue Ribbon Commission on America's Nuclear Future, disposal of high-level radioactive waste (HLRW) is a problem for which "we know what to do, we know we have to do it, and we even know how to do it." But for more than fifty years, the U.S. has failed to find a way to dispose of commercial HLRW. Despite having the necessary knowledge, experience, and financial resources, the U.S. has no place to dispose of approximately 70,000 metric tons of accumulated HLRW and 2,200 metric tons added annually. It is now arguably further from a solution than it was a decade ago. The Department of Energy filed a license application in 2008 for construction of a HLRW repository at Yucca Mountain, Nevada, but in 2010 requested withdrawal of the application. The rest of the world has done little better. No country has yet to achieve a full, satisfactory resolution to the problem. A handful of countries-Finland, France, and Sweden-appear to have success in sight, but still years or decades off. In contrast, the U.S. is also home to a success story. The Waste Isolation Pilot Plant (WIPP) near Carlsbad, New Mexico, is a deep geological repository that disposes of the nation's defense-related transuranic radioactive wastes. WIPP opened in 1999 and its success has been seen as an indicator that eventually it will prove possible to site, construct, and operate HLRW disposal facilities for commercial waste. Recent events, however, raise doubts. In early 2014, two accidents resulted in the closing of WIPP; the re-opening date is uncertain. This paper discusses proposed frameworks for design of a siting process; reviews the history of failed efforts to site a U.S. HLRW disposal facility and the successful siting of WIPP; and reviews the history of siting efforts in other countries, particularly the few where success appears most likely. It summarizes lessons learned and conclusions from analysis of efforts to site HLRW disposal facilities.

T3-F.1 Lyle, TS; Ebbwater Consulting; tamsin@ebbwater.ca
 Is it worth the effort? A case study of cumulative-based risk assessment versus scenario-based risk assessment methods for sea level rise.

Coastal flooding is a great concern for many regions of the world, especially with the onset of climate-induced sea level rise. Planning for and adapting to these changing coastal hazards is a critical issue that many cities are grappling with. Planning for coastal flooding is inherently complex as the hazard associated with flooding (i.e. the water level) is combination of deterministic information (tides for example) and probabilistic events (storm surges and waves for example). When quasi-deterministic sea level rise (i.e. we know it is rising, but not at what rate) is added to this, the picture becomes even murkier. If we consider future flood risk specifically, we are dealing with both incremental changes in flood hazard levels and extents as a result of sea level rise, on top of which lies the hazard associated with storm events. Traditionally, most planning and engineering decisions have been made based on single extreme scenarios. Where a dike is built to a specific height to protect from a specific event for example; this is often regulated. Using climate change as a catalyst for a paradigm shift in how we plan for coastal flood risk, this paper will explore the value of completing a cumulative risk assessment (i.e. one that considers multiple hazard events and multiple climate futures) using the City of Vancouver as a case study. Starting in 2013, the City of Vancouver has completed hazard, vulnerability and risk assessments for multiple events and sea level rise scenarios. These are used as the basis of this research. For this paper, we explore if cumulative risk assessment methods ultimately show different preferred adaptation options than more traditional scenario-based assessments. We also explore if the substantial additional effort required to complete a cumulative assessment is warranted.

P.164 Lundberg, RP; Sam Houston State University;
 russell.lundberg@gmail.com

Surveillance of a Comparative Set of Homeland Security Risks

This research is designed to identify perceptions of homeland security risk relative to other risks following a homeland security event. While it is well known that a people become more concerned about a risk if there is a recent event of that type that is fresh in an individual's memory, it is not as clear the extent to which a recent homeland security event of one type affects perception of homeland security events of other types. For example, a terrorist bombing may increase concern for a range of terrorist scenarios but not natural disasters, or perhaps a hurricane response perceived as a failure will increase concern for all disaster scenarios. These spillover effects of how perceptions of one homeland security risk are correlated with another are unclear but may be important for disaster planning and response. To do this we examine perceptions of risk in the U.S. public using Amazon Mechanical Turk across a set of ten hazards, including natural disasters, terrorist events, and major disasters. After establishing a baseline level of concern for each of the risks, additional surveys will be taken following homeland security events. These additional surveys shall be conducted: immediately after the event; two weeks after the event; four weeks after the event; and eight weeks after the event. One contribution of this research is the assessment of risk both individually and relative to the other hazards; if an event occurs we would expect the concern for that hazard to increase, but understanding whether perceptions of risk for similar hazards increase or decrease and over what timeframe may be useful as well.

W4-G.4 Lynch, MTK*; Brown, L; Chiger, A; Abt Associates;
 meghan_lynch@abtassoc.com

Case Studies for Neurotoxic Chemicals

In recent years, numerous studies have been published in the literature both on the association between environmental contaminants and adverse neurobehavioral effects and on the associated costs of these adverse outcomes. We have developed case studies exploring methods to quantify these effects for inclusion in cost-benefit analyses. We start with the well-established relationship between lead exposure and IQ loss. Many environmental regulations for lead have relied on estimated benefits based on avoided IQ loss. We will present updates to the concentration-response functions used to estimate these benefits of avoided IQ loss for lead. We will also present progress on the development of additional concentration-response functions for endpoints previously not quantified such as ADHD. Our discussion will include extrapolations to other neurotoxic chemicals with less well established concentration-response functions such as arsenic and IQ loss.

T3-D.4 MacDonald Gibson, J*; Stillo, F; University of North Carolina at Chapel Hill; jackie.macdonald@unc.edu
Racial Disparities in Access to Community Water Service in Wake County, North Carolina: Public Health Risks and Costs of Interventions

Over the last 100 years, installation of community water systems substantially decreased US waterborne diseases. However, throughout the South, some communities were excluded from these systems as a result of racial segregation, and some of the resulting disparities persist. The magnitude of exclusion risks, water quality in affected areas, health implications, and costs of connecting to nearby municipal water utilities are not well understood. This presentation will summarize four years of research to characterize the locations of affected communities, their drinking water quality, potential health risks, and costs of and barriers to extending municipal water service in Wake County, NC's second-largest county by population and location of the state capital. The research has included analysis of tax parcel and census data, water quality testing, population intervention modeling using hospital emergency department data, development of preliminary engineering plans for extending municipal water pipes, and open-ended interviews. Overall, our analysis has documented significant and persistent exclusion from municipal water service with associated negative health consequences. Odds of exclusion from municipal water service increase by 4% for every 10% increase in a census block's African American population proportion. Water testing in 57 affected homes found 49% tested positive for total coliform bacteria. Our population intervention model estimated that 21% (95% CI 14-31%) of 110 annual emergency department visits for acute gastrointestinal illness among approximately 3,800 affected county residents are attributable to exclusion from municipal water service. Cost is a major barrier to extending water service, with per-household costs of approximately \$20,000 and disagreements over who should bear those costs. Overall, our research suggests the need for interventions to improve water quality and protect health in these communities.

W4-H.3 MacGillivray, BH; Cardiff University; macgillivraybh@cardiff.ac.uk
Is social capital an important component of disaster resilience? A taxonomy clarifying inconsistency in empirical results
 Theory suggests that social capital should moderate the impacts of natural disasters and the capacity of communities to recover from catastrophe, yet the empirical evidence is rather mixed. Here we classify the underlying drivers of this heterogeneity, arguing that whilst in large measure it reflects objective variability in the nature and operation of social capital, in part it is a methodological artefact. We first show that bonding, bridging, and linking capital interact in ways that generate outcomes that could not be predicted by analysing them in isolation, and moreover, that they combine in significant ways with other sources of capital (e.g. human and physical capital). We then stress the importance of institutional context as a source of heterogeneity. Whilst the importance of institutions is well understood at the macro level (i.e. the role insurance markets in conditioning the effects of social capital), there has been less focus on the properties of particular institutions which communities interact with in disaster preparation and recovery. Finally, we explore how culture both conditions the effectiveness of social capital, and introduces measurement error. Specifically, we argue that the content of norms - rather than just the degree to which they are widely shared within a community - is a critical dimension of resilience that is not captured in measures of social capital. Complicating this, measurement error is often introduced by the uncritical exportation of analytical frameworks from Western contexts to middle and low income nations. Throughout our analysis we acknowledge the "dark side" of social capital as a component of resilience - emphasizing that it can lead to the exclusion of marginalised groups from recovery efforts and to the reproduction of inequality. Our overarching claim is that a focus on the multi-dimensional and contextually-modified nature of social capital is a necessary precondition for theory-building and for reconciling (seemingly) conflicting empirical findings.

M3-F.2 MacFarlane, AJ; Health Canada; amanda.macfarlane@hc-sc.gc.ca
Current realities and future options for using chronic disease endpoints to set Dietary Reference Intake (DRI) values

The Institute of Medicine stipulated that risk associated with chronic disease is a concept that should be included in the formulation of nutrient reference intake values where sufficient data for efficacy and safety exist. However, considerations of chronic disease risk reduction in defining reference values have challenged the applicability of the traditional DRI framework. Whereas the traditional framework relies on concepts such as the essentiality of the nutrient, a threshold effect for adequacy, and safe intervals of intake, among others, these concepts do not universally apply to the relationships between essential nutrients, or other food substances, and chronic diseases. As a result, there are but a few nutrients for which chronic disease endpoints were used to set DRI values, and each application identified a limitation of the traditional framework. Recognition of these limitations has led to suggestions that either a modified or different framework is needed to improve the incorporation of chronic disease endpoints. Recently, a working group sponsored by the Canadian and US governments identified options for the improved use of chronic disease endpoints in the development of DRI values. This presentation will include examples of past DRI values based on chronic disease risk reduction that highlight the limitations of the traditional framework. Options identified by the working group for modifying and/or expanding the traditional DRI framework, and options for new types of DRI values based on chronic disease endpoints, including their strengths and weaknesses, will be discussed.

M4-C.3 Madasseri Payyappalli, V*; Behrendt, A; Zhuang, J; University at Buffalo, SUNY; vineetma@buffalo.edu
Cost-benefit Analysis of Fire Protection Resource Allocation in the United States: Models and a 1980-2011 Case Study
 Fire-related hazards and incidents are an everyday phenomenon, and firefighting in the United States owe to more than one million firefighters in about 30,000 fire departments across the country. The estimated total cost of fire was \$329 billion in 2011, and yet there is little work in the literature about risk assessment, cost-benefit analysis, and resource allocation in fire protection. However, there is a large amount of data available from various sources, the primary of which is the National Fire Incident Response System (NFIRS). Leveraging this data set, we conduct a data-driven study to propose empirical and theoretical models to assess risk levels and develop risk-reduction strategies that include optimal resource allocation, optimal facility design, and optimal routing solutions. This study will be of use to policymakers and analysts in fire protection and safety, and will ultimately help in mitigating economic costs and saving civilian and firefighter lives.

P-42 Maeda, Y*; Muramatsu, G; Shizuoka University;
maeda.yasunobu@shizuoka.ac.jp

Comparison of evaluation functions for setting priority of risk management

In a risk management process, risk managers firstly recognize and describe risks that they try to deal with, secondly assess the magnitudes of these risks, thirdly make the plan of risk control measures, and fourthly carry out it. In the third step, they have to determine what risks are preferentially treated and what are not treated but accepted. In other words, they have to rank the risks. So, how should they do? In this research, five evaluation functions for ranking risks, that is, magnitude of risk, cost-effectiveness of risk control measure, benefit-risk ratio, voting, and majority judgement, were used to rank twenty risks and compared. The twenty risks were chosen from the result of a questionnaire survey in which students in a university were questioned to enumerate risks around you. These risks were ranked by using the five evaluation functions. As for voting and majority judgement, the results were obtained from the answer of another survey of the same students. As a result, we obtained the following remarks. Firstly, ranks of risks derived from these evaluation functions are different from each other. In particular, ranks based on rational approaches, i.e., magnitude of risk, cost-effectiveness, and benefit-risk ratio, are entirely different from ranks derived from the other functions, voting and majority judgement. Secondly, risk of nuclear plants is highly ranked by voting, while lowly ranked by other four functions. And thirdly, risk of traffic accident is highly ranked by most of functions while benefit-risk ratio ranks this risk lowly. These results suggest importance of risk evaluation policy in risk management process.

M4-G.4 Malladi, S*; Weaver, JT; Mlakar, JA; Spackman, E; Pantin-Jackwood, M; 1 University of Minnesota, 1971 Commonwealth Avenue, St. Paul, MN 55108, 2,3 U.S. Department of Agriculture, 2150 Centre Avenue, Fort Collins, CO 80526, 4,5 U.S. Department of Agriculture, 934 College Station Road, Athens, GA 30605; todd.weaver@aphis.usda.gov

Evaluating the risk of spread of highly pathogenic avian influenza virus to wild migratory birds via leachate from municipal solid waste landfills accepting poultry carcass waste

During recent outbreaks of highly pathogenic avian influenza (HPAI), risk perceptions associated with disposal of poultry carcass waste in Subtitle D Municipal Solid Waste landfills resulted in some landfill operators refusing to accept waste due to concerns over the potential presence of HPAI virus in leachate and the risk of exposure of wild migratory birds. Risk mitigation options proposed to reduce the level of HPAI virus in leachate include: 1) only landfilling waste from clinically normal (test negative) flocks; 2) using bio-containment bags; 3) placing carcass waste further from the leachate collection system; or 4) treating leachate at a waste-water treatment plant. We developed a model to predict HPAI virus titers in landfill leachate under various carcass viral load scenarios and landfill operational conditions, and used this to evaluate the relative impact of risk mitigation options on the probability of infection of wild mallard ducks. First, we used within-flock HPAI disease transmission models to predict the prevalence of HPAI infection in table-egg-layer flocks to estimate the quantity of HPAI virus in carcass leachate produced by infectious birds from clinically detected and test-negative flocks. We then modelled the heat inactivation of HPAI virus in the leachate considering the time taken to reach the leachate collection system and the temperature profile of waste in a landfill cell. The probability of infection of wild mallard ducks was predicted using dose response models, while considering the dilution of HPAI virus due to mixing with leachate generated from other waste in holding ponds at artificially constructed wetlands. The combination of increasing placement height, disposal of low prevalence (test negative) flocks, and using containment bags had the largest impact on lowering final titers. Model predictions will be used in further risk analyses to evaluate the benefits and costs associated with landfill disposal options.

W2-A.3 Magliocca, NM; Walls, MA*; Resources for the Future;
walls@rff.org

The role of risk perceptions in shaping coastal development dynamics

In highly dynamic systems, particularly those characterized by frequent natural hazards, the ways in which people perceive their environment, formulate expectations of risk, and make decisions influence the long-term vulnerability of the built landscape to natural hazards. A common observation in landscapes prone to natural hazards, such as flooding and/or hurricanes, is the emergence of overly reactive (i.e., out-of-equilibrium, or 'boom-bust' cycles) market dynamics. Housing prices and insurance uptake rates have been shown to decline and spike, respectively, immediately after hazard events and then return to long-term trends as time since the event increases. Theoretical explanations for such dynamics typically point to psychological factors, but conclusive evidence is difficult to extract from empirical data alone. Here, we use an economic agent-based model (ABM) of coupled housing and land markets in a coastal region to investigate the explanatory ability of alternative decision-making models and to explore potential behavioral mechanisms driving these observed outcomes. We compare and contrast results using a model with a) fully rational decision-making with complete information about storm risks, b) boundedly rational decision-making with Bayesian updating of storm risks, and c) Bayesian updating combined with salience (i.e., recent events are weighted more heavily in the utility function). Our model simulations show spatial patterns of development, housing types, house prices and land prices over a 30-year simulation period. We use the well-known pattern-oriented modeling approach to simultaneously select and calibrate our ABM to identify the set of parameter values and decision rules that most accurately reproduce observed housing and land price dynamics. Our modeling results provide tentative support for boundedly rational decision-making with salience—i.e., housing and land prices after repeated storm events tend to mimic real-world results.

M4-F.1 Malloy, TF; University of California, Los Angeles;
Malloy@law.ucla.edu

Models of alternatives analysis: evaluating the evaluation

This presentation will explore the legal and regulatory contexts in which alternatives analysis is used in the United States and Europe: the California Safer Consumer Products, the federal Toxic Substances Control Act (including any reforms under consideration or enacted into law), and the European Union's REACH program. Businesses operating within such programs, and the agencies that implement the programs, are faced with difficult choices as they seek safer alternatives to incumbent materials, technologies and processes. The complexity of such comparative analysis is increased by several factors. First, in many cases the data regarding toxicity, exposure, functionality and economic impact will be incomplete and highly uncertain. Second, the data that are available will be quite diverse in nature; some will be qualitative and other quantitative, and much will be incommensurable. Third, in many cases the alternatives can present thorny trade-offs. Lastly, in the regulatory setting in particular, concerns regarding consistency and transparency are also raised; good governance calls for similar treatment of similar cases and openness regarding the decision-making process. The presentation will compare and contrast how the alternatives analysis methods—and in particular decision analytic approaches and tools—can be used in each of the programs to address these four factors. It will also evaluate the extent to which each alternatives analysis approach meets norms for rigorous decision analysis and incorporates public values such as consistency, equity, public engagement, and accountability.

M4-H.4 Malloy, TF; University of California, Los Angeles; Malloy@law.ucla.edu

Integrating resilience into mainstream regulation: a thought experiment

Society faces of threats of catastrophic disasters and substantial harm resulting from terrorism, the results of climate-change and potentially even from emerging technologies such as nanotechnology and synthetic biology. And as technology and infrastructure becomes ever more complex, the threat of system failures has grown more acute. In the face of these threats, calls have come from a variety of sources for a shift from conventional risk assessment and management approaches to resilience-based approaches. Resilience has many definitions, including the National Academy of Sciences' description of it as a system's ability "to plan and prepare for, absorb, respond to, and recover from disasters and adapt to new conditions." This presentation uses a thought experiment to examine the implications of adopting a resilience-based approach on risk assessment and risk management in the regulatory setting. It will focus upon the examples of (1) facility safety planning under the Environmental Protection Agency's Risk Management Plan rule for industrial facilities and (2) the Nuclear Regulatory Commission's facility licensing and oversight process. The presentation will explore the extent to which changes would be required in the way regulatory agencies define and assess risk and will identify, evaluate and implement risk management measures. It will also address the legal reforms, if any, needed to allow for the adoption of a resilience-based approach in the two examples.

P.69 Mansfield, TJ*; MacDonald Gibson, J; University of North Carolina at Chapel Hill; tedmans@live.unc.edu

Health impacts of transportation and the built environment: A quantitative risk assessment

The design of urban transportation networks can affect three kinds of human health risks: (1) motor vehicle crashes, (2) air pollution from automobiles, and (3) physical inactivity occurring when motor vehicles replace walking and cycling as the main means of transportation. However, the relative magnitude of each of these risks in relation to the way cities are designed is poorly understood, and tools and methods that simultaneously assess all three risks are limited. Furthermore, available tools rely on static methods that fail to account for cumulative health impacts over time. This work developed the first dynamic micro-simulation model for quantifying all three risks and then applied the model to compare transportation health risks between neighborhood groups of varying designs within the Raleigh-Durham-Chapel Hill region. The model combines information on crash risk as a function of vehicle miles traveled, demographic and built environment variables routinely collected by the US Census Bureau, modeled estimates of fine particulate air pollution arising from traffic computed at the census block scale, and baseline public health data from the North Carolina State Center for Health Statistics in order to estimate premature mortality risks from each of the three transportation-risk sources at the census block group scale. The model estimates that the combined health impacts of transportation are lowest in the most walkable block groups in the region (18.4 annual excess deaths per 100,000 persons on average over 10 years, compared to 22.9 in the least walkable block groups). While air pollution health impacts are higher in the most walkable block groups (2.14 annual excess deaths per 100,000 persons compared to 1.15), physical inactivity and crash risks are lower in these areas (2.70 annual excess death per 100,000 compared to 6.66 and 13.5 compared to 15.1, respectively). Thus, designing neighborhoods to encourage walking has important net health benefits.

P.84 Manning, KL*; Dolislager, F; Bolus, KA; Walker, S; University of Tennessee, Knoxville, TN; Oak Ridge National Laboratory, Oak Ridge, TN; US EPA, Washington, DC; manningkl@ornl.gov
Improvements in biota modeling for EPA's Preliminary Remediation Goal and Dose Compliance Concentration calculators: intake rate derivation, transfer factor compilation, and mass loading factor

Recent improvements have been made in biota modeling for EPA's Preliminary Remediation Goal (PRG) and Dose Compliance Concentration (DCC) calculators. These risk assessment tools set forth EPA's recommended approaches, based upon currently available information with respect to risk assessment, for response actions at Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) sites (commonly known as Superfund). Previously, produce intake rates were based on general fruit and vegetable consumption rates. Now, the produce intake rates are derived from 22 individual produce items, found in the 2011 Exposure Factors Handbook, that contribute to the overall produce ingestion PRG and DCC. Mass loading factors (MLFs) were also improved from a single MLF that was applied to all produce to 22 individual MLFs that correspond with the 22 individual produce items that make up the new produce intake rates. MLFs from Hinton (1992), the Environment Agency's Contaminated Land Exposure Assessment (CLEA) model, and Pinder and McLeod (1989) were used and converted, where necessary, from dry weight to fresh weight. In site-specific mode, a user is now able to select additional animal products including Goat Milk, Sheep Milk, Duck, Mutton, Goat Meat, Rabbit, Turkey, and Venison as well as Rice and Grains, which are not included in the default produce intake rates. Formerly, the transfer factors used in these risk assessment tools were specific to element only. Now, the transfer factors are element-specific, biota-specific, climate zone-specific, and soil type-specific. These new transfer factors are from the recent IAEA TRS-472 and TRS-479 as well as Science Report: SC030162/SR2 from the Environment Agency of the United Kingdom and were used to replace most of the old generic values from NCRP, BAES, RESRAD, and RAD-SSL. These updates will greatly improve the accuracy and utility of the PRG and DCC calculators.

W3-D.2 Marasteanu, I*; Sassi, A; U.S Food and Drug Administration ; ioana.marasteanu@fda.hhs.gov

A Retrospective Analysis of Procedures for the Safe and Sanitary Processing and Importing of Fish and Fishery Products: the Seafood HACCP rule

In December, 1995, the U.S. Food and Drug Administration published "Procedures for the Safe and Sanitary Processing and Importing of Fish and Fishery Products," which mandated that all seafood processors and importers implement Hazard Analysis Critical Control Point (HACCP) principles to the processing of seafood to ensure the safety of their products to consumers. This included conducting a hazard analysis to determine the risks associated with the products, and based on the results of the analysis, deciding what type of HACCP plan to put into place. The Seafood HACCP rule went into effect in December, 1997. In February of 2001, FDA instituted a mid-course correction to strengthen the Seafood HACCP program by intensifying its focus on products and processors who were deemed as presenting the highest risk to consumers. As part of the published Seafood HACCP rule, FDA included a prospective Regulatory Impact Analysis, in which they estimated the discounted benefits of the rule as the reduction of approximately \$1.5 - \$2.5 billion worth of foodborne illnesses at the cost of about \$0.7 - \$1.5 billion. To the best of our knowledge, there does not exist an analysis of the actual impacts of the Seafood HACCP rule on the U.S. food system and economy as a whole. The purpose of this study is to quantify the overall impact of this rule, and compare it to the analysis that was presented in the rule's Regulatory Impact Analysis. Using data on foodborne illnesses, imports, and industry costs from sources such as the Centers for Disease Control and Prevention, we examine the realized costs and benefits of the Seafood HACCP rule, as well as the specific impact of the rule on importers. Our results provide new interesting insights as to how the Seafood HACCP rule has impacted U.S. consumers' health, seafood safety, and the U.S. economy as a whole in the almost 20 years since implementation of the rule.

M4-H.3 Marchant, GE; Arizona State University;
gary.marchant@asu.edu

Implementing Resilience in Regulatory Law: Substantive Provisions

A resilience-based regulatory system should include both substantive and process components – this presentation focuses on the substantive provisions of a reliance-based regulatory system. Many proponents of resilience emphasize the need to build in a margin-of-error or safety factor to provide additional protection against uncertainties about future harms. However, since these safety factors seek to prevent harm in the first place, they are more properly considered part of a risk-based approach (risk-based and resilience-based approaches can be complementary and not necessarily exclusive). A more relevant focus of resilience is to attempt to identify unintended or unanticipated consequences of a regulatory program or technology, to be better prepared to address such problems if and when they occur. By definition, unanticipated consequences are difficult to anticipate, but tools such as scenario analysis and multi-criteria decision analysis can help prepare for such unknowable effects. A resilience-based approach also requires adoption of provisions for compensation, remediation, and prevention of additional harms once injury does occur. This presentation will discuss the opportunities and challenges in designing and implementing such measures, using climate change adaptation as a case study.

M3-J.6 Marynissen, HMF*; Van Achte, T; Pieters, S; Antwerp Management School; hugo.marynissen@ams.ac.be
Inverting the dominant crisis communication logic. A case study based on the Brussels terror attacks.

Research in the field of risk and crisis communication indicates that large disasters cause distress among those affected by a crisis situation, but also among a larger group of people involved. These feelings of anxiety and dread are rooted in a heuristic interpretation of the situation, what leads to both individual and collective elevated stress levels. From the literature on stress, we know that the lack of information, the shortness of guidance on what to do, and the absence of acknowledgement for any emotional distress, all have an immediate negative impact on the individual's stress level. If we want to tackle that phenomenon, there might be an adapted way of dealing with communication during a crisis situation. The dominant crisis communication literature suggests its primal aim is to save the sender's reputation, and subsequently restoring trust in the organization. This is a tenacious logic among many organizations and communicators. We inverted that logic by arguing that the primal aim of communication during a crisis situation is gaining trust, and listening to those who are involved in the first place can achieve this. As a consequence, the sender of information will automatically safeguard its reputation. Hence, the challenge was to introduce a new crisis communication methodology that firstly inverts the dominant logic (gaining trust instead of restoring own reputation), and secondly offers a general communication strategy that is capable of diminishing the victims and other stakeholders' stress levels. Based on two real life cases, the Brussels Lockdown (November 2015) and the Brussels terror Attacks (March 2016), we proved the effectiveness of this approach and the diminishing effect on the population's stress levels.

W2-H.1 Marchant, GE; Arizona State University;
gary.marchant@asu.edu

Molecular Data Is Driving Risk Assessment Changes for International and National Decision Making on Health Related Subjects

The rapid expansion and understanding of molecular data in health care research (e.g. various sets of "omic" data) is now flowing into and rapidly transforming risk-based decision-making by regulatory agencies. Moreover, data streams on molecular treatment tools (e.g. CRISPR/gene editing) are rapidly emerging, and leading to accelerating efforts towards achieving global decision-making or consensus standards. These newer approaches stand in marked contrast to past regulatory programs that, by necessity, used the convenient assumptions that populations and individuals are essentially the individuals same, and that large data sets and long term population studies were needed prior to decision making. This presentation will discuss case studies where results of molecular variability analysis, and new sets of data, are disrupting the traditional risk-based decisions of national and international regulatory agencies and/or advisory groups. The case studies include decision making at drug agencies and advisory groups, at agencies involved with setting standards for environmental and workplace situations, and efforts by private groups or ngos to embrace new approaches and methods for treating or recognizing molecular variables. The case studies will be used to demonstrate the potential benefits and challenges of the increased use of molecular and other genomic data in regulatory decisions, including issues relating to data quality and validation, global decision-making possibilities, influences of national or multi-nation statutes or rules, ethical concerns, regulatory precedents, and stakeholder interests.

W2-G.1 Mason, A*; Howard, B; Arnold, S; Kingsbury, T; American Chemistry Council; brett_howard@americanchemistry.com
Why do we need exposure to inform an integrated approach for assessing alternatives?

The community working to assess alternative ingredients and products face a variety of challenges to balance sometimes competing goals including 1) reduction or elimination of the risk associated with chemical ingredients; 2) rewarding chemicals and products that are designed using the principles of green engineering and chemistry; 3) viewing multiple impacts across the spectrum of life cycle stages, all the while 4) maintaining functional and economic performance. Overall, any alternative chemical or product must perform similarly or better than its predecessor, be measurably safer for the user and the environment, and have an economic profile comparable to the chemical or product it replaces. Full alternative assessments as currently practiced involve a substantial amount of expert resources, data, and time so it is important that there is a screening approach to focus resources on viable candidates. Given the broad spectrum of functional roles chemicals and products play, there is currently no "best" solution that will work in all circumstances. This work suggests a set of concepts and elements useful for a screening-level evaluation that directly responds to the question or problem and provides relevant information to the decision at hand. The goal is to suggest conceptual elements and approaches to relate risks to individuals with life cycle environmental impacts and to discuss the challenges and possibilities when working toward a process for integrated decision-making. A series of case studies or examples will be used to illustrate the concepts

M2-H.3 Matsuo, M; the University of Tokyo;
matsuoma@j.u-tokyo.ac.jp

Interconnectedness of multiple risks- the case of infectious diseases pandemic

The 2014 Ebola epidemic in West African countries revealed that the interaction of a single hazard (infectious disease) with various risks - within health sector (health/health risk), and other sectors (health/economic risk, health/society risk etc)- can cause various consequences, through multiple layers of media. Particularly in the vulnerable countries, not only the fragile health system but also other factors like lack of basic social infrastructure can contribute to the worsening of situation. This is, however, to some extent, also true in developed countries. It is now acknowledged that the risk assessment of infectious diseases must include context assessment, the so-called STEEP (Social, Technical and scientific, Economic, Environmental, Ethical, and Policy and Political) factors. However, as opposed to a more technical hazard assessment and exposure assessment, how to carry out context assessment needs further development. Current assessment is limited in its scope to physical/tangible health risk but it also have to consider consequences as a result of its interaction with "other physical" risks and what the consequences of such interaction in turn bring about. It must also consider behavioral consequences amplified by "intangible" risks (increase of other "unexpected" risk as a consequence of "fear" to avoid certain risks). In short, risk assessment/governance of infectious disease must expand the scope to include, interactions between health related risk and non-health "physical" risk, "intangible" risk, and the impact posed by loops of consequences. This presentation analyze more in detail the different patterns of interactions of risks. Exploring the whole mapping of the risks and their interactions will enable the identification of responding actors and the needed coordination amongst those actors. This can contribute to the capacity to prepare/respond/recovery and enhance the resilience of society as a whole.

P.142 Mayeda, AM*; Boyd, AD; Washington State University;
allyssa.mayeda@wsu.edu

Examining factors influencing risk perceptions of hydropower

Public opinion is increasingly recognized as a critical factor in the development and management of energy systems. The perspectives of those living near current or proposed projects are particularly critical to assess because these residents may have a greater interest in the project and potentially have more input into the siting of the technology. A systematic review of quantitative and qualitative empirical research published between 1980 and 2015 was conducted to synthesize and consolidate the results of studies that examined public perceptions of hydropower. The review involved searching databases and journals using multiple keywords and synonyms for hydroelectricity and perceptions. The initial searches yielded 12,398 articles. Sixteen of these articles met the criteria for inclusion and were examined further to assess the factors associated with the support for or opposition to hydroelectric dams. Factors influencing public perceptions of hydroelectric dams included: (1) public participation and consultation in hydroelectric dam development; (2) availability of information about the energy source to members of affected communities; (3) socio-economic impacts associated with hydroelectric dams; and (4) environmental and ecological impacts of the technology. The findings from this review will provide insights for future research to help guide the development of more effective risk communication research and policy development in this area.

P.73 Mattuck, R; Gradient; rmattuck@gradientcorp.com

Comparison of Risk-Based Concentrations Derived for Pesticides in Drinking Water with US EPA Human Health Benchmarks

We conducted an analysis of risk-based concentrations (RBCs) for pesticides in wastewater being discharged from a manufacturing facility to a municipal wastewater treatment plant (POTW), to allow the facility to develop an in-house monitoring program. We calculated human health-based RBCs for 10 pesticides (Cadusafos, Carfentrazone, Chlorimuron, Clomazone, Cloransulam, Fluthiacet-methyl, Metsulfuron, Pyoxasulfone, Quinclorac, Sulfentrazone), and used the published EPA Regional Screening Levels (RSL) for 7 additional compounds (Atrazine, Bifenthrin, Carbofuran, Carbosulfan, Imazaethapyr, Metribuzin, Zeta-cypermethrin). The RBCs were calculated to be protective of human health assuming no dilution in the POTW or receiving waters, and were derived using the methodology used by US EPA to derive the RSLs for tapwater. The facility's wastewater concentrations were all below the drinking water RBCs. The RBCs were compared to the US EPA human health benchmarks for pesticides currently registered for use on food crops. Our analysis found that the RBCs differed from the US EPA human health benchmarks (HHBP), with RBC/HHBP ratios ranging from 0.004 to 1143. These differences were mainly due to differences in input assumptions, including whether the value was based on child vs. adult intake; the relative contribution of the drinking water source; whether the endpoint was based on a cancer or non-cancer effect; and the source of the toxicity factor. Our analysis demonstrates that the acceptable discharge values can vary widely depending on which EPA methodology is used.

P.54 Mayfield, DB*; Skall, DG; Gradient;

dmayfield@gradientcorp.com

Improving Ecological Risk Assessment by Embracing Benchmark Dose Analysis

Benchmark dose (BMD) analysis is routinely used in the assessment of human health effects from exposure to environmental contaminants. Accordingly, the US Environmental Protection Agency (US EPA) has developed technical guidance and software tools (i.e., benchmark dose software [BMDS]) to allow risk assessors to characterize exposure-response relationships following a systematic process. By comparison, ecological risk assessments (ERAs) seldom employ dose-response modeling and rely upon the use of no- or lowest-observed adverse effect levels (NOAELs/LOAELs). For example, ecological screening levels and remediation goals for wildlife are often developed using food-web models based on conservative assumptions of exposure and toxicity. The toxicity reference values (TRVs) underlying these concentration goals are typically based on NOAELs or LOAELs derived from available laboratory toxicity studies. In many cases, these procedures result in unrealistically low estimates of hazard. Fortunately, BMD modeling can be employed in ERAs by using existing BMD-methods and EPA guidance. In this study, we applied BMD analysis to characterize exposure-response relationships for selected chemicals following a systematic process. This analysis demonstrates the utility of the BMD approach for developing more robust toxicity values for use in wildlife risk assessments.

W3-I.2 Mayo, MJ*; Ikeda, S; Gradient; *mmayo@gradientcorp.com*
Positional Uncertainty in Imagery Analysis: Establishing Historical Site Operations and Evaluating Land Cover Evolution in Support of Risk Assessment

The analysis of historical and contemporary images is an important aspect to assessing environmental risk and informing decision making. Aerial and satellite imagery and documents such as engineering plans provide insight on current and historical site operations and land cover. These resources can be used to identify pertinent features, including potential contamination sources. Changes in land use and land cover through time can also be quantified. Understanding the evolution of the land at a site and its vicinity through time is critical for developing a conceptual site model of contamination sources, quantifying damages to natural resources, informing future investigation activities, and communicating potential risks to human health and the environment. However, there is often variability in the quality, spatial scale, and timeframe for the types of images used for imagery analyses. The challenge is to spatially align each image in a manner that minimizes individual and cumulative positional uncertainty in order to be able to extract accurate geospatial information. In this presentation we will a) highlight the sources and types of images utilized in typical environmental risk assessments, describe the basis for establishing their geospatial alignment, and summarize the baseline uncertainty that may exist prior to performing any analysis; b) outline some general techniques used in imagery analysis and feature identification, focusing on those that support risk assessment initiatives and contribute to decisions about future investigation; c) summarize the process of evaluating and addressing the uncertainty in the imagery analyses and feature extraction process; d) highlight some techniques used to visualize and describe the positional uncertainty in the results of these analyses; and e) underscore how understanding positional uncertainty contributes to the assessment of risk and helps inform decision making.

WI-J.4 McComas, K*; Lu, H; Keranen, K; Furtney, M; Song, H; Cornell University; *kam19@cornell.edu*
Societal Acceptance of Enhanced Geothermal Systems and their Potential for Induced Seismic Activity

Efforts to develop enhanced geothermal systems may face frustration if inadequate attention is paid to the societal acceptance of potential risks associated with this technology, including its potential to induce seismic activity during the stimulation process. This study presents a web survey that used a between-subjects factorial experimental design to explore the views of 325 U.S. adults, who were asked about their experiences with earthquakes; risk perceptions related to different causes of earthquakes (e.g., natural versus human induced); and acceptability of human induced earthquakes depending on the benefits, beneficiaries, and decision making process. The results found that respondents had more negative feelings toward human induced versus naturally occurring earthquakes. Although they rated no earthquake as "acceptable," human induced earthquakes were rated significantly less acceptable than naturally occurring ones. Attributing the benefits to the provision of renewable energy or climate change mitigation did not increase earthquake acceptability, and no one beneficiary made earthquakes more acceptable than the others, although private companies as beneficiaries made them less acceptable. Finally, earthquake acceptability was significantly higher when people believed that people like them had a voice in the decision, underscoring the importance of public involvement in the development of enhanced geothermal systems.

P.48 McCant, DD*; Lange, SS; Haney, JT; Honeycutt, ME; Texas Commission on Environmental Quality; *darrell.mccant@tceq.texas.gov*

A Series of Unfortunate Events: Perpetuation of the Pervasive Misconception that Rats Receive a 3-5 Times Lower Lung Tissue Dose than Humans at the Same Ozone Concentration

Unfortunately, researchers continue to perpetuate the misunderstanding that human lung tissue doses of ozone (O₃) are 3-5 times greater than rat tissue doses at the same O₃ concentration, referencing Hatch et al. (1994). The origin of this erroneous assertion lies in the fact that Hatch et al. did not expose humans and rats under the same conditions, which continues to not be accounted for but pervades the scientific literature. Hatch et al. exposed exercising humans to 0.4 ppm and resting rats to 2 ppm and found comparable 18O incorporation into bronchoalveolar lavage constituents. This important difference in activity state is not always appropriately considered when the perceived implications of the Hatch et al. study are cited in the peer-reviewed literature. However, this difference in activity state explains the comparable incorporation of 18O by exercising humans and resting rats at 5-fold different exposure concentrations. More specifically, although exercising humans were exposed to a 5-times lower O₃ concentration than resting rats, their ventilation rate was 5-times higher than the resting rate, offsetting the 5-times lower exposure concentration and producing the same dose that would be expected at rest when exposed to 2 ppm (i.e., 0.4 ppm x exercising human ventilation rate of 64.6 L/min ≈ 2 ppm x resting human study ventilation rate of 13.5 L/min). In other words, humans exposed to 2 ppm at rest should be expected to experience approximately the same dose as exercising humans at 0.4 ppm, which produced a dose comparable to resting rats at 2 ppm. Correcting the misconception that rats must be exposed to 3-5 times environmental concentrations to achieve the same environmentally-relevant O₃ doses as in humans is important for a correct understanding of available O₃ studies by the scientists and policy makers responsible for making regulatory decisions (e.g., setting the federal O₃ standard).

P.126 McComas, K; Lu, H*; Cornell University; *kam19@cornell.edu*

Exploring the Acceptability of Human Induced Earthquakes

Earthquakes generate little positive affect and even less so when they are human induced. Even so, are some human induced earthquakes more acceptable than others, especially if they help to diversify energy portfolios and mitigate the effects of climate change? In response to this question, this paper presents data collected from a representative sample of New York state residents (N=800) February to April 2016 on public acceptance of earthquakes depending on their causes. Not surprisingly, respondents felt significantly more negative about human induced versus naturally occurring earthquakes. Further, although no earthquake was deemed "acceptable," respondents rated human induced earthquakes significantly less acceptable than naturally occurring ones. Some human induced earthquakes were, however, deemed more acceptable than others. Specifically, respondents felt significantly more negative and rated as less acceptable earthquakes caused by the disposal of wastewater in wells related to natural gas development as compared to earthquakes caused by enhanced geothermal systems, groundwater extraction for agriculture, and carbon capture sequestration. This finding is perhaps related to the ongoing controversy in New York State related to the development of natural gas in the Marcellus Shale, although this linkage was not explicit in the survey. It also may be due to the perceived benefits of the process; however, the survey connected each human-induced earthquake to some type of benefit, including providing a source of energy to local communities. Finally, procedural justice mattered to human-induced earthquake acceptability, as acceptability was significantly higher when people believed that people like them had a voice in the decision and significantly lower when they learned that the decision was entirely expert-driven. This finding underscores the importance of public involvement in decision making.

W2-H.3 McCullough, SD; U.S. Environmental Protection Agency;
mccullough.shaun@epa.gov

The Epigenetic Seed and Soil Model: A Framework for Understanding the Role of Environmental History in Disease Susceptibility and Risk Assessment

Traditional risk assessment paradigms rely on factors such as age, genotype, and disease status to explain variability in responsiveness to chemical exposures; however, these are not sufficient to faithfully identify the inter-individual variability in exposure responses. Recent advances in the field of epigenetics have placed us on the verge of a new era that holds the promise of understanding risk on the basis of factors such as exposure history, diet, and socioeconomic status, among others. Epigenetic regulators, such as chromatin modifications and DNA methylation, function as dynamic master regulators of gene expression that shape the way that cells, tissues, and individuals respond to chemical exposures. While some epigenetic modifications are stable and have the potential to persist throughout an individual's lifetime and across generations, others are pliable and offer the potential to identify modifiable risk factors that could be used to ameliorate exposure-associated disease. Further, specific patterns of epigenetic modifications can be used as biomarkers of inherent (biological) susceptibility. This presentation will feature data demonstrating the utility of specific epigenetic modifications as predictors of exposure responsiveness. This presentation will also discuss the recently proposed "epigenetic seed and soil model", which integrates intrinsic and environmental influences on the epigenome with exposure effects, as a framework for understanding how cumulative effects on the epigenome impact disease susceptibility. Overall, furthering our understanding of the relationship between the epigenome, exposure effects, and susceptibility will open the door to the next generation of risk assessment and prevention.

W2-D.3 McLaughlin, CF; U.S. Food and Drug Administration;
cristina.mclaughlin@fda.hhs.gov

Measuring the Benefits of FDA Import Inspections

The United States Food and Drug Administration (FDA) inspects thousands of shipments of imported food each year. The benefits from these inspections include preventing the entry of shipments found to be contaminated and deterring importers from attempting to bring contaminated food into the country. As a first step towards a full measure of these benefits, we constructed a measure of the human health benefits from preventing the importation of food found to be contaminated with pathogens such as Salmonella. The public health benefits from preventing the consumption of contaminated food arise from non-events or the illnesses that do not occur. That is, the public health benefits arise when illnesses that would otherwise occur in the absence of FDA action do not occur. To assess these benefits, we must therefore place a value on the risk reduction that has already taken place, or for health-related costs of illnesses that did not take place. The conjectural nature of the risk reduction suggests that any estimate of health benefits from interdicting contaminated food shipments or limiting the distribution of such food shipments must be uncertain. We made the uncertainty explicit by using Monte Carlo simulations to estimate benefits. Before we present the results of the simulations, we explain the method of calculating a single point estimate of the health benefits associated with preventing the distribution and consumption of contaminated food in the U.S.

W3-J.2 McDaniels, TL; University of British Columbia;
timcmd@exchange.ubc.ca

The crying gap in governance for building regional infrastructure resilience in extreme events

This presentation addresses an under-recognized but profoundly important gap in governance that could be crucial for building resilience to extreme events in cities and urban regions. This gap arises in the context of potential infrastructure failure interactions, in which failures in one infrastructure system (such as electric power) lead to failures in other regional systems (such as water supply or public transportation). Since the Kobe earthquake the role of infrastructure failure interactions has been increasingly recognized. Empirical research has been conducted to explore how such failure interactions arise, which are most prevalent and to understand their persistent impacts. Here we will discuss two empirical cases we conducted in British Columbia that point to the lack of governance mechanisms for interactions that may arise in extreme events. We document an approach to help set priorities for mitigation efforts that could reduce persistent adverse events that extend and prolong the adverse consequences of extreme events. We then turn to discussion of governance analogies that shown successful management of potential impacts on commons resources in terms of regional resilience. We review examples of managing electrical industry reliability as one extreme example of how industries have cooperated in the past to maintain resilience. Finally we turn to cooperative models, tax strategies and other mechanisms that could help establish the regulatory arena to improve regional resilience for infrastructure systems.

M4-G.1 McMullin, TS*; Bamber, A; Flores, J; Vigil, D; VanDyke, M; Colorado Department of Public Health and the Environment;
tami.mcmullin@state.co.us

Addressing Colorado's Public Health Concerns on the Potential Health Risks of Hydraulic Fracturing Through Surveillance and Science

Colorado's population growth along with increased hydraulic fracturing (HF) operations in densely populated areas has elevated public and policy makers concerns about the potential health effects of HF to local communities. To date, there are limited published exposure and health risk data at the community level and many health risk uncertainties still remain with insufficient evidence to guide regulatory decisions. In response to these issues, the State of Colorado has established a new program to address these important public health knowledge gaps. A main goal of this program is to conduct surveillance of citizen health concerns. Currently, the main symptoms reported to the program include ocular, nasal, respiratory, neurological and gastrointestinal effects. In addition to surveillance, the success of this program in addressing health concerns has been through the development of exposure and risk assessment tools and fostering collaborative relationships with multiple stakeholders, including other state and local government agencies, industry and the public to bring solutions. Single ambient air samples during times when citizens believe they are experiencing symptoms suggest that some compounds may approach odor thresholds but generally do not exceed short and long term health risk screening levels. Although many uncertainties still exist, a preliminary evaluation of multiple ambient air samples in Colorado from 2008-2016 suggest that the majority of volatile organic compounds that may be emitted from HF are well below screening health levels but a sub-set of compounds may warrant further exposure characterization and health evaluation. We have also used newly developed scientific approaches to conduct a consistent, systematic review of health outcome literature. Overall, this presentation highlights how a state can develop pragmatic scientific solutions to address citizen health concerns potentially related to emissions from HF.

W2-A.5 Melick, K; Fu, Z; Igusa, T*; Garzon, JL; Ferreira, CM; Dewberry, Johns Hopkins University, George Mason University; tigusa@jhu.edu

Identification of critical storms conditions for hurricane-induced coastal surge in the Mid-Atlantic Region

It is useful to classify hurricanes according to their potential to generate damaging coastal surge. Such classifiers are needed in practice to rapidly assess incoming tropical storms; in research they can be used as a screening tool to identify storms that would be of most interest in the analysis of regional hazards. In this presentation, we show how the framework in (Irish, et al., 2008) can be extended to a classification algorithm suitable for the Mid-Atlantic, including the inland coasts. For the storm characteristics, we use central pressure deficit, radius of maximum wind speed, forward speed of the storm, Holland's B as a measure of the peakedness of the distribution of the storm wind speed (Holland, 1980), and the heading direction. These are the primary inputs to planetary boundary layer models that are needed in the computation of wind and pressure fields that were consequently used to as input into hydrodynamic models such as the ADvanced CIRCulation (ADCIRC) long-wave hydrodynamic computational tool (Luettich, et al., 1992; Westerink, et al. 1992). We use a spatial profile of the coastal surge that is dependent on the distance from a location on the coast that is offset from storm landfall. For the ocean coast, we use an exponential profile that is a simplification of the profile used by (Irish et al, 2008). For the inland coast (of the Chesapeake Bay), we use a profile that is location-dependent. This is necessary because of the substantial influence of local coastal characteristics on storm surge. We find that the residuals obtained by subtracting the profiles with storm surge are approximately Gaussian with significant spatial correlation. The variogram was found to follow a power model. We used maximum likelihood to determine the parameters for the mean spatial profile and variogram. A subset of these parameters were found to have significant dependence on location, particularly in some of the inlet regions of the Chesapeake Bay.

W3-B.3 Merad Myriam, ; INERIS; myriam.merad@ineris.fr
From problems to solutions: experience feedback on the use of multiple criteria decision aiding methods to assess risks

The great majority of decision aiding methods tends to structure the decisional aid process into three principal phases: • Formulation of decision-aid problems, • Exploitation, and • Recommendations. Formulating a risk problem (eg. Risk assessment or risk management) should start by: • Describing the decision making context and process. This requires the identification of the actors and the stakeholders, their value systems and the different significant points that affect the decision making process which can vary in time. • Defining the actions that are elements of decision-making. • Identifying decision making situations by looking at how the recommendation or the results should be presented. • Identifying the spirit in which the decision aid process was designed. • Defining a set of criteria and a set of indicators, modeling the consequences of actions and drawing up criteria in order to compare the different actions with each other. This first phase is undoubtedly the most sensitive, because the conclusions reached and the recommendations provided depend on the way in which the risk is defined and described. The second phase is more mathematical; The so-called operational phase consists of defining or choosing an "aggregation procedure" for the available information for each action with the aim of reaching an overall conclusion (recommendation) that will provide decision support. Based on practical risk assessment and risk management case-studies, we will discuss the advantages and limits of different aggregation procedures. De

W2-E.2 Merad Myriam, *; Aven Terje, ; INERIS; myriam.merad@ineris.fr

Reflections on assessment frameworks for safety and security risk prevention actions and public risk prevention policies

Objectives This paper aims at: a) Identifying the advances and developments, over the past forty years, in risk prevention in the field of safety, security and the environment - health (SSEH). b) reporting on the difficulty of defining new assessment frameworks of risk prevention actions and public risk policies in SSEH. c) suggest a new assessment framework of risk prevention actions and public risk prevention policies. **Context** The analysis of the State of art shows that: - devices as well as public policy in risk prevention and management has become a common framework to analyze complex problems in SSEH. Segmentations of risks areas have conditioned the structuring of expertise and decision problems and have closed de facto the scope of possible solutions; - the fields of the risk prevention in SSEH fall within the scope of the public sphere. In this sense, the State and its services remain under increasing scrutiny of civil society; facing both a transformation of the legitimacy of their actions and at the same time a downward trend in the public funds. - approaches to public policies analysis such as the RIAs , economic analyses, risk perception studies rely on partial indicators, and are in some situations relatively not sufficiently robust and flexible, when facing different types of uncertainties. These approaches offer a limited place to citizen participation; - risk prevention policies have focused, these last 15 to 20 years on the principles to_ in theory_ "optimize the administration and the management of risks " of State' services as well as broadly the economic sphere. These underlie principles have in different situations led to the progressive removal of three spheres: the theory of risk in SSEH, the regulation of risks as well as operational practices in risk management.

T4-E.5 Miller, S; Gurian, PL*; Daley, J; Elwell, H; Matsil, M; Montalto, F; Drexel University; pgurian@drexel.edu
Managing Risk to Buildings from Coastal Storms: Lessons Learned from Hurricane Sandy

This study investigates the effect of NYC coastal green infrastructure on the risk of building damages during Hurricane Sandy. Specifically, whether damages can be adequately predicted using discrete physical relationships, such as topographic elevation, distance to the coast, or proximity to a green space. This study examined three study sites – Coney Island, Brooklyn; Rockaway, Queens; and the South Shore of Staten Island. Binomial logistic regression was used to estimate the probability that a structure sustained damage conditional on different explanatory variables. Large scale landscape features were not consistently associated with increased or decreased risk. Distance from the coast was associated with a significant decrease in risk for Coney Island, a significant increase in risk for the Rockaways, and no significant effect for the South Shore of Staten Island. Elevation significantly increases risk on Coney Island but had no significant effect at either of the other sites. These inconsistencies suggest an important role for the exact physical configuration of the landscape which is confounded with the simple measures of distance and elevation. The study also finds that small scale features are significantly associated with damage probabilities. On the Rockaways tree cover is significantly associated with lower risks of damage, on Coney Island bare ground is significantly associated with an increased risk of damage, and on the South Shore both tree cover and bare ground have significant effects on risk of damage (lowering and increasing risk, respectively). While large scale landscape features such as elevation and distance from the coast are difficult to modify, these small scale, lot-level characteristics can be modified by property owners and municipalities.

W3-D.3 Minor, T; Parrett, M; Sassi, A*; Vardon, P; Food and Drug Administration; *Aliya.Sassi@fda.hhs.gov*

A Retrospective Analysis of the Costs and Benefits of FDA's Juice HACCP Rule

The Food and Drug Administration (FDA) published a final rule in January 2001 titled Hazard Analysis and Critical Control Point (HACCP); Procedures for the Safe and Sanitary Processing and Importing of Juice (the Final Juice Rule) aimed at ensuring the safe and sanitary processing of fruit and vegetable juices by requiring the application of HACCP principles to juice processing. This rule, which became effective in January 2002, was issued in the wake of a large number of documented foodborne illnesses associated with juice products, particularly in the 1990s. In this retrospective analysis of the Final Juice Rule, we revisit the costs and benefits of the Final Juice Rule using new data sources and techniques and compare these cost and benefit estimates with those which were estimated by the FDA in their final regulatory impact analysis of the Final Juice Rule.

P.100 Miranda, R*; Schaffner, DW; Rutgers, The State University of New Jersey; *robym14@scarletmail.rutgers.edu*

Data Resources for the Development of a Quantitative Microbial Risk Assessment for Norovirus in Foodservice facilities

Norovirus is a highly contagious virus and presents an increased risk to the elderly, young children, and the immunocompromised. Norovirus can be spread through contaminated food, water, and virus particles in vomit or feces. Norovirus is most commonly spread through direct contact. This can include shaking hands, caring for someone who is sick or sharing drinks or utensils. Norovirus can survive on surfaces for weeks and some disinfectants are less effective in eliminating the virus. This research project develops mathematical models to predict survival, spread and cross-contamination of Norovirus in food production, processing and handling environments from published literature data and combines those models into a quantitative microbial risk assessment (QMRA) framework to assist in Norovirus risk management efforts. The data are extracted from tables or figures provided in the literature as they pertain to the conditions of interested. Data from the literature include viral shedding, survival of Norovirus on food and surfaces, prevalence in water and food, disinfectants and inactivation treatments, dose response models, hand hygiene, and environmental factors. Data from outbreaks are used for model validation. Validation will be considered successful if we are able to recreate past Norovirus outbreaks given reasonable assumptions regarding the starting conditions. The software platform used for the development of the QMRA is AnyLogic. This software supports system dynamics models, process-centric (or discrete event) models, and agent based modeling. Its modeling language allows the description of complexity and heterogeneity to a variety of level of detail. The software uses a graphical interface, tools, and library objects to model food retail, foodservice or manufacturing as well as human resources and consumer behavior. The object-oriented model design paradigm provides for a modular and hierarchical designed, and incremental construction of large models.

M2-B.3 Mishra, A*; Pang, H; Buchanan, RL; Schaffner, DW; Pradhan, AK; University of Maryland and Rutgers University; *amishra1@umd.edu*

A system modeling approach to estimate the risk of E. coli O157:H7 contamination of pre-harvest leafy greens

A majority of foodborne outbreaks in the U.S. associated with the consumption of leafy greens contaminated with *E. coli* O157:H7 have been reported during July-November. A dynamic system model consisting of subsystems and inputs to the system (soil, irrigation, cattle, wild pig, and rainfall) simulating a hypothetical farm was developed. The model assumed two crops of lettuce in a year, and simulated planting, irrigation, harvesting, ground preparation for the new crop, contamination of soil and plants, and survival of *E. coli* O157:H7. The concentrations of *E. coli* O157:H7 in the crops harvested in different months as predicted by the baseline model for conventional fields estimated that 11 out of 221 (4.98%) first crops harvested in July will have at least one plant with more than 1 CFU of *E. coli* O157:H7. The maximum *E. coli* O157:H7 concentration in a plant was higher in second crop (150 CFU) than in first crop (113 CFU), with the probability of having at least one plant with more than 1 CFU of *E. coli* O157:H7 in a crop predicted as 21/253 (8.3%), 4/333 (1.2%), 11/307 (3.58%), and 6/105 (5.71%) in August, September, October, and November, respectively. For organic fields, the probabilities of having at least one plant with more than 1 CFU of *E. coli* O157:H7 in a crop (3.9%) were predicted to be higher than those for the conventional fields (2.65%). Results of the presented system model indicate that the seasonality of *E. coli* O157:H7 associated outbreaks was in good agreement with the prevalence of this pathogen in cattle and wild pig feces. The current system model also suggested that probability of presence of *E. coli* O157:H7 in the harvested crop was higher during July-November. On the basis of comparison between the results of different scenarios, it can be recommended that risk of *E. coli* O157:H7 in leafy greens can be reduced considerably if contamination of soil with wild pig and cattle feces is mitigated.

T4-F.5 Mitchell, JB*; Rose, JB; Donahue, D; Michigan State University; *jade@msu.edu*

Expert Evaluation of the Water Crisis in Flint, Michigan

In 2013, a decision was made to switch the source of the City of Flint's drinking water from the Detroit Water and Sewer System to the Flint River, which has high organic matter content. There were devastating immediate and longer term effects which began in April 2014, with residents reporting problems with taste, odor, and color; and subsequently three boil water orders by the fall of 2014. Following this, increased chlorine levels to reduce bacterial loading resulted in exceedance of regulatory standards for disinfection byproducts. The treated water was highly corrosive leading to leaching of pipe materials within the distribution system, especially lead service lines at aging homes. Water testing efforts through citizen science revealed tragically higher lead levels than established safe limits in drinking water and shortly thereafter the discovery of children with elevated blood lead levels within the City were confirmed. Furthermore, amass conditions known to support the proliferation of opportunistic pathogens, a *Legionella* outbreak sickened 91 people in confirmed cases from June 2014 to date. In January 2016, Governor Rick Snyder and President Barack Obama declared a state of emergency in the city of Flint, Michigan. In response to the emergency status of the city, many researchers and institutions have stepped in to collect data on harms and provide interventions in reducing harms. Questions on such topics as risk based decision making; regulatory oversight; risk governance and management; trust and risk communication are being addressed in light of the occurrence of such a crisis and the ensuing fallout.

M3-D.4 Monast, J; Murray, B; Wiener, JB*; Duke University;
wiener@law.duke.edu

Markets, Morals, and Climate Change

Markets are attracting both favor and criticism as an economic incentive instrument to address climate change and reduce greenhouse gas emissions. Climate markets (e.g. cap and trade, emissions trading, allowances, quotas, credits) are expanding around the world, including in Europe (the ETS), the USA (California, RGGI, and the EPA Clean Power Plan), China (its seven pilot programs and proposed national market), and elsewhere. The Paris Agreement (2015) includes Article 6 endorsing international mitigation transfers. Yet there is also criticism, including in Pope Francis' 2015 Encyclical (paragraph 171, opposing carbon credits as a ploy that may hurt the poor while doing little to reduce actual emissions), and in moral and ethical debates about emissions trading as licensing the right to pollute. This paper assesses the moral arguments about climate markets. It addresses the history of support and opposition to market-based environmental policy design; the virtues of climate markets; the moral critiques of climate markets; potential responses to these moral critiques; and ways that market-based climate policy might be (re)designed to help reconcile these points of view.

M2-C.3 Montibeller, G*; Jaspersen, J; Loughborough University;
g.montibeller@lboro.ac.uk

Increasing the Behavioral Validity of Counter-Terrorism Risk Analysis Models

A recent trend in adversarial risk analysis is to focus on modelling decision making processes of terrorists and terrorist organizations, by considering their objectives and preferences, their judgments, or the sequence of actions that they may take. In the first part of this talk we will review some of the key assumptions made in such models and contrast them with empirical evidence on terrorist behavior (drawn from behavioral decision theory, political science and related fields). This review shows a gap between normative assumptions of full rationality that are employed in many models of adversarial risk analysis in contrast to the behavioral evidence of boundedly rational agents. This conceptual gap has led to a growing concern on how to increase the validity of attackers' behavior in such models, which may help to improve the predictive power of such models. However there is still a dearth of empirical analysis of behavioral models based on actual behavior of terrorist organizations. To help to address this gap, in the second part of this talk we will present some early results of a study on how the selection of targets for bomb attacks by terrorist organizations can be explained by a simple model of reinforcement learning adopted from behavioral game theory. We employ a large database of evidence about terrorist attacks and show that the model on average outperforms alternative prediction models based on historic attack patterns. Our model performs particularly well if the argument of the value function is closely aligned with the ideological goals of the organization. We draw implications for game theoretic as well as decision theoretic models in counter-terrorism applications.

W4-F.4 Montibeller, G*; Franco, LA; Loughborough University;
g.montibeller@lboro.ac.uk

Supporting the Prioritization of Emerging Animal Health Threats for the UK Department of Agriculture

Emerging animal health threats, such as new strains of avian influenza or of swine fever, pose serious risk to humans and countries, due to their potential to critically impact public health, society, and the economy. Indeed, policy makers face many challenges when needing to managing such threats. Firstly, their emerging nature means that gathering enough reliable evidence about impacts and the probability of an outbreak can be extremely difficult. Secondly, these threats require regular but careful prioritization, given the scarce resources available for deploying risk mitigation actions. Thirdly, policy makers are often concerned with multiple impacts that go beyond health and economic consequences, including issues related with public perception and capability building, and this requires a rigours and systematic consideration of the limited available hard evidence combined with experts' judgments. To address these challenges, we employed a decision analytic framework to develop a risk management support system to help the UK Department of Agriculture (DEFRA) with their prioritisation of emerging animal health threats. It employs multi-attribute value functions to assess the actual and perceived impacts caused by a threat as well as the organizational capabilities available to manage it. The probabilities of outbreaks are elicited from experts via an ordinal rank of likelihoods. The system provides an effective mechanism for ranking these threats and support the design of policy recommendations. The system is supporting the recommendations of Defra's Veterinary Risk Management group since 2009, when it was embedded into their decision making process, evaluating since then a large number of threats in the UK. Benefits for the client organisation include making the evidence gathering more rigorous and systematic, the assessment more transparent, the recommendations more justifiable, and their decision process more streamlined.

P.15 Moody, Joel; Electrical Safety Authority;
joel.moody@electricalsafety.on.ca

Understanding cause and outcomes of electrical injuries at Institutions from an Epidemiological Perspective

This paper will be presented by the Electrical Safety Authority (ESA), who is responsible for enhancing public electrical safety through training, inspection, authorization, investigation, registration, enforcement, audit, and other regulatory and non-regulatory public electric safety quality assurance services. ESA will discuss the causes and outcomes of injuries sustained by occupants at these locations due to electrical technologies using a population based epidemiological perspective.

W4-D.1 Moore, MA*; Boardman, AE; Vining, AR; Simon Fraser University (Moore and Vining); University of British Columbia (Boardman); *markm@sfu.ca*

Pricing risk in benefit-cost analyses of public sector projects and regulations

Policy analysts regularly evaluate the effects of government projects and regulations on social welfare using benefit-cost analysis (BCA). Inter alia, this requires analysts to project uncertain or risky future expected net benefits and to express these in present values using a social discount rate (SDR). In this paper, we consider what types of public sector risk can occur and which risks matter for BCA. "Small" projects and regulations with only idiosyncratic risks should be evaluated by discounting expected net benefits at a risk-free SDR. If projects are "large" or have expected net benefits that are correlated with aggregate consumption, then analysts face the problem of how to correctly price these risks. The alternatives are: to replace expected net benefits with their certainty equivalents and to discount these at a risk free SDR; or to discount expected net benefits using a higher SDR that includes a premium for risk. The latter is a straightforward extension of the private sector's capital asset pricing model to the problem of public sector BCA. We show that the two alternatives are equivalent only under extremely special circumstances that are unlikely to hold in practice, and that the first approach is generally the correct one. We examine when replacing expected values with certainty equivalents will matter, and how this might be done in practice.

P.85 Msibi, SS*; Chuang, YC; Wu, C; Wu, KY; National Taiwan University; *siveskhulu@gmail.com*

Probabilistic health risk assessment of

2-amino-3,4-dimethylimidazo[4,5-f] quinoline on fish consumption
2-Amino-3,4-dimethylimidazo[4,5-f] quinoline (MeIQ) is a heterocyclic amine formed during the condensation reaction of creatinine and amino acids. It is formed during cooking of meat and fish. Thus the general public is exposed to the compound through the ingestion of such foods. It was found in different concentration in different types of meat. Sun-dried sardines were found to have the highest concentration of the compound. Cooking method of the meat and fish have been found to have an impact on the concentration of the compound, as studies have shown that pan-frying and grilling/barbecuing, yield higher levels of the compound. The concentration of the compound also depends on the cooking temperature and time. Generally, higher temperatures and longer cooking times increase the amount of all heterocyclic amines produced during cooking. Studies have shown that MeIQ is a potent mutagen as it tested positive to the Ames test. In several toxicology animal studies, it was found to be a carcinogen as there were significant incidence of fore-stomach, liver and intestine tumor formation in the experimental groups. There is no sufficient data available on the carcinogenicity of the compound on humans, thus the compound is currently reasonably anticipated to be a human carcinogen. Exposure to MeIQ via fish consumption was calculated using world population consumption rate data. After extrapolation using data from CDF1 mice study, the human BMDL10 was calculated to be 0.299 mg/kg/day, with a cancer slope factor (CSF) of 0.334 (mg/kg/day)⁻¹. Data on the consumption rates of marine and freshwater fish consumption was pooled together. The life-adjusted daily dose (LADD) was reported to be 2.71 x 10⁻⁶ mg/kg/day, at 95th percentile, with an estimated risk of 9.1 x 10⁻⁷. The risk of getting cancer from the consumption of meat and fish is very low. However, this risk may be compounded by other factors and other carcinogens found in the diet and environment.

P.101 Mraz, AL*; Weir, MH; The Ohio State University; *ALEXIS.L.MRAZ@GMAIL.COM*

Quantification of the Effect of 17 β -estradiol on Escherichia coli and Enterococcus faecalis Survival and Persistence in Water
Endocrine disrupting chemicals (EDCs) are known to have a disparate set of negative effects on human health, such as early onset puberty, infertility and certain cancers. In an attempt to remove EDCs from the environment, particularly water systems, the effects of bacteria on EDCs have been studied for decades. However, there is little information on the effects EDCs have on microbial communities. Through a greater understanding of EDCs' effects on microbiology and microbial ecology we can develop a first step to a greater understanding of wider EDC effects and how best to combat them. For example, this can help inform EDC removal processes to combat human health effects caused by EDCs, and better understand the effects on the human gastrointestinal flora. Performing a survival analysis of Escherichia coli and Enterococcus faecalis when exposed to varying levels of 17 β -estradiol and conducting a genetic analysis of those bacteria can inform the underlying health effects of EDCs, and the best way to treat EDCs before health effects occur. Modeling survival and persistence of common bacteria can provide an accessible projective model to inform future science and decision-making efforts to other researchers, scientists, engineers, regulators and the general public.

P.5 Murayama, T, TM*; Toshida, M, MT; Tokyo Institute of Technology; *murayama.t.ac@m.titech.ac.jp*

Estimation of human risks induced by chemical accidents

While environmental risks induced by dispersion of chemical substances from factories in normal condition are estimated and managed with some data such as PRTR system, it is still under development process to manage impacts generated through discharge of hazardous substances in emergency situations such as accidents and earthquakes. After identifying the target substance and factory in a prefecture, we estimated environmental risks which included casualty and health impact by the acute effect, as well as distribution of risk levels considering the annual probability and population based on wind and other atmospheric conditions. The results suggest that casualty risk would be higher within around 1 km, and the estimation could be suitable to understand distribution of risks.

T3-A.4 Murphy, S*; Apt, J; Carnegie Mellon University; sjmurphy@andrew.cmu.edu

Correlated power plant failures in North America

We analyze historical generator availability data from the North American Electric Reliability Corporation's (NERC) Generator Availability Data System (GADS) to construct an hourly time series of unavailable capacity from unscheduled generator failures for North America from 2012 through 2015. The units reporting to GADS represent 85% of installed generation capacity in the conterminous United States and Canada. Unscheduled unavailable capacity on typical days is ~5% of installed capacity, but this base rate and its variance is regionally specific. Significant events such as storms cause up to 22% of installed capacity in some regions to become unavailable on an unscheduled basis. We present probability distributions of unscheduled failures disaggregated by geographic region and generator attribute, finding that the histograms of unscheduled unavailable capacity are moderately well modeled by lognormal fits. We also present data on the number of failures per generating unit per year, disaggregated by geographic region and generator attribute. We analyze the time series of unscheduled unavailable capacity to determine resource adequacy risks of correlated generator failures in the eight North American NERC regions. Currently, system planners determine capacity needs by calculating an availability statistic separately for each unit in their system and then using these values as inputs to simulation or convolution methods. Such an approach implicitly assumes that generator failures are independent. We find that this assumption generally does not hold and examine alternative approaches for improving the estimation of future capacity needs.

P.86 NAITO, W; National Institute of Advanced Industrial Science and Technology; w-naito@aist.go.jp

Measuring, Assessing and Communicating Individual External Doses in the Evacuation zone in Fukushima

Five years after the Fukushima nuclear disaster, the radiation levels have greatly decreased due to physical decay, weathering, and decontamination operations in the affected areas in Fukushima. In order for the government to lift the evacuation order and for individuals to return to their original residential areas, it is important to assess current and future realistic individual external doses. In this study, we used personal dosimeters along with the Global Positioning System and Geographic Information System to understand realistic individual external doses and to relate individual doses, ambient doses, and activity-patterns of individuals in the affected areas in Fukushima. The results showed that the measured individual doses were well correlated to the ambient doses based on the airborne monitoring survey. The results of linear regression analysis suggested that the additional individual doses were on average about one-fifth that of the additional ambient doses. The reduction factors, which are the ratios of the individual doses to the ambient doses, were calculated to be on average 0.14 and 0.32 for time spent at home and outdoors, respectively. We have developed a user-friendly tool using the obtained data to assess and communicate the individual external doses among various stakeholders. Our results and the tool are a valuable contribution to understanding and communicating realistic individual doses and the corresponding airborne monitoring-based ambient doses and time-activity patterns of individuals.

M2-H.4 Nagai, Y; The University of Tokyo; nagai.yuichiro.01@gmail.com

Interconnected risks in space and cyberspace

This research will deal with the interconnected nature of risks in space and cyberspace as medium that may potentially diffuse the risks to other critical sectors of society. Outer space and cyberspace are the domains on which our modern society is deeply reliant in many facets. The two domains have an interconnected nature with each other, as well as with other critical sectors. Cyberspace consists not only of computer network but also of electromagnetic spectrum, including uplink/downlink of satellite and Global Navigation Satellite System (GNSS) services. In other words, space system can be considered as a connective tissue of cyberspace. This connective nature represents potential risks, which may have adverse effects on other critical sectors in case that something happens in outer space. For example, disruption or loss of Global Positioning System (GPS) services may have huge effects on many other critical sectors of society (land/marine/air transportation, commercial aviation, emergency response, military operation, financial transaction, and so on), and may cause unexpected consequences through both physical impact on critical infrastructures and human behavior affected by the events. This study will describe such interconnected risks in the areas of space and cyberspace, and will consider what will happen in case that something happens in these domains.

T3-A.3 Nateghi, R; Guikema, SD*; Wu, Y; Bruss, B; University of Michigan; sguikema@umich.edu

Critical Assessment of the Foundations of Power Transmission and Distribution Reliability Metrics and Standards

The U.S. federal government regulates the reliability of bulk power systems, while the reliability of power distribution systems is regulated at a state level. In this article, we review the history of regulating electric service reliability and study the existing reliability metrics, indices, and standards for power transmission and distribution networks. We assess the foundations of the reliability standards and metrics, discuss how they are applied to outages caused by large exogenous disturbances such as natural disasters, and investigate whether the standards adequately internalize the impacts of these events. Our reflections shed light on how existing standards conceptualize reliability, question the basis for treating large-scale hazard-induced outages differently from normal daily outages, and discuss whether this conceptualization maps well onto customer expectations. We show that the risk indices for transmission systems used in regulating power system reliability do not adequately capture the risks that transmission systems are prone to, particularly when it comes to low-probability high-impact events. We also point out several shortcomings associated with the way in which regulators require utilities to calculate and report distribution system reliability indices. We offer several recommendations for improving the conceptualization of reliability metrics and standards. We conclude that while the approaches taken in reliability standards have made considerable advances in enhancing the reliability of power systems and may be logical from a utility perspective during normal operation, existing standards do not provide a sufficient incentive structure for the utilities to adequately ensure high levels of reliability for end-users, particularly during large-scale events.

M2-A.4 Nateghi, R; Purdue University; mateghi@purdue.edu
Electricity demand analysis in the residential sector

Electric demand forecast is a critical component in adequacy planning of the energy infrastructure. Electric power demand is categorized into four clusters of residential building sector, commercial building sector, Industrial sector and transportation. While the residential building-stock accounts for a significant portion of the total electricity use, its characteristics and main drivers are least understood compared to other sectors. Residential demand is a function of complex interactions between climatic, demographic, socio-economic and technological factors. In this paper, statistical learning methods are leveraged to identify the key factors that drive residential electricity consumption using the EIA Residential Energy Consumption Survey (RECS). The model's insights are important for assessing future residential electricity demand risks and can have great policy implications.

P.182 Naufal, Z; Blake, U*; American Petroleum Institute; blakeu@API.org

Air Quality and Unconventional Oil and Natural Gas Development: A Systematic Review of the Literature from a Public Health Perspective.

The expansion of oil and natural gas development from unconventional resources in the US brought significant benefits along with increased scrutiny by academicians, NGOs, and regulators. Air emissions associated with Oil and Gas operations and their potential impacts on human health and the environment is among the cited concerns. A number of studies on ambient air quality and oil and gas emissions have been conducted in several major unconventional oil and natural gas development areas in the US. By using the measured air quality data as surrogate for personal exposures, some of these studies have attempted to determine whether associations exist between concentrations of air pollutants near oil and gas operations, and human health effects in neighboring communities. A systematic review of peer-reviewed published studies (January 2008 – June 2016) and a qualitative analysis (due to the heterogeneity of the studies) of the ambient data was conducted to assess the usability and generalizability of the data as surrogate for personal exposures. Based on defined inclusion/exclusion criteria, a total of 25 out of over 400 identified peer-reviewed studies were determined to be eligible for review. Our findings suggest that there are clear limitations that hamper the applicability of the current data in elucidating the relationship between oil and natural gas industry activities, ambient air quality, and implications to public health. This review also outlines the challenges to generalizing study findings by highlighting the importance of temporal and spatial variability in air emissions from industry operations.

P.171 Nguyen, KD*; John, RJ; University of Southern California; hoangdun@usc.edu

Aviation Security: Examining the Effects of Agent and Screening Procedure on Perceptions of Risk, Safety, and Fairness

Public perception about airport security screening is an important factor to determine the continuance of aviation security policies. Although the TSA have been using many different security screening polices, there is a lack of research to describe how travelers perceive these measures. Applying Organizational Justice Theory, we hypothesized: a) a randomized screening procedure is perceived as being fairer, both procedurally and distributively, than either a profiled-based or a behavioral screening, b) computerized screening is viewed as being more procedurally fairer than human screening. We also explored the effects of different screening procedures and human vs. computer on perceptions of personal risk and safety as well as the effects of fairness on policy satisfaction. Six-hundreds respondents from Amazon Mechanical Turk were randomized into one of a 2 (Human vs. Computer) by 3 (Randomized vs. Behavioral vs. Profiled Screenings) conditions. They read a description of a hypothetical screening policy and rated the policy on several dimensions. The results provide partial support for both hypotheses. Interestingly, there was an interaction effect. Randomized screening was perceived as being more consistent and more equal in distributing screening costs than the other two procedures, and this effect was larger when the screening was conducted by a computer than by a human. Randomized screening was also perceived as being safer than the other two screenings. Respondents believed they have a lowest risk of being selected for a security screening under a behavioral procedure than under a profile-based procedure. Mediation analyses suggest that perceptions of procedural fairness and distributive fairness partially mediate the effects of screening consistency and equal distribution of screening cost on satisfaction with airport screening policy, respectively. These findings have important implications for the design of future security screening policies.

M2-F.2 Nicol, AM*; Brokaw, WA; Simon Fraser University; anicol@sfu.ca

Communicating radon risk: from workplace to community testing

Radon gas is the second leading cause of lung cancer in Canada overall and the primary cause of lung cancer for non-smokers. Many educational initiatives have been developed to encourage people to test their homes as radon is a colorless, odorless, radioactive gas which can only be detected through monitoring. While awareness of radon is increasing in Canada, national research has found that, in 2013, only 45% of people were aware of radon gas and just over half of this group (53%) were able to correctly identify what radon actually is. Unfortunately, only 5% of Canadians have reported testing their homes. This research project examined the opportunity of linking workplace testing initiatives to home testing, as many government agencies are testing workplaces such as offices, law enforcement, schools, utilities and public health facilities for radon gas across the country. Drawing from experiences in two provinces, this work reports on the challenges and successes of using occupational radon programming to drive residential testing protocols.

M4-J.2 Niles, MT; University of Vermont; mtniles@uvm.edu
Farmer experiences and perceptions of climate change influence adaptive behaviors

Farmers are a population of individuals potentially slated to be heavily affected by climate change since agriculture is vulnerable to climate impacts. Smallholder farmers in the developing world are particularly susceptible given fewer technologies to manage risk and production and the high reliance of these farmers on their own production for food security. A large body of work has developed to understand how farmers may respond to climate change and what influences this. However, most of this research remains focused on one region and often at the household level. Thus, most current studies can't distinguish what varying factors across places and genders may differentially influence adaptive behaviors. In this study I examine data across three countries (Kenya, Uganda, and Senegal) to understand how biophysical variables including different experiences, agroecosystems, and climatic contexts as well as demographic characteristics including gender, household size, farm size, education, and income may influence farmer perceptions of climate change and adaptation behaviors differently. Using survey results from 800 households in which male and female occupants were interviewed separately (total n=1616). I apply the "limiting factors hypothesis", which suggests that farmers will be motivated to change behavior in response to potential changes to the most limiting factor in their system (e.g. water, temperature, pests, etc.). Using structural equation modelling I demonstrate the relationships between farmer experiences, climate beliefs, future climate concerns, and adaptation responses and their variations across regions and gender. I conclude by discussing the potential policy implications of the results and the broader theoretical context for risk analysis and behavior change.

M2-J.6 O'Neill, PF; RiskLogik; pfoneill@live.ca
Building Resilience by Means of Risk Analysis

Resilience is the ability of systems and organizations to maintain an acceptable level of service in spite of crises or adverse operating conditions and to recover quickly in the event that service falls below acceptable standards. By creating network models of infrastructure, resources and processes, it is possible to prioritize risks and identify critical vulnerabilities in organizations and systems. Subsequently, network models can be used to create effective plans for achieving resilience. The main idea is to use directed graphs to construct network risk models. Methods and tools for building and analyzing such models will be presented along with results of actual case studies from both the public and private sectors.

P.31 Norrman, J*; Söderqvist, T; Volchko, Y; Rosén, L; Franzén, F; 1, 3, 4) Chalmers University of Technology; 2,5) Enveco Environmental Economics Consultancy; jenny.norrman@chalmers.se

Implementation of a decision support tool for sustainable remediation in practice - lessons learned

Sustainable Choice of REmediation (SCORE) is a multi-criteria decision analysis tool developed for evaluating economic, environmental and social sustainability of remediation strategies at contaminated sites. In the SAFIRE research project, SCORE is applied and evaluated in five real case studies to compare and evaluate the potential remedial strategies, with input from and together with stakeholders. One of the case studies is the Southern area of the BT Kemi industrial site in Teckomatorp in the municipality of Svalöv, Southern Sweden. The company BT Kemi manufactured pesticides from 1965 and secretly buried oil drums with organic pollutants. The site is associated with a famous Swedish environmental scandal culminating in 1977. The factory was closed, but although the site was remediated at that time, the site is today still not fully remediated and the final remediation will take place in the 2-3 coming years. The project is publicly funded and is run by the municipality. In the project, it is acknowledged that psychology is an important factor, and one of the main goals of the project is to change the attitude towards the village and the bad reputation. SCORE is applied in the Southern area of the BT Kemi site. Social sustainability is evaluated with selected stakeholders in a workshop, the economic sustainability is evaluated by means of a cost-benefit analysis with input from stakeholders, and the ecological sustainability is evaluated together with consultants and the project leader based on the environmental risk assessment. Additional information from the public for the assessment of social and economic sustainability is collected by means of a questionnaire. Feedback on the process, the SCORE tool and its input into the decision process is collected after the SCORE analysis. The lessons learned from this case study, together with the other case studies, will help improving the process of applying SCORE, as well as the SCORE tool itself.

T3-I.1 O'Reilly, MV; SUNY School of Public Health and ARLS Consultants; ARLS.OReilly@gmail.com

Risk Perception, Risk Communication and Human Language

As important as it is to harmonize risk language across a variety of professions, it is equally important to understand how risk perception and risk communication occur at evolutionarily older brain levels which underlie cortical-based language. These underlying neurological systems react quickly, without reflection, to risky situations in basic emotional terms such as trust, fear and anger. In these circumstances the older underlying neurological networks make decisions before language even comes into play. Better risk communication depends on integrating the cortical and sub-cortical thought processes as well as harmonizing risk language.

P.96 Ocampo Pantoja, FA*; Villalba, NA; Muñoz, F; Universidad de los Andes; fa.ocampo2005@uniandes.edu.co

Reference framework for the application of Quantitative Risk Analysis for hydrocarbon pipelines, coupled with uncertainty treatment methods: Uncertainty in scenario identification through event trees

Risk assessment is imperative to reduce consequences and frequency of accidents generated by leaks on pipelines. After a failure in an urban pipeline, the contents can be released rapidly forming a spreading pool and generating a vapor cloud that can lead to different events such as fires and explosions. Generally, deterministic assessments are carried out, where certain assumptions are made in the models that are used to calculate failure and event probabilities, event consequences and risk values. This approach causes the existence of uncertainty that is not considered and therefore generates results only for “mean” or “worst-case” scenarios. Not taking uncertainty into account can lead to decisions with an unknown degree of conservatism: overestimate results could increase cost of decisions and underestimate results can lead to poor risk management. There is a lack of a clear directive to use methods of uncertainty assessment in QRA, making them difficult to be applied widely. For that reason, a framework is needed for carrying out such evaluations in order to handle, reduce, and properly inform uncertainty to the decision makers. To develop such framework uncertainty should be evaluated in two main steps of the QRA methodology: 1) scenario identification/frequency estimation and 2) consequence analysis. All these applied to a case study of an urban gasoline pipeline. This work deals with the first one by evaluating three approaches of addressing uncertainty in event tree analysis (a known technique for scenario identification and frequency calculation) in order to compare its results in treating epistemic uncertainty: evidence theory, fuzzy set theory and a hybrid probabilistic – possibilistic representation. Since coupling of these results with consequence analysis is needed in subsequent steps, an evaluation of transformation methods from non-probabilistic to probabilistic representation (crisp values) is performed to provide guidance in their selection in this particular field.

P.118 Ohkubo, C; Japan EMF Information Center; ohkubo@jeic-emf.jp

Risk perception on health effects of EMF among high school students in Japan

Risk perception of high school students (n=1006) on electromagnetic fields (EMF) and health effects issues was surveyed and compared with young adults (n=1224 in 20-30 years old) as a control in Japan. The internet survey was conducted in June, 2014. The questionnaires include degree of risk perception on health effects of EMF, concerned items in daily life, ill health effects imagined to be caused by EMF exposure, and reliability on information sources. The high school students are concerned about EMF and health issues (43%) than the control (40%); however, scientific knowledge about EMF in high school students is lower (47%) than the control (58%). Among the high school students, ill health effects imagined to be related to EMF exposure are none, sleep disturbance, impairment in concentration, brain tumor, other tumors, and childhood leukemia and others whereas those among control are none, sleep disturbance, maldevelopment of fetus, fetal malformation, brain tumor, infertility, and others, in descent order of indication, respectively. All the degree of information reliability from international organization, government agencies, universities, research institutes, power companies, cellular phone companies, electronics companies, NPOs, and civic activists among high school students are higher than the control. The high school students are slightly higher concerned about EMF & health issues than the control; however, they have poor knowledge of scientific on EMF than the control. Degree of reliability on all information sources are higher than the control which may be due to their innocent mind than the control. In conclusion, scientific information about EMF and health issues should be provided to them during their school days before they are influenced by rumor.

WI-E.3 OConnor, RE; National Science Foundation; roconnor@nsf.gov

Uncertainty Analysis to Inform Risk Management

Outside of the cliché about death and taxes, uncertainty is always with us regardless of our levels of discomfort with reality. This talk will link two qualities of regulatory processes--transparency and uncertainty analysis—that have varied greatly across time and place in Europe and North America. Although at a superficial level supporting transparency and uncertainty analysis would seem to be similar to supporting apple pie and motherhood as cultural norms, consensus quickly dissipates in practice (e.g., trans fats may increase health risks). This talk will explore uncertainties whether aleatory, epistemic, or something else in an effort to identify risks from communicating uncertain risks in the context of transparency requirements. The talk will suggest research priorities toward better risk analyses in a world where confidence in institutions is low.

P.134 Olson, MK*; Sutton, JN; Vos, SC; University of Kentucky; jeannette.sutton@uky.edu

Communicating threat and efficacy through the media: An analysis of news broadcasts about the Zika virus

News media, such as local or national news programs, are often tasked with providing risk related information to their audiences. This subsequently affects audience awareness and protective and preventative behaviors (Neuwirth, Dunwoody, & Griffin, 2000; Parrot 1996). The Zika virus has become a popular news topic due to its impact on maternal and infant health and its potential to spread within the United States as seasons change. Therefore, the news media has an increased role in communicating information not only about the threat of the Zika virus, but also how audiences can protect themselves. Using content analytic procedures, this study applies the Extended Parallel Process Model (EPPM) to assess the extent to which the news media presents EPPM message elements and seeks to provide a comprehensive depiction of how threat and efficacy messages are presented to audiences. We start by examining CDC media statements to identify what threat information and recommendations have been provided nationally and internationally. We then analyze three months of evening news segments in 2016 from national broadcast and cable news channels to assess how news media present severity and susceptibility (i.e., threat) of contracting Zika and self and collective efficacy information. In general, we find that news stories focus on details about virus transmission and population susceptibility but fail to communicate efficacy information present in CDC press releases to audiences. Such a lack of information may lead to maladaptive or unproductive behaviors in response to the Zika threat. In contrast, effective risk communication will contain information that promotes efficacy, leading to self protective behaviors and collective preventive actions.

W2-A.4 O'Meara, KM*; Zaitchik, B; Ferreira, C; Maryland Institute College of Art; katie.omeara@gmail.com

HIGHER GROUND: Leveraging Baltimore's Topography to Increase Social and Climate Resiliency

Our group is studying the potential flooding risks that Baltimore City faces from storm surge and increased rain events due to climate change. Baltimore City was built around its fall-line river, the Jones Falls, and grew around the industrial-age harbor. These dynamic water systems are now presenting flooding hazards to the businesses and communities that surround them. Because Baltimore City's population is half of what it was at its peak, we can re-envision the large swathes of underutilized and abandoned factories and homes that currently isolate struggling communities from thriving centers. Integrating environmental and social findings will inform a strategic plan that accommodates anticipated increased water volume through landscape intervention, with a method for re-centering businesses and communities to higher ground; simultaneously addressing infrastructure needs and entrenched social inequalities. We are combining riparian and coastal flooding models with detailed demographics that study social and spatial isolation. To study the potential for riverine flooding in Baltimore, we simulate flood patterns for historic storm events and potential increases in storm intensity under future climate. River levels are simulated using a watershed model of the entire Jones Falls watershed linked to a hydrodynamic model of the reach within the City. To explore the potential for coastal flooding in Baltimore Harbor, we simulate the storm surge generated by the same historical events using hydrodynamic models specifically tailored to the Chesapeake Bay. Understanding how flood models interact with current spatial and demographic patterns will allow us to reorganize around a more resilient landscape that accommodates the changing terrain with greater resiliency to climate change and shared access to resources. Thus our plan simultaneously addresses the need for resiliency to climate change and entrenched social disparity.

M2-B.4 Oryang, D*; Fanaselle, W; Anyamba, A; Cooley, M; Burdett, C; Van Doren, J; FDA, FDA, NASA-GSFC, USDA-ARS, Colorado State University, FDA; david.oryang@fda.hhs.gov

Forecasting Produce Contamination Potential Using Geospatial Risk Assessment in a Multicriteria Decision Analytic Framework

FDA is developing innovative tools and approaches to protect food safety and public health, including using risk assessment methods to support and inform decision making. FDA, in collaboration with NASA, and in consultation with USDA-ARS and Colorado State University, is developing a novel approach to reduce foodborne illness from pathogen contaminated produce. This approach marries geographic information systems (GIS) and remote sensing in a multi-criteria framework to provide an early warning system capable of forecasting the location, modes, and dates of produce contamination. The approach takes into account spatial and temporal dimensions, and characterizes and evaluates the impact of: a) hazards found in fresh produce; b) contamination modes; c) production practices (such as soil amendment, and irrigation water sources, amounts, and systems); d) factors that impact growth and spread of pathogens; e) environmental impacts of urbanization and industrialization; f) livestock and wildlife population and proximity to crops; g) topography and soil types; h) microbial status of surface water, wells, and reservoirs proximate to crops, and used for irrigation; and i) impacts of temperature, rainfall, irradiation, fog, and extreme events on environmental contamination likelihood and amounts. These factors vary spatially and temporally, and acquiring geospatial and time series data on these factors, is crucial to the development of this novel system. This paper presents a synopsis of the efforts undertaken to compile and evaluate required data, and to develop the geospatial forecasting tool. Modelling methodology, results and lessons learned will be presented.

M2-B.1 Oryang, D*; Chen, Y; Mokhtari, A; Kowalczyk, B; Van Doren, J; FDA and RTI International; david.oryang@fda.hhs.gov
Using a risk-based approach to evaluate intervention options for fresh produce in post-harvest processing plants

Fresh produce can become contaminated due to contact with different contamination sources in the growing field such as irrigation water, soil amendment, and wild and domestic animals. The purpose of post-harvest processing for fresh produce is to remove the dirt, pesticide residues, and cell exudates that may support microbial growth and reduce the bacterial load added to the product in the growing field. Improper post-harvest practices, including inadequate sanitary measures, can result in potential cross-contamination or spread of microbial contamination among the processed products. The purpose of this project was to develop and demonstrate a mathematical model for the post-harvest processing stage of fresh produce production that could (1) support the investigation of contamination scenarios, and (2) allow for the comparison of different risk interventions. A pilot study evaluated E. coli O157:H7 contamination of fresh-cut lettuce bags during the processing stage. An Agent-Based Modeling framework was used to predict the contamination prevalence and levels in the fresh-cut lettuce bags and investigate the intervention options. Model input values were derived using data from the refereed scientific literature as well as data on pathogen transfer and redistribution generated during a pilot-scale experiment using a processing line for fresh-cut lettuce. Risk assessment methodology offers a transparent, practical, and robust modeling approach with which to evaluate the efficacy of different risk intervention options in the post-harvest processing plants.

M3-A.3 Oughton, EJ*; Skelton, A; Kelly, S; Leverett, E; Thacker, S; Pant, R; Hall, JW; University of Cambridge; e.oughton@jbs.cam.ac.uk

Cyber-Attack Risk and Critical Infrastructure: The Economic Impact of a Cyber-Attack on London's Electricity Distribution Network

The risks associated with cyber-attacks on critical national infrastructure are growing in 3 dimensions simultaneously: the vulnerability of infrastructure through ongoing digitisation, the widespread impact and interdependence of infrastructure, and the willpower and capability to attack infrastructures remotely. For example, in December 2015 three energy companies in the Ukraine had failed to detect cyber-attack reconnaissance which had been taking place in their network. This attack resulted in 225,000 people in 3 regions losing power for 8 hours. In this paper we explore the potential effects of a cyber-attack on the electricity distribution network of London and South East England. This is undertaken firstly by quantifying the potential customer disruptions due to cascading failure across different infrastructures using a system-of-systems model, and secondly by estimating the potential economic supply chain disruptions resulting from a loss of power. The results demonstrate the risks associated with cyber-attacks on electricity distribution network infrastructure, especially that the economic impacts of such attacks have the potential to aggregate to significant economic losses.

T4-H.4 Oye, KA; Massachusetts Institute of Technology;
oye@mit.edu

On Gene Drives: Scientific Uncertainty, Technical Safeguards and Policy Gaps

By raising the probability of inheritance of introduced genetic elements from 50 to 99+ percent, self-propagating gene drives could be used to control vector borne diseases, to suppress invasive species, and to alter herbicide or insecticide resistance. Gene drives could also alter the genetic commons with uncertain environmental, safety and security effects. This presentation will discuss what is known on effects, identify sources of uncertainty, discuss technical safeguards to limit, reverse, and localize effects, and flag domestic and international regulatory gaps.

T2-F.2 Pagsuyoin, SAT*; Santos, JR; University of Massachusetts Lowell; *Sheree_Pagsuyoin@uml.edu*

ADVISED model: an adaptive decision tool for analyzing regional drought impacts

Droughts cause profound societal impacts that range from minor to catastrophic proportions. Because water is an essential resource in delivering goods and services, drought events can lead to tremendous economic losses that propagate through inherently interdependent economic sectors. Consequently, in water-scarce regions, policymakers must formulate equitable water sharing strategies that have varying implications on the productivity and operation of these sectors. In this paper, we discuss the visual and dynamic Adaptive Drought Vulnerability Index for Strategic Emergency Response (ADVISED) model, a decision support tool that enables the adaptive mapping of regional vulnerabilities to increasing drought severity. The ADVISED model integrates several drought-related databases to identify gaps in current drought management programs and assists in formulating targeted approaches for addressing region-specific drought emergencies. Its dynamic features allow policymakers to examine how the regional resilience to drought evolves over time in response to external factors (e.g., water management interventions) triggered by prolonged drought. A case application of the ADVISED model is demonstrated for the State of Massachusetts.

T2-F.3 Pagsuyoin, SAT; Gondle, R*; University of Massachusetts Lowell; *Sheree_Pagsuyoin@uml.edu*

GIS-based hotspot analysis of residual antimicrobials in the environment

The widespread consumption and environmental discharge of antimicrobials is an increasing ecological and public health concern due to the risks associated with the development of antimicrobial resistance in pathogens. The present work demonstrates the application of GIS tools to identify vulnerable and priority areas where high levels of residual antimicrobials are expected. A GIS-based spatial analysis was performed to identify hotspots for priority residual antimicrobials in a mixed-use watershed serving a population of 1 million inhabitants and a mix of commercial, industrial, and agricultural sectors. Our research methodology included the collection and synthesis of databases (e.g., farm data, population, wastewater treatment plant characteristics) from several sources (literature and federal agencies) and the application of mass balance models to spatially delineate the expected levels of antimicrobials in the environment (water and soil matrices).

W3-A.2 Pala, A*; Zhuang, J; University at Buffalo; *alipala@buffalo.edu*

Subsidizing Cybersecurity Information Sharing: A Game between A Government and N Companies

More cybersecurity information sharing would lead to stronger resistance against cyber-attacks in the presence of a cooperative and trustworthy sharing network. Sharing cyber-attack information, however, could harm reputation, create disadvantages against competitors and additional costs, and cause disclosing vulnerabilities and some private information. In this research, we study what, how, and to whom government incentives should be provided in order to encourage and improve information sharing. We incorporate game theory and agent-based simulation modeling to develop a dynamic decision support tool that generates information sharing strategies in the face of strategic attackers.

T3-B.5 PALMA-OLIVEIRA, JM*; Trump, BD; Wood, M; Linkov, I; University of Lisbon; palma.jmanuel@icloud.com

The Tragedy of the Anti-Commons: A Solution for Coordination Failures in for a “NIMBY” Post-Industrial World

Coordination failures driven from anti-commons problems have plagued many government and commercial projects in the 21st Century. Such failures are the product of mistrust by those members of the lay public that would be affected by such projects, where fears of diverse hazards and exposures (chemicals, toxins, noises, etc.) influence many to resist change in their communities. These concerns drive local communities to resist the institution of such projects in or near their living spaces, and thereby reduce the probability of successful development of these often necessary and beneficial projects. Overall, the failure to adopt such projects at the local level prevents the larger community from realizing the benefits that such an infrastructural or technological improvement may yield, such as within the local economy, infrastructural services, public health, and many others. Dubbed the ‘not-in-my-backyard’ effect (NIMBY), these scenarios represent the growing Tragedy of the Anticommons, or a breakdown in coordination of a particular good or resource due to its declared ownership by multiple conflicting parties. Such a coordination failure produces major stalls in policy and project implementation that, until recently, have often been addressed in a fashion that does not resolve the root causes of mistrust and resistance by the lay public – particularly through risk communication efforts that do little to build community engagement and trust. In this paper, we discuss the growing concern of anticommons problems via coordination failures in our modern age, while also discussing an approach to overcome persistent public distrust and coordination failures that plague many industrial and infrastructural development projects. Where such an approach is grounded in experimentally-driven hypothesis testing and jointly constructed risk analysis and management, we argue that 21st Century anticommons coordination failures may be resolved through the direct partnership with the lay community.

P.6 Pan, SC*; Huang, CC; Ho, WC; Chen, BY; Guo, YL; National Taiwan University; u9865006@cmu.edu.tw

Association between air pollution exposure and acute myocardial infarction emergency room visits: the effects of comorbid chronic conditions

Background: There has been increasing epidemiological evidence showed that exposure to air pollution could be association with increasing risk of emergency room (ER) visits for acute myocardial infarction (AMI). However, the information on susceptibility caused by chronic medical conditions has been limited. Objective: The aim of this study was to investigate whether comorbid chronic conditions modify the adverse effects of air pollution exposure on AMI ER visits. Methods: Healthcare utilization information was obtained by using the National Health Insurance Research Database (NHIRD). Daily ambient air pollutants were extracted from the Taiwan EPA air monitoring data. The first time AMI ER visits during 2006-2011 were included. We used time-stratified case-crossover study design and conditional logistic regression adjusted for temperature and relative humidity to investigate the relationship between air pollutants exposure and AMI ER visits in comorbid and non-comorbid chronic disease groups. Results: There were 963 first time AMI ER visits during 2006-2011. The odds ratio (OR) of AMI ER visits associated exposure to per interquartile range increase in PM2.5 of the same day (lag 0 day) was 1.12 (95% confidence interval, CI= 0.97-1.28). The OR was 1.26 (95% CI= 1.00-1.57) for the diabetic group, and 1.04 (95% CI=0.87-1.23) for the non-diabetic group. Conclusions: In conclusion, exposure to PM2.5 would increase the risk of AMI ER visits. People who have pre-existing diabetes are especially susceptible to increased AMI ER visits related to PM2.5 exposure.

T4-H.2 Palmer, MJ*; Evans, SW; Stanford University; mjpalmer@stanford.edu

Mechanisms to engage scientific and policy communities on risk governance challenges of gene drives

A critical challenge for risk governance is the development of mechanisms of engagement across innovation and policy communities that are effective in identifying, analyzing and managing emerging issues. Despite earnest efforts to bridge communities, including the development of rigorous methodologies and the emergence of expert communities in risk analysis, there is a dearth of positive examples of engagement that are translated across technical domain areas. This presentation will discuss several ‘experiments’ in engagement in risk governance through the lens of communities pursuing gene drive technologies and related regulatory policies. We will then explore opportunities to adapt lessons from other areas, and ways in which gene drives may – or may not – become a critical site for advancing models of engagement in risk governance.

W2-D.1 Pana-Cryan, R; National Institute for Occupational Safety and Health; rfp2@cdc.gov

Using attributable risk to assess the burden of worker injury and illness and prioritize research and prevention

The limited funds that are available for government-sponsored research aiming to improve worker safety and health are allocated to research and prevention activities that target specific problems in specific industry sectors, such as hearing loss in manufacturing. To understand how to best prioritize the funding of government-sponsored research and prevention activities, we need to assess the burden by condition and sector. This helps to identify where the burden is highest, when measured with several metrics. In turn, this offers a way to prioritize activities that is based in part on addressing the biggest problems first. To demonstrate how this approach can be used, we will describe the distribution of the burden of worker injury and illness in a program portfolio matrix that organizes research activities in 10 sectors and 7 health-outcome focused cross-sectors. We will discuss challenges related to estimating the portion of each condition that is attributed to exposures at work, and will present a recent update of several such attributable risk estimates. Then, we will discuss in detail example conditions to explain two processes. First, how surveillance and epidemiologic data and methods were used to derive cases and rates of conditions attributed to work and, second, how economic data and methods were used to derive economic metrics based on these cases and rates. Economic burden metrics included medical costs and productivity losses, and disability-adjusted life years. Conditions by sector were ranked by each individual metric. Conditions by sector were also ranked through the use of indexes that combine individual metric rankings. Conditions that consistently ranked highest by both individual metric rankings and index rankings indicate the highest priorities for research and prevention, based on burden.

W2-G.3 Pang, CB*; Neubauer, N; Hristozov, D; Marcomini, A; Wolleben, W; Ca' Foscari University of Venice, Italy; chengfang.pang@unive.it

The release of Nanoscale copper phthalocyanine from automobile coating and their transformation in environmental (freshwater) and biological (cell culture) media

Nanoscale copper phthalocyanine (n-CuPc) has been increasingly used in different products, including printing inks, coating for automotive products, plastics, and textiles. Its use can improve the mechanical properties and add new features to the products, such as exhibit excellent transparency, lightfastness, heat stability, chemical and bleed resistance, processing capabilities and durability. It is estimated that Europe consumed an estimated 8 thousand metric tons of n-CuPc pigments (dry weight basis) in 2010. The automotive industry is the largest consumer of organic pigments, where increasing market requires stylish automobile coatings with vibrant colors due to the pigments. This application of n-CuPc may result in release of n-CuPc into the aquatic environment, especially during washing or repairing the automobile. Presently, very little is known about the exposure and hazard of n-CuPc in the aquatic environment, where n-CuPc may pose risks to freshwater and sediment organisms. The aim of the study is to develop methods and to generate data to assess the exposure of n-CuPc in the aquatic environment. In order to achieve this, we estimate the release of n-CuPc from automobile coatings through sanding approach, which is representative of a car repair process. Typically such repair operations are done in repair facilities where sanding dusts is collected and disposed, but an indirect emission from disposal into aquatic environment (e.g. freshwater) cannot be completely ruled out. Further, risk management measures (local exhaust on the sanding equipment, face masks) are typically in place at such operations to reduce occupational exposure. However, knowledge of the fate and hazard of sanding fragments in occupational settings is required. Accordingly, we investigated how the physicochemical properties of the released fragment n-CuPc from automobile coating changes in environmental (freshwater) and biological (cell culture) media.

T4-C.1 Pang, CB*; Hristozov, D; Zabeo, A; Pizzol, L; Tsang, M; Sayre, P; Marcomini, A; Ca' Foscari University of Venice, Italy; chengfang.pang@unive.it

Probabilistic approach for assessing infants' health risks due to ingestion of nanoscale silver released from consumer products

In contrast to the anticipated huge benefits from nanotechnologies, there are concerns over their potential health implications. In order to promote nanotechnologies innovation and their proper regulation, it is important to develop robust methods and tools for human health risk assessment (HHRA) of manufactured nanomaterials (MN), which are capable of supporting risk management decision making. To address this need, we propose a quantitative stochastic approach for HHRA of MN, which combines dose-response and exposure probability into distributions of risk, and uses Monte-Carlo simulations to estimate the uncertainty in the final results. The approach is illustrated in a case study involving infants who are orally exposed to consumer products containing silver nanoparticles (e.g. sippy cups and baby blankets). The analysis demonstrated that even in cases of low data availability, the approach could be successfully applied to estimate distributions of hazard, exposure and risk. It also allowed us to determine with sufficient confidence the contribution from different sources of uncertainty (e.g. quality of toxicity experiments, dose-response and exposure analyses, and use of extrapolation factors) to the total uncertainty in the HHRA. In this regard our results showed that the use of default intra-species, interspecies, and subacute-to-chronic extrapolation factors had the largest contribution to the overall uncertainty in the assessment.

M2-B.2 Pang, H*; McEgan, R; Micallef, SA; Pradhan, AK; University of Maryland College Park; haopang@umd.edu

Evaluation of Meteorological Factors Affecting Pre-harvest Contamination Risk of Listeria Species in a Mixed Produce and Dairy Farm

Produce (fruits and vegetables) from mixed farms are at higher risk of pre-harvest contamination with foodborne pathogens due to the unique agricultural settings of mixed farming. Such contamination risk can be affected by meteorological factors. This study sought to investigate the prevalence of *Listeria* species (including *Listeria monocytogenes*) in a mixed produce and dairy farm and to identify specific meteorological factors affecting *Listeria* spp. presence. Environmental samples were collected monthly from locations within the mixed farm over 14 months and were analyzed for *Listeria* spp. Meteorological factors were evaluated for their association with the presence of *Listeria* spp. by using logistic regression (LR) and classification tree (CT). The developed LR model identified wind speed as a significant risk factor, indicating that higher average wind speed 2 days prior to sampling increased the probability of isolation of *Listeria* spp. (odds ratio = 4.02). In addition, precipitation was identified as a moderate risk factor, as probability of *Listeria* spp. isolation increased with increasing average rainfall amount in the previous 5 days before sampling (odds ratio = 1.24). Results from CT revealed that wind speed and precipitation were the most important factors influencing the presence of *Listeria* spp., which supported the findings from LR. The CT predicted that a farm sampling location was more likely to be *Listeria* spp.-positive with higher average wind speed (>2.5 m/s) and higher average precipitation (>5.1 mm) within a week before sampling. These findings indicate that occurrence of *Listeria* spp. was influenced by wind speed and precipitation, suggesting rain facilitated runoff and wind-driven dust might be possible routes of pathogen transmission on mixed farms. The developed models can help with evaluation of farm management practices and development of control strategies aimed at reducing pre-harvest microbial contamination in a mixed farming system.

T2-A.2 Pant, R*; Hall, JW; University of Oxford; raghav.pant@ouce.ox.ac.uk

Modelling systemic criticalities and risks in multi-modal transport networks at the national scale

Critical infrastructures such as transport are consistently at risk due to exposure to extreme weather events and random shocks. Given the key role of transport infrastructures, there is a clear need for a risk assessment framework built around a detailed understanding of infrastructure network properties, and their customer and economic impacts. But an exhaustive network analysis of all possible failures and risks is challenging due to the large size of transport networks. Hence such a risk assessment should be based on network level prioritization to identify the relative criticality of the network elements. It should also lead towards identifying the economic losses due to potential logistics disruptions to operations of ports, airports, road and railway corridors. We present a methodology to meet this need, by analysing the systemic criticalities and risks to multi-modal transport infrastructure. A procedure is developed for assessing the relative criticality of different nodes and edges on the network based on different metrics such as: (i) physical network topology, (ii) passenger traffic, (iii) key linkages to wider transport logistics hubs, and (iii) macroeconomic impacts. A case study on the flood vulnerability and risk to Britain's multi-modal transport systems (roads, railway, ports and airports) is used to demonstrate how criticality assessment can identify key parts of the multi-modal transport networks that are most at risk of causing substantial disruption to traffic and economic activity, and therefore are most critical to maintaining national mobility. It has further implications for prioritizing investment decisions for enhancing the resilience of large scale networks.

M3-J.4 Parker, DJ*; Pearce, JM; Lindekilde, L; Rogers, MB; KING'S COLLEGE LONDON, King's College London / UNIVERSITY OF AARHUS, University of Aarhus; david.l.parker@kcl.ac.uk

COMMUNICATING ABOUT LONE-ACTOR TERRORISM: THE CHALLENGES IN PRACTICE, Communicating about Lone-Actor Terrorism: The Challenges in Practice

In February 2010 then C.I.A. Director Leon Panetta described 'the lone wolf strategy' as the main threat to the United States. European leaders have echoed this concern, with lone-actor terrorist attacks in Brussels, London and Copenhagen testifying to the gravity of the threat. Indeed, British security officials have described a lone-actor attack in the United Kingdom as almost inevitable. Risk communications targeting the general public and distinct audiences, such as schools and faith organisations, can not only increase the number of stakeholders able to contribute to efforts to prevent the radicalisation of individuals and to interdict attack planning but also increase the ability to mitigate against the impacts of a lone actor terrorist event. Despite this, few communication measures specifically focused on lone actor extremist events (LAEs) have been developed in many countries that face such threats. By reviewing the challenges of communicating about more traditional group-based terrorism in the UK and Denmark, countries with comparable counter violent radicalisation programmes but quite different experiences of lone actor extremism, this paper reveals the existing factors practitioners must consider when designing LAEE risk communications if they are to be effective. These challenges, identified through interviews with over 30 practitioners across a wide spectrum of agencies, apply to risk communications designed to prevent radicalisation, interdict attack planning and mitigate the impacts of a terrorist attack. The paper highlights that certain challenges will be particularly acute when applied to the issue of LAEEs whilst some existing risk communications are likely to be less relevant in the lone actor sphere despite being central to traditional counter-terrorism communications.

M3-J.5 Pearce, JM*; Parker, DJ; Lindekilde, L; Rogers, MB; King's College London (authors 1, 2, and 4) and Aarhus University (author 3); julia.pearce@kcl.ac.uk

Communicating public guidance for firearms and weapons attacks: Factors influencing intention to 'run, hide, tell' in the UK and Denmark

Effective risk communication is an integral part of responding to terrorism, but until recently there has been very little pre-event communication in a European context to provide advice to the public on how to protect themselves during an attack. Following terrorist attacks involving mass shootings in Paris, France in November 2015, the UK National Police Chiefs' Council released a 'Stay Safe' film and leaflet that advises the public to 'run, hide and tell' in the event of a firearms or weapons attack. However, other countries including Denmark do not provide preparedness information to the general public on how to protect themselves in the event of such an attack, in large part because of concern about scaring the public. This paper presents the findings of an online demographically representative survey that was conducted in the UK (n=1500) and Denmark (n=1500), comparing national differences in response to a hypothetical arms attack on a shopping mall. The survey tested the strength of association of trust in authorities, coping appraisals, communication method and comprehension of advice on intention to follow official guidance to 'run, hide and tell' in the event of a firearms or weapons attack. Emotional responses to receiving pre-event risk communications on firearms and weapons attacks were also examined. The results of this survey will be discussed in relation to improving the effectiveness of pre-event risk communication content, delivery model and strategic assumptions. The extent to which generic pre-event risk communication messages need to be adapted to take into consideration local concerns and likely behavioral responses will also be discussed.

T4-J.4 Partridge, T*; Harthorn, BH; Thomas, M; Pidgeon, N; University of California, Santa Barbara; tristan.partridge@ucsb.edu
Deliberating shale development in the US and UK: emergent views on issues of urgency and inequality

Based on a series of public deliberation workshops held in the US and UK, this research examines emergent public perceptions of shale oil and gas extraction by hydraulic fracturing ('fracking') for connections between those emergent attitudes and broader ideas about energy, society, and risk in both countries. This paper focuses on ideas about urgency as they figure in public views on the risks, benefits and impacts of fracking, and explores the diverse ways that urgency appears in or is absent from participants' accounts and their relation to respondents' sense of responsibility, fairness and inequality. Preliminary understanding gained from conducting these deliberative workshops suggests that issues of urgency arise when people discuss the promotion of (and/or resistance to) technological developments and their consequences as being located in an immediate temporal plane. That is, when issues around technological developments and their impacts are seen to be pressing, acute, imperative, timely or similar. From other deliberative work, we know that urgency also appears when short-term concerns, needs and views are emphasized (and/or prioritized) over those that operate in the longer-term or are associated with precaution, techno-scepticism, and increased regulation. In contexts where urgency-based pleas are being made by governments and other actors in support of rapid implementation and expansion of fracking operations, we explore public views on such urgency discourses and their deployment, and their perceived impact on producing social and environmental inequalities – with consequences for developing policy approaches that are more socially responsible and equipped to assess both the consequences and aims of technology developments including fracking.

P.71 Pelot, RP*; Etienne, L; Stoddard, MA; Dalhousie University; Ronald.Pelot@Dal.ca

Visualizing uncertainty in marine navigation in the Canadian Arctic

Quantitative Risk Assessment of marine traffic in the Canadian Arctic is fraught with difficulties: incomplete data sources, low trip frequency, complex causal factors, consequences in the relatively pristine environment are hard to estimate, response resources are remote, and conditions are evolving due to climate change. This study is part of a broader effort to deal with these risk assessment challenges. Invoking POLARIS (Polar Operational Limitations Assessment Risk Indexing System), an evaluation system recently developed by the International Associations of Classification Societies (IACS) to specify the navigability in diverse ice regimes for various ice-class ships, we have developed tools for exploring and visualizing the outcomes. The Canadian Arctic waters are divided up into 16 navigation Zones by Transport Canada, so we developed stacked column charts by week to illustrate the accessibility of each zone for a given ice-class depending on whether they operate with icebreaker escort or not and/or at reduced speed. This can serve for advanced planning, having a broad perspective on the limitations in the entire region. More specifically, one can also calculate the various levels of passability likely to be encountered along a specific path for a planned voyage at a given time, and colour code the route accordingly. The preceding calculations and views are based on an eight year time series, from which average case, or worst case, can be deduced. A supplementary view therefore shows the variability in each week using box plots, adding further information for voyage planners and anticipating the likely conditions encountered. This presentation focuses on information to help avoid hazardous ship-ice encounters, and its importance is underscored by the potential consequences, ranging from minor such as delays or extra fuel consumption by unexpectedly diverting the route, to getting stuck in ice thus requiring rescue or suffering vessel damage.

M2-J.5 Petit, FD*; Dickinson, D; Phillips, JA; Argonne National Laboratory; fpetit@anl.gov

Multi-Asset Protection and Resilience Assessment

Several resilience assessment methodologies exist at both facility and regional levels; however, these methodologies are not really appropriate for analyzing systems, campuses, and clusters of assets, and specifically to address the issues that arise for an organization with a number of linked assets, with possibly diverse capabilities, where the loss of an asset impacts the whole organization. An assessment approach tailored to multi-asset systems would provide owners and operators with a comprehensive perspective of overall risk and support decision making to implement mitigation measures designed to resist disruptive events through an understanding of the vulnerabilities, capabilities, and impacts of loss of critical assets. This presentation proposes an assessment approach, using decision analysis concepts, to identify and prioritize the most critical assets within a system for assessment and define security management, resilience management, and dependency considerations for enhancing the protection and resilience measures at asset, facility, and system levels. The proposed assessment methodology allows (1) comparison of the multi-asset system's security, resilience, and dependency characteristics to other similar system across the Nation (e.g., water system to water system) by way of system-level indices, and (2) verification that each critical asset can support the system-wide protection and resilience posture. In addition, it provides owners and operators with an interactive decision analysis tool to compare assets within the system based on criticality and threat susceptibility, and to identify vulnerabilities and prioritize corresponding options for consideration to better detect, deter, delay, mitigate, and recover from an adverse event at the asset-level as well as the enterprise-level. The presentation will be specifically organized into three key areas: (1) Background and Principles, (2) Process, and (3) Implementation.

T4-I.1 Pidgeon, NF*; Steentjes, K; Poortinga, W; Corner, A; Bohm, G; Tvinnereim, E; Arnold, A; Sonnberger, M; Mays, C; Poumadere, M; Pidgeon, Steentjes, Poortinga, Corner (Cardiff University); Bohm, Tvinnereim (University Bergen); Arnold, Sonnberger (University Stuttgart); Mays, Poumadere (Symlog Paris); pidgeonn@cardiff.ac.uk

EPCC - the European perceptions of climate change project

This paper describes the background rationale, core methodology and sampling, and initial headline findings of the EPCC Project - European Perceptions of Climate Change. This research is a major 1.2 million euro risk perceptions project undertaken by 4 collaborating national teams and supported by the Joint Programme Initiative on Climate Change (JPI-Climate). The aim is to generate comparative cross-cultural data on how climate risk perceptions and their antecedents vary across different countries. The survey took place in June of 2016 with a total sample size of 1000 nationally representative respondents collected in each of Great Britain, Germany, Norway and France using a specially designed multi-item survey instrument translated into the four national languages. The aim of the survey as a whole is to understand how cross-nation differences in - e.g. climate scepticism, the psychological distance of climate change risk, and political orientation, together with key aspects of national cultural and energy systems contexts - might help us understand both climate risk perceptions and people's preferences for energy and other policy responses.

W4-E.3 Pho, YH; Suryanarayan, SX*; Cascone, JB; Deloitte & Touche, LLP; vpho@deloitte.com

SAFER - Sensing Analytics for Emerging Risks

As organizations sift through piles of data in an ever changing world, they are looking for capabilities to provide early warning signals to stay on top of emerging risks and opportunities. We have developed an approach and solution to synthesize signal intelligence through risk analytics with human intelligence to curate data to identify emerging issues, industry trends, potential business disruptors, and macro-environmental risks. Two areas where this study approached this problem was with managing vast amounts of data regarding both product safety issues and early identification of risks along the food safety supply chain. The approach that was taken used data from relevant external sources and applied cognitive computing methods such as: machine learning, natural language processing, concept extraction, sentiment analysis and topic detection to drive insights that were then conveyed in visualization dashboards and reports. The purpose of the discussion is to present case studies on how our risk analytics solution helped global, multi-billion dollar organizations address strategic management of emerging issues before they escalate.

M4-J.3 Pidgeon, NF*; Sposato, R; Capstick, S; Demski, C; Spence, A; Pidgeon (Cardiff University); Sposato (Alpen-Adria Universität, Austria); Capstick, Demski (Cardiff University); Spence (University of Nottingham); pidgeonn@cardiff.ac.uk

Experiences of extreme weather, belief bias and perceived climate change risks

One important line of research on public perception of climate risks has focused upon the role of extreme weather events, such as local flooding or heatwaves, to modify core beliefs about the causes and existence of climate change. Some studies have indeed revealed a correlational relationship between reported experience and changed perceptions. However, this pattern of results might be due either to the impact of the event on perceptions (seeing is believing) or alternatively a belief bias effect where people who already believe in climate change are more likely to report having experiences of extreme climate change-related weather (believing is seeing). Distinguishing between these two effects in empirical studies is critically important for designing effective risk communications about extreme weather and climate and for informing policy. This paper explores the relationship between belief bias and different self-report measures through a focus on people's experiences of the major UK winter floods which occurred in 2013/2014. The study used a nationally representative sample (n=1,002) with a second sample of people most directly affected by the floods (n=995). We predict, and show, how belief bias is more prevalent where the self-report measure of experience allows for greater ambiguity in its interpretation. We conclude that researchers studying 'experience' and climate risk perceptions need to pay far greater attention than they have in the past to the self-report measures of experience used.

P.41 Pierce, A*; Warsaw, C; Posin, L; Hancock, G; General Electric Co. and Gnarus Advisors; anna.pierce@ge.com
Optimizing Resources: An Environment, Health & Safety Risk Model

Are you facing challenges allocating resources and prioritizing support in a constrained environment? The GE Environmental, Health and Safety (EHS) function faced the same challenges as they moved from a business support model to a shared service and continue to face them today in a dynamic business environment. GE partnered with Gnarus Advisors to develop a risk model to provide objective insights into the risk of their fixed facilities and services operations. The output of the model is a ranking of operations globally, by business, region and EHS media aimed at allocating resources, program development and support. This session will focus on the model's development and real world application with a special focus on their governance program.

WI-F.3 Pierce, A*; Kipperman, F; Hill, T; General Electric Co. and Praedicat; anna.pierce@ge.com

Big Data - Connecting Risk Insights to Business Strategy

In today's digital world, we are swimming in a sea of data. Are you facing challenges in determining how to use data to gain insights into your risk? Using data to connect risk to inform business strategy is often an elusive goal. The GE Environmental, Health and Safety (EHS) team partnered with Praedicat to leverage data science and analytics to develop topic-specific risk analyses based on scientific literature and the regulatory landscape. The output of the analyses is used to inform strategic business decisions regarding emerging EHS risks that may impact future commercial operations and to strengthen their identification, assessment and management. This session will provide an overview of the initiative and potential real world applications of the results.

P.7 Pinheiro, EG; Stringari, D*; Disaster Research Center of Parana State - Brazil; danystringari@gmail.com

Creation of REDESASTRE as a strategy for capacity building and support for the implementation of the Sendai Framework in the Parana State - Brazil

The State of the Paraná, located in the south of Brazil, established the first thematic network in the country to address the issue disaster risk reduction (DRR), called REDESASTRE. This network has more than 15 institutions of higher education and research centers cooperated, meeting to integrate the different areas in search for technical and scientific alternatives for the DRR. The initiative resulted as of the perception of the public managers that something was needed to be done, besides the usual preparation for the answer. Unlike other research centers in Brazil, the University Centre for Studies and Research on Disasters - CEPED/Paraná was created by official act of Governor and, in spite of being a university center of the Paraná State University, it is linked directly to the Coordinator of Protection and Civil Defense of the State. The Centre and the REDESASTRE aims to research and university extension; education (training and training courses); and technological innovation for the development of new technologies aimed at DRR. Among the actions implemented by the CEPED/Paraná, there is the cooperation with the UNISDR, which credited the CEPED/PR as the only multiplier training course focused on the global campaign "Building Resilient Cities", in Brazil. The REDESASTRE has the potentiality of joining the academy, stimulating it on the importance of the subject and narrowing the contact between the real necessities indicated by the public managers and the demands of the local community, which require science and technology so that the risks can be known and, consequently, diminished. The REDESASTRE also enables the awareness of strategic sectors of the economy, such as industry, to financially support initiatives aimed at fostering research, extension and technological innovation, so as to make the network sustainable monetarily. The expected results of this combination, show signs that the REDESASTRE has relevant role in the implementation of Sendai Framework.

P.87 piotrowski, A; De Guidici, P; Soledano, B; Payre, C; Cabanes, PA*; EDF; pierre-andre.cabanes@edf.fr

City Noise: Propagation and Health Impact

The objective of our study was to assess the potential effects of different scenarios of an urban development project on population health, with an initial focus on the effects associated with noise. Beyond this first objective, we sought to propose and test a methodology a priori applicable to other projects of a similar nature underway in other urban areas. Acoustic levels were evaluated for the present and for 2020 and 2030, based on planning scenarios developed with the city. Noise propagation was modeled with NoiseM@p software, which enabled us to describe the time distribution of sound emissions, that is, their distribution throughout the day, according to the day of the week. The exposure-risk curves recommended by the World Health Organization (WHO) used to calculate impacts are discussed and completed by qualitative data for the cases studied (for example, the noise contains strong tonal components, emergence time) to refine results that do not fully express all of the relevant situations, especially the emergence of sound source events in a quiet background (nighttime noise, for example). The modeling of noise levels showed that this urban development project will increase the number of people exposed to high noise levels. This proportion will rise by around 50% from today to 2020. Nonetheless, the proportions of individuals bothered and of those whose sleep is disturbed by noise will return to close to their current levels by 2030 if a proactive scenario is implemented, one that promotes in particular the use of public transportation. The difference in the incidence of myocardial infarctions attributable to noise will remain less than 1 per year between today and 2020 or 2030. This approach will be extended to other pollutants.

M4-J.4 Poortvliet, PM*; Ngo, CC; Feindt, PF; Wageningen University; marijn.poortvliet@wur.nl

Flood experience, community involvement and climate change risk perception in coastal and delta communities

While climate change has been widely recognized as a long term driver of increasing natural hazards, public's perception of climate risks is significantly varied across the world. Scientists and practitioners argue that although local residents are often familiar with natural hazards, they are less aware of risks associated with a changing climate. Previous studies were in part contradictory to confirm the hypothesis that direct experience in climate change related phenomena (flood or drought) influences people's perception on climate change's impact and intention to take mitigation or adaptation actions. This paper explores the determinants of flood and climate risk perceptions of residents of coastal and delta communities in Vietnam, based on a survey among 1,086 households. Pair-wised analysis for demographic and socio-economic factors showed a significant association with flood and climate change risk perceptions. Surprisingly, in multivariate analysis, only flood experience, city of residence and community participation remain as predictors for climate change risk perception and intention to take adaptation measures. Respondents who experienced flooding were more concerned about climate change risks. Flood risk perception is positively associated with climate change risk perception, but not with perceived adaptive capacity for climate change. Still, people who are more willing to prepare for flood risks did also better comprehend climate change risks, vulnerability, sensitivity and adaptive capacity. Implications for communicating flood and climate change risks are discussed with a view to designing an effective communication method for informing adaptive measures for flood hazard and climate change.

M4-C.5 Pourakbar, M.*; Zuidwijk, R.; Rotterdam School of Management, Erasmus University; mpourakbar@rsm.nl
On the Role of Customs in Securing the Containerized Global Supply Chains

As of 2009, approximately 90% of non-bulk cargo worldwide is moved by containers stacked on transport ships. Customs has to inspect a massive number of containers arriving at ports. This massive flow provides an opportunity for antagonists to infiltrate. Therefore, enhancing customs risk and security management has been a top priority for public, business firms and governments. To mitigate the security risks, this study develops a sequential game between customs, firms, and antagonists wherein antagonist sets the rate of infiltration and customs reacts accordingly and sets the inspection policies. The model allows customs to optimize their inspection process to target the high risk containers without hurting the flow of safe containers with extra delays at ports. The model characterizes the optimal informational and physical inspection rates as a function of the risk factors assigned to containers. Then, we use this model to analyze how an effective public-private partnership (PPP) for risk and security management can be established between customs and private firms. Even though customs administrations are in the front-line of battling illicit activities, the physical flow of goods and its related information is in the hands of private companies that own the shipments, containers and ships. Therefore, customs needs private sector information on the containers histories in order to assess how secure these containers are. Private companies also need the benefits of the intelligence and enforcement resources owned by government in order to reduce the probability of disruption in their supply chains. This explains why PPP becomes a major point of discussion in businesses and government agencies concerned with security. We consider several mechanisms that can be used to establish an efficient PPP through information sharing and characterize investment thresholds by stakeholders involved to achieve such partnership.

M3-G.4 Pouillot, R*; Gamalo, M; Spungen, J; Abt, E; Van Doren, JM; Food and Drug Administration; Regis.Pouillot@FDA.HHS.GOV
Improved accuracy for total dietary exposure estimates: estimation of food analyte mean concentrations for exposure assessment using a Dirichlet process.

Estimating dietary intake of chemical contaminants and nutrients requires combining food consumption figures with estimated mean concentrations for the particular contaminant or nutrient of interest in a large number of foods. Datasets of chemical contaminant and nutrient concentrations in foods may be characterized by a large proportion of left-censored data (i.e. values below the limit of detection (LOD) of the analytical method). Further, such data sets may include a large number of foods with a relatively small number of data points per food. For example, the Food and Drug Administration's Total Diet Study program (FDA's TDS) data set includes analytical results from >250 foods with <30 data points per food and a high proportion of values below the LOD for some analytes. Until now, no inference method has been recommended in this situation. We propose a method to estimate the mean analyte concentration in foods using the assumption that the concentration patterns follow a zero-inflated lognormal distribution and that some patterns may be shared among foods. Grouping of foods based on their analyte concentration patterns is inferred through a dependent Dirichlet process. Simulation results indicate that the method is more accurate than other methods used for these datasets. We illustrate the method using a dataset of manganese concentrations in foods obtained through the FDA's TDS. The method's flexibility and applicability suggest that it could be used widely for generating more robust exposure estimates for both contaminants and nutrients in food in exposure assessments.

M4-B.5 Powell, MR; US Dept Ag; mpowell@oce.usda.gov
Considering the Impact of Classification Uncertainty in Weed Risk Models

Weed risk models are used in the hazard identification stage of risk assessment to assess the likelihood of a plant being a weed based on plant traits and receiving environment characteristics. To date, the literature on the impact of uncertainty in weed risk models has focused on the uncertainty in model inputs and outputs. However, weed risk model development begins with the a priori classification of plants into categories, e.g. non-invader, minor invader, major invader. Model developers then seek inputs that predict weed categories that are treated as known. This presentation considers the impact of uncertainty in the a priori classification of plants into weed categories on a weed risk screening model developed by Koop et al (2012). The uncertainty scenario considered is one in which $p(\text{one category misclassification error}) = 0.1$. Under this scenario, there was no statistically significant difference in the logistic regression parameter estimates derived with and without the assumed classification error, and the confidence intervals about the generalized R-square and percent discordant pairs generated assuming classification error contained the values calculated assuming no classification error. Therefore, the model appears robust to an appreciable amount of random a priori classification error in the data used in model development. This scenario, however, only considers random classification uncertainty analogous to measurement error on the dependent variable. It does not consider systematic misclassification or the impact of omitted variables that may reduce variance unexplained by the model. Weed classification decisions involve intrinsic ambiguity because a weed could include any plant growing where and/or when it is unwanted; plants that are desirable in some settings could be considered weeds in others.

T2-C.4 Powers, DG*; Howard, PM; ABS Consulting Inc.;
dpowers@absconsulting.com

Quantifying Risk of Terrorist Transfers

Interdicting adversaries while they plan, reconnoiter, or conduct terrorist attacks is not the only way to mitigate domestic terrorism. While some adversaries are homegrown violent extremists already in the U.S., others are external and must be transferred to the U.S. before conducting attacks. To prevent domestic terrorism, we not only can stop an adversary after arrival in the U.S. but can also interdict the adversary while in transit to our country. To mitigate terrorism threats, U.S. government agencies advocate the use of quantitative risk analysis (QRA) to understand which attacks the adversary seeks to conduct, his probability of success, and the consequences he can cause. Following a literature review, it appears that while QRA has been applied to assess the risk presented by adversaries already in the Homeland, it has not been adapted to assess the risk of the terrorist transit itself. Such analyses would provide a better understanding of the threats that terrorist transfer into the U.S. would present to our nation, and how that risk would compare to terrorist attack risk from adversaries present in the Homeland. We have designed a new methodology to quantify risk of terrorist transfers through the maritime domain in consistent with and comparable to legacy USCG analysis of terrorism risk from adversaries already in the U.S. The methodology quantifies relative likelihoods that an adversary will transport terrorists into the U.S., assesses likelihood of security boardings and regulatory regimes detecting and interdicting terrorists in transit, and estimates the consequence of the terrorist transfer event itself; even when no specific target or attack method is yet known. Results are consistent with and comparable to analysis of attacks from adversaries already in the U.S. to facilitate better understanding of the entire risk profile and comparison of anti-terrorism measure performance and evaluation of future improvements to the anti-terrorism regime.

P.66 Prieto Recarey, R*; Cueto Alonso, AO; Empresa Ingeniería y Proyectos del Petróleo, CUPET; roxanapr@eipp.cupet.cu
CUBA, ENFOQUE DE SEGURIDAD DE PROCESOS EN INSTALACIONES INDUSTRIALES CON PELIGRO MAYOR. ENFOQUE DE INGENIERÍA Y PROYECTO*This is the title*

It is exposed as Cuba focuses on Process Safety (PS) from regulators and controls, regulatory frameworks, risk analysis and treatment; establishing for it the Safety Report (SR) in Risk Management (RM). The Cuban state from its Regular Bodies, control is established the SR in the Facilities Hazard Major (FHM), corresponding to the Holder of Environmental Licenses (HEL) performing the Safety Assessment (SA) that must correspond with the size and nature of the hazards of major accidents in existing facilities. Engineering and projects associated with the FHM allow materialize from early stages the approach SR passing from the conception of the installation through PS, allowing incorporate not only the compliance and environmental and safety regulations, but to realize a RM in future and existing FHM in high-risk industries

WI-B.3 Pradhan, AK*; Guo, M; University of Maryland, College Park; akp@umd.edu

Modeling the risk of human Toxoplasma gondii infection through consumption of meat products in the United States

Toxoplasma gondii is a widely prevalent protozoan parasite that is able to infect humans and animals worldwide. The Centers for Disease Control and Prevention reported T. gondii as the fourth leading cause of hospitalization and the second leading cause of death among 31 major foodborne pathogens in the United States; it is associated with an estimated 4,428 hospitalizations and 327 deaths annually. Meat animals act as reservoirs for T. gondii and meat products have been identified as important sources of T. gondii infections in humans. Consumption of undercooked pork and lamb products has been identified as an important route of T. gondii exposure to humans. However, quantitative evaluation of T. gondii risk associated with these meat products are limited to inform risk management actions. The goal of this study was to develop risk models to predict the public health burden associated with consumption of fresh pork and domestically-produced lamb in the United States. Logistic regression and log-linear regression models were developed to predict the reduction of T. gondii during further processing and consumer preparation, respectively. A mouse-derived exponential dose-response model was developed and used to predict infection risk in humans. The estimated mean probability of infection per serving of fresh pork products ranges from 3.2×10^{-7} to 9.5×10^{-6} , corresponding to a predicted approximately 95,000 new infections annually in the U.S. population. The mean probability of infection per serving of lamb was estimated to be 1.5×10^{-5} , corresponding to approximately 6,300 new infections per year in the U.S. population. Sensitivity analyses suggested that cooking is the most important parameter impacting human health risk. This study provides a risk modeling framework to quantify T. gondii infection risk in humans through consumption of meats and a scientific basis for developing potential risk mitigation strategies to manage such risk.

W4-B.5 Pugh, G; The Coca-Cola Company; gepugh@coca-cola.com
Risk Assessment Principles for Food Ingredient Safety

The food industry is witnessing rapid growth and development, largely driven by new product innovations that are designed to meet growing consumer expectations. Along with these advancements comes the need for a robust system or process to evaluate the safety of existing and novel ingredients. In several markets around the world, a number of food safety events have occurred over the years, resulting in increased media attention, regulatory scrutiny and heightened consumer fears. Today, we live in a world that's extremely connected where a food safety issue isolated to one country can span the globe within a matter of minutes. As our global landscape changes, it is essential to have in place a robust and harmonized framework for assessing the safety of food ingredients added to the food supply. Risk assessment is the systematic process used to identify and analyze information on risks of food ingredients. Although the risk assessment framework involves a basic set of core principles, the execution of the process by regulators can vary from country to country, resulting in ingredients deemed safe in one geography, but unsafe in another geography. Risk management, an integral component of the risk assessment process, is intended to protect human health. This underscores the important role of science-based risk assessments in shaping regulatory policy and strengthening current food safety management systems. Product safety is the foundation of consumer trust, and the food and beverage industry continues to work in conjunction with government regulators and organizations representing consumer interests to effectively build and maintain this trust in our food supply.

T4-G.3 Qian, H*; Dudzina, T; Rodriguez, C; Zaleski, R; ExxonMobil Biomedical Sciences, Inc.; hua.qian@exxonmobil.com

REACH Consumer Exposure and Risk Tools

Under the EU Registration, Evaluation, and Authorization of Chemicals (REACH) regulation, the uses of classified substances (with tonnage >10 Ton per year) require the development of exposure scenarios to describe safe use conditions of the substance and then communicate these conditions throughout the supply chain. To meet this requirement, several consumer exposure and risk assessment tools at screening or higher tier level have been used since 2010, including ECETOC TRA, EGRET, A.I.S.E. REACT, and RIVM ConsExpo tools and an European Chemical Agency's Chesar platform. Recently, several of these tools have been updated to address the additional assessment needs and provide additional functionalities. An overview on these consumer tools and their features will be presented. Further, HESI Risk21 lookup tables developed based on the screening level REACH consumer tools (i.e. TRA and EGRET) will also be discussed. These lookup tables present a novel perspective on how to use the existing REACH tools and methods in a high throughput manner.

P.102 Qu, Y*; Lambertini, E; Buchanan, RL; Pradhan, AK; University of Maryland, College Park; qyz1216@terpmail.umd.edu
Evaluation of Salmonella survival and growth in Rehydrated Dry Pet Food

Salmonella enterica is one of the major foodborne pathogens linked to several disease outbreaks and product recalls. Salmonella has been reported to survive for extended periods in dry food products. Recent human salmonellosis outbreaks have been associated with dry pet foods and treats. Such outbreaks and product recalls have raised the concern for these products as potential vehicles for pathogens, which can be infectious for both pets and their owners. The ability of Salmonella to survive or grow in dry dog food, in case of intentional or accidental rehydration, is currently not available. The goal of this study was to characterize the behavior and evaluate the risk associated with the survival and growth of Salmonella in rehydrated dog food. Dry dog food formulations from different brands were rehydrated to a moisture content of 35% and stored at ambient temperature of about 30°C for 3 days. A cocktail of several Salmonella serovars isolated from pet food or pet treats was used for the inoculation of the dog food. Sampling was done at 8-10 time points to derive Salmonella growth or decline curve. Time trends of Salmonella growth or survival were modeled by fitting the data points with suitable mathematical equations. This study was helpful in providing critical information to develop potential contamination prevention strategies for Salmonella in pet food.

M3-G.2 Qian, H*; Dudzina, T; Zaleski, R; Foreman, J; Adenuga, D; Rodriguez, C; ExxonMobil Biomedical Sciences, Inc.; hua.qian@exxonmobil.com

Approaches for refining the assessment of short-term infrequent consumer exposures in a screening level risk assessment

Consumer exposure to substances in products may last from seconds to hours per use event and occur on a regular or sporadic basis (e.g. every day vs. few times a year). The default approach in consumer exposure assessment is to assume that the products are used daily taking the event exposure as a starting point, for which the control of risk should be demonstrated. However, for realistic risk assessment it is essential to consider product application time patterns to match the actual exposure duration and frequency with the corresponding DNEL (Derived No Effect Level). For the purpose of comparison to a long-term daily DNEL, which is protective of health risks related to chronic exposures, ECETOC (European Center for Ecotoxicology and Toxicology of Chemicals) has developed a use frequency banding approach and included it as a refinement option for infrequent exposure events in the latest version of the ECETOC TRA tool. The four frequency bands allow adjusting the daily event exposure up to a factor of 100, aligning the exposure scenario frequency with the long-term DNEL that assumes daily exposure over a lifetime. The approach follows common practices from other well established higher tier exposure tools, and yields more conservative exposure estimates than a straight linear averaging approach. The European Chemical Agency is updating their Consumer Exposure Assessment Guidance. As part of this initiative, several approaches to assess the risk of chronic effects from short-term infrequent exposures have been proposed and reviewed during the Partner Expert Group (PEG) consultation bringing together experts from industry and national competent authorities. Case studies will be used to characterize exposure and risk predictions under varying approaches, to assess the relative impact on modeled exposure and risk output. When developing risk assessment approaches, integrated engagement from both the toxicology and exposure fields is ideal.

M2-E.3 Røed, W; University of Stavanger; willy.roed@uis.no
Reflections on Historical Events, Unforeseen Events and Major Accident Risk

Many severe accidents such as Piper Alpha and Deepwater Horizon are mainly a result of long event sequences, which have developed gradually for a significant period, before it comes to a point of no return where control is lost, and emergency preparedness has to take over. During the significant build-up period, sometimes referred to as a 'spiral to disaster', there are often several opportunities where control could have been regained, if the awareness and understanding of the sequence of events had been sufficiently understood. However, since it was not, the opportunity to prevent the major accident failed. This paper presents and discusses some selected historical accidents and near-misses in the Norwegian oil and gas industry, the aim being to improve the understanding of accident propagation and in particular signals and warnings that could have been seen, but was not. The ambition is to achieve insight that can be used to improve future risk assessments and the ability to detect unforeseen events in general.

W2-E.3 Røyksund, M; University of Stavanger;
marie.royksund@uis.no

Current changes in risk perspectives and understanding: implications for risk regulation

In recent years, several authors have argued for a broader view on risk, which emphasizes uncertainties rather than probabilities in the way risk is defined. A key point is that the probability-based perspective does not sufficiently reflect the knowledge and strength of knowledge supporting the judgements made. The uncertainty-based approach to risk corresponds with international trends as shown by the ISO 31000 standard on risk management and the new Society for Risk Analysis (SRA) Glossary on risk-related terminology. The main purpose of this presentation is to illuminate how these conceptual changes may influence the regulation of risk, and further reflect on its implications for the different actors in a regulatory context. We use the Norwegian Oil and Gas industry as a case.

P.162 Rak, A*; Barry, J; Morgan, A; Noblis and University of Dayton Research Institute (UDRI); andrew.rak@noblis.org
Hazard Assessment of Four Selected Flame Retardant Chemicals of Importance to National Defense

The Department of Defense's (DoD's) Chemical and Material Risk Management (CMRM) Program has a well-established three-tiered process for over-the-horizon scanning for Emerging Contaminants, conducting qualitative and quantitative impact assessments in critical functional areas, and developing sound risk management options. This "Scan-Watch-Action" process was used to examine potential risks from selected flame retardants (FRs). FRs are chemicals added to materials, or chemically reacted into them, to prevent or slow the ignition or spread of fire. While they play a crucial role in the safety and protection of DoD personnel and assets, the use and disposal of products containing flame retardants may result in their release into the environment, depending upon how they are incorporated into the product, with potential negative impacts to human health and the environment. In our prior study, subject matter experts (SMEs) from throughout DoD evaluated the potential risks to DoD associated with these mission-critical chemicals. The SMEs did not identify any DoD-critical applications for TBB or TBPH that would be threatened by a potential phase-out, nor did they identify risks associated with their use. Therefore our current assessment focused on TBBPA, TCEP, HBCD, and decaBDE. We qualitatively identified risks for the five DoD functional areas based on a scale of probability the adverse impact will occur, and the severity of the potential impact. Here we present the risks identified and the potential risk management options to address them. The conclusion of the assessment indicates that select FRs require risk management actions to mitigate possible risks to operation and maintenance, including additional research into safer alternatives that meet performance requirements. Overall the risk posed to DoD by these FRs remains moderate, due to the risk that DoD could be without the flame-retardant products it needs before satisfactory substitutes are available.

T3-C.2 Rak, A*; Underwood, PM; Shatkin, JA; Noblis, Department of Defense, Vireo Advisors; andrew.rak@noblis.org
Developing DoD Guidance for Evaluation of Engineered Nano Materials During the Systems Acquisition Process

The Department of Defense (DoD) is looking to integrate nanomaterials into multiple weapon system platforms to improve system effectiveness, reduce costs, and protect forces. The DoD is developing policy and guidance that ensures an evaluation of the potential for engineered nanomaterials to adversely affect environmental and human-health during the systems acquisition process. This presentation describes specific chemical, physical, and toxicological (CPT) data needed for informed environmental and human health-sensitive choices among available nanomaterials during weapons systems acquisition. The presentation discusses how new DoD guidance focuses on data collection during the early acquisition phases, with an emphasis on data collection before Milestone B. The guidance incorporates elements from four existing risk-screening and testing approaches in a nano-specific and tiered assessment methodology. Environmental and human-health hazards can be managed, life cycle costs (LCCs) can be reduced, and environmental sustainability can be enhanced by informed nanomaterial choices—based on environmental and human health considerations in conjunction with performance requirements—throughout the acquisition process. DoD Program Managers and researchers should be prepared to evaluate CPT attributes of new engineered nanomaterials before they are deployed and potentially generate significant human health or environmental risks and associated costs. This presentation shows how information collection should support characterization of health risks and the associated lifecycle risks and costs for new weapon systems.

M4-E.3 Ram, B*; Clausen, NE; University of Delaware and Danish Technical University (Guest Sr. Researcher); bonnieram@gmail.com
Lessons from Denmark for Risk Governance of Renewable Energies

Denmark is a leading demonstration country with a high penetration of renewable energy, particularly wind energy on their power grid. In 2015, over 42% of their electricity use was powered by wind turbines on land and at sea—a worldwide record. They also have a more ambitious goal of being 100% fossil free by 2050. However, implementation obstacles for future wind turbine siting may be rising and public opposition to larger projects may be increasing around the country. What can we learn about the planning successes of the past and the challenges in the future? Since "social acceptance" is a conundrum and certainly not defined, how shall researchers select and measure criteria to assess whether wind is "socially acceptable" to the range of stakeholders and residents at a local site? With a focus on case study research, the potential relationship between project development and some elements of local social acceptability of wind power in Denmark is explored in theory and in practice. Interviews with different developers and planners examine a variety of local conditions, site histories, wind farm developer practices, national co-ownership schemes, and the dynamics of local risk governance. This bottom up exploration sheds light on whether different planning approaches may be needed to address the range of local responses and evaluations, including perceptions of risks, benefits, and uncertainties as well as risk communication strategies. These case studies seek to shed light on the risk governance dynamics and complexities of the energy transition in some communities in Denmark.

T4-C.3 Ramchandran, V*; Gernand, J.M.; Pennsylvania State University; vzr124@psu.edu

A Clustering Analysis of CNT Pulmonary Toxicity in Rodents

A quantitative, analytical relationship between the characteristics of emerging nanomaterials and related toxicity is desired to better assist in the subsequent mitigation of toxicity by design. Experimental toxicology studies are accompanied by drawbacks relating to time and cost which can be overcome or limited by the development of computational approaches. Quantitative structure activity relationships (QSAR's) and meta-analyses are popular methods used to develop predictive toxicity models. A meta-analysis for investigating the dose-response and recovery relationship in carbon nanotube (CNT) pulmonary toxicity studies on rodents was performed using a new clustering algorithm. The primary objective of the clustering is to classify groups of similarly behaving CNTs (similar dose-response-recovery relationship) leading to the identification of any physicochemical differences between the various clusters and evaluate their contributions to toxicity. The studies are grouped together based on their similarity of dose response, the algorithm uses a robust hierarchical clustering to classify the different CNT particles. The algorithm uses the Akaike information criterion (AIC) as the performance metric to ensure there is no overfitting in the clusters. Differences in the toxicity of the clusters can be explained by their respective potency and attributed to variations between the attributes of the clusters. The results from the clustering analysis of CNT particles (for 5 response variables) revealed that there are at least 4 toxicologically distinct groups present among the CNTs on the basis of similarity of dose-response. Analysis of the attributes of the clusters reveals that they also differ on the basis of their length, diameter and metallic impurity content. The CNT particles with short lengths and small diameters were found to be more potent than the other CNT's analyzed.

W4-J.3 Rath, BA; Vienna Vaccine Safety Initiative; barbara.rath@gmail.com

Refugee Health - Research and Communication

Unprecedented numbers of migrants and refugees have reached Europe in 2015, the majority being children and young adults. This poses new challenges with regards to general medical care, public health and vaccine prevention. National recommending bodies have developed targeted immunisation programs for this highly vulnerable population, to be implemented at the regional level. We are presenting the results of a first survey assessing self-perceived healthcare needs among children and young adults at the campus of the central registration site in Berlin, the Regional Office for Health and Social Affairs, between October, 2015 and March 2016. The survey confirmed that immunisation records are unavailable in the majority of refugees and migrants. Immunisations may have been missed due to migration or suboptimal medical care. Smaller children arriving from war zones in particular, have often been unable to complete the basic immunisation program in the home country. At the same time, the refugee population is at risk while spending the first months after migration in shelters and interim housing conditions. At the same time, vaccination uptake in the local population is not always optimal due to vaccine hesitancy in the destination country. The presentation aims to raise awareness of the need for evidence-based vaccine communication in an increasingly globalised world. The presentation will also highlight the interconnectedness between preventive medicine and individualised vaccine communication with regards to newly arriving refugees and migrants as well as the receiving population. Symposium Proposal ID: SY-4ypx9q Symposium Title: Vaccines and risk: A global perspective on lessons learned 2

P.103 Rani, S*; Lambertini, E; Pradhan, AK; University of Maryland; sur1404rani@gmail.com

Development of a risk model to predict Mycobacterium avium subsp. paratuberculosis contamination in bulk tank milk

Infectious diseases in dairy cattle are of significant concern to dairy industries because of their huge impact on animal health, milk production, and economics. Mycobacterium avium subsp. paratuberculosis (MAP) is a pathogenic bacterium that is associated with Johne's disease, one of the important endemic infectious diseases in dairy cattle. The contamination of MAP can be through its direct shedding in milk by cows (internal route), or mixing with milk via contact with feces or farm equipment (external route). Humans can be exposed to MAP via milk consumption, since there are evidences of its survival in milk after pasteurization. While current farm management practices aim to limit milk contamination, to-date the relative importance of different contamination routes is poorly understood. The goal of this study was to develop a risk model of MAP transmission in dairy farms, with a focus on herd and farm environmental practices. A probabilistic modeling framework was used to predict the MAP contamination from cows' shedding (internal route), feces, feed, surfaces of milking parlor and other environmental sources into the bulk tank milk. The data was extracted from a survey on dairy farms across the U.S. and published literature. The model estimated the probability and level of MAP in raw milk and the likelihood of MAP exposure to consumers.

WI-H.1 Rath, BA; Vienna Vaccine Safety Initiative; barbara.rath@gmail.com

Friend or Foe? Challenges in Influenza Treatment and Prevention

Health officials have coined the phrase that "the only thing predictable about the flu is that it is unpredictable". Influenza is virtually impossible to eradicate as it affects both, human and non-human hosts. Affected individuals are usually asymptomatic during the incubation period when infectious virus is already being transmitted. In lay language, the term "the flu" is used to denote anything from common cold symptoms to severe influenza-like illness, posing communication challenges for public health stakeholders and clinicians alike. The disease severity associated with individual influenza cases however, remains impossible to predict. The development of new antivirals requires clinical trials to be conducted internationally and data standardization efforts have been undertaken to improve data quality and interoperability. Meanwhile, influenza vaccine hesitancy is on the rise. Because of the continued evolution of influenza viruses, the effectiveness of annual vaccines is dependent on the quality of a global surveillance efforts and prediction models. The "classical" influenza vaccines are based on principles developed in the mid-20th century. Progress has been made with intranasal live vaccines in children. Universal vaccines are in development, and once available, will provide a real break-through. For the time being, healthcare providers will need to communicate consistently to raise influenza awareness and to keep patients motivated to receive the influenza vaccine annually. The presentation will highlight key communication challenges from a provider perspective with a focus on the management and prevention of influenza infections in infants and children, who are not only at risk but also the most avid transmitters of disease. Symposium Proposal ID: SY-4ypx9q Symposium Title: Vaccines and risk: A global perspective on lessons learned 1

P.189 Razzolini, MTP*; Lauretto, MS; Sato, MIZ; Nardocci, AC; University of Sao Paulo and CETESB; razzolini@usp.br
Integrated microbial risk assessment of infection by Giardia and Cryptosporidium from drinking water delivered by eleven surface water systems in Sao Paulo State, Brazil.

Giardia and Cryptosporidium were quantified monthly in surface water catchments from 11 cities across the Sao Paulo state, during a year, for supporting surveillance actions based on risk assessment. Sample percentages below the DL (0.01/L) ranged from 16.7% to 100% for Giardia (mean=70.5%) and 1.7% to 91.7% for Cryptosporidium (mean=69.8%), with maximum concentrations of 17.7 cysts/L and 11.5 oocysts/L, respectively. Usually, the high numbers of negative samples and high variability in pathogen concentrations represent a challenge to adjust data and estimate risk in an integrated approach. In this study variability was treated via cluster analysis: each catchment point was summarized by the pair of geometric mean logs for the parasites (assuming half-DL for concentrations

WI-1.1 Redinger, CF; Redinger 360, Inc. ; cfr@redinger360.com
Using Organizational Objectives and Context to Drive Risk Management: Risk in the new ISO Regime

Science and Decisions (2009) presents several shifts-in-thinking about risk management. A key one is that risk assessments need to be informed by clearly posed risk management questions and goals. The same year that Science and Decisions was published, the International Organization for Standardization (ISO) published a risk management standard (ISO 31000), and then in 2012, it instituted a framework requirement (Annex SL) for all future ISO management systems. ISO has made “risk-based thinking” a key distinction in this new framework, along with a requirement that risk requirements be integrated in an organization’s business processes. ISO’s “risk approach” applied to organizational risk management parallels Science and Decisions, in that risk-based decisions must be informed by an organization’s context and objectives. This symposium will examine the history of risk norms and requirements in ISO since its inception. The way Annex SL requirements have played out in real time will be examined with examples from ISO 14001 (Environmental Management) and the proposed ISO 45001 (Occupational Health and Safety Management) standard. A certification registrar will provide a conformity assessment perspective on how organizations are responding to these new requirements. A lively roundtable discussion will address pros and cons on ISO’s venture into the risk arena, and the way this development may impact organizational risk management as well as public policy.

WI-1.5 Redinger, CF; Redinger 360, Inc. ; cfr@redinger360.com
Roundtable Discussion

The speakers will engage attendees in discussion and dialogue about the presentations and attendee thoughts.

T3-1.4 Redinger, CF; Redinger 360, Inc. ; cfr@redinger360.com
Is harmonization possible? Solutions and Looking at ISO

Words and language matter when seeking impact or change in organizations, especially with worker health and safety. This presentation explores challenges with seeking a common language for risk. Recent developments within the International Organization for Standardization (ISO) framework will be presented that provide guidance. Examples from several large multinational companies will be presented that point to the emergence of new language that is impacting performance.

W4-H.5 Redmon, JH*; Womack, DS; Elledge, M; Wanigasariya, K.P.; Wickremasinghe, R; Levine, K; RTI International, University of Sri Jayewardenepura, and University of Kelaniya; jredmon@rti.org

Addressing Sri Lanka's Public Health Crisis – Employing a Tiered Investigation Approach to Pinpoint the Risk Factors Associated with Chronic Kidney Disease of Unknown Etiology (CKDu)

Sri Lanka recently transitioned from a low to middle income nation and its disease pattern has shifted from infectious diseases and maternal/child health toward non-communicable diseases. Over the past decade, the emergence of chronic kidney disease of unknown etiology (CKDu) in the country's rural agricultural dry zones has become a public health crisis. CKDu is characterized as asymptomatic until late stages and is not attributed to diabetes, hypertension, or other known risk factors. Despite efforts, no study has yet pinpointed the likely causes of CKDu with supporting data, and most studies have focused on individual concerns (e.g., arsenate pesticides). We postulate that CKDu etiology is multifactorial, involving genetic predisposition, nutritional/dehydration status, environmental nephrotoxin exposure, and behavioral/lifestyle factors. We completed a broad panel, metallomics/mineralomics laboratory analysis to screen whether heavy metal and trace nutrient concentrations in biological, environmental, and food samples collected from two endemic towns contain above average background values or exceed current health benchmarks. Our regional geochemical screening analysis identified specific constituents above levels of potential concern, including cadmium, lead, mercury (human blood or hair); arsenic (soil); fluoride and lead (drinking water). The goal of this screening study was to use this data to design and implement a comprehensive study. We recommend analyzing a high-volume of georeferenced multimedia samples and demographic/lifestyle surveys to create a robust dataset, allow for comparative statistical analysis among cases and controls in endemic and non-endemic areas, and facilitate the completion of a human health risk analysis. This approach will improve the likelihood of identifying the collective risk factors associated with CKDu in Sri Lanka and other geographical hot spots in Central America, Mexico, and India.

M4-E.4 Renn, O; Institute for Advanced Sustainability Studies (IASS); ortwin.renn@iass-potsdam.de

Systemic Risks: Challenges for Risk Governance

ABSTRACT The history of the last four decades has been a success story in terms of conventional risk management. All data show that life expectancy is increasing, accidents become less frequent and habitual risks less severe. The picture becomes, however, less favorable if we look at globally interconnected, non-linear risks such as those posed, for example, by climate change or the global financial system and the closely related growing inequality between rich and poor. Systemic risks can be characterized by four major properties: they are (1) global in nature, (2) highly interconnected and intertwined leading to complex causal structures, (3) non-linear in the cause-effect relationships and (4) stochastic in their effect structure. The main features of systemic risks include ripple effects beyond the domain in which the risks originally appear and the threat of a multiple breakdown of important or critical services to society. Insidious systemic risks tend to be underestimated and do not attract the same amount of attention as catastrophic events that occur suddenly. There are three main sources of global hazards that we need to focus on: the growing extent of human intervention in nature (climate change, pollutant emissions, use of land and water); inadequate or ineffective control of central processes in the realms of business and politics (capital markets, corruption, capacity deficits); and adverse by-products of globalization and modernization (unequal living conditions, lack of security, cyber-risks, loss of identity). Responding adequately to global systemic risks is a challenge for our world society where national interests and different cultures conflict with efficient responses. Governance of systemic risks require strategies that address the complexity, scientific uncertainty and socio-political ambiguity of its underlying relationships.

M2-A.3 Reilly, AC*; Tonn, G; Guikema, SD; University of Michigan; acreilly@umich.edu

The effects of residential decisions on electric-power system reliability in areas that experience repeated hurricanes

Electrical-power outages caused by hurricanes tend to be widespread and prolonged. Given the strong reliance for electric power and minimal tolerance for interruptions, customers are increasingly placing collective pressure on regulators to require utilities to harden their system and enhance restoration planning. Further, many customers take personal action by purchasing generators to guarantee a continuous stream of power. An individual's choice over which action to take, or to take no action, is at least partially based on their preference for reliable power, their beliefs about the likelihood of losing power in the future, and their perceived ability cope with outages. The choice to purchase a generator may come at the expense of collective action however, whereby those who buy generators do not participate in the collective grievance and thus reduce the demand for system hardening. By using a validated power-outage forecasting model in conjunction with an agent based model, we characterize how a community's likelihood of losing power in repeated hurricanes is affected by the complex interactions among individuals' behavioral responses in whether to engage in personal or collective action.

W2-E.1 Renn, O*; Dreyer, M; Institute for Advanced Sustainability Studies (IASS); ortwin.renn@iass-potsdam.de

Testing for resilience in energy scenarios: a summary of the National German Academies Report

The German national project "Energy Transformation" involves risks and uncertainties, which require a targeted risk governance approach. Transitions are always associated with higher vulnerability before a new steady state is achieved. It is all the more important, therefore, to identify the potential weak points in the transformation process and to take appropriate countermeasures. Moreover, especially with high uncertainty, such processes may include surprising developments that require more robust and more resilient strategies. Because of complex interrelationships minor events can trigger large effects on the overall system. Increasing the resilience of the energy system in the transformation process is therefore a key task of precautionary sustainability policy. The German national academies have launched a national platform for assessing and evaluating strategies for increasing resilience against surprising developments in the course of transformation. The mandate of this platform (chaired by Ortwin Renn and managed by Marion Dreyer) is to apply the concept of resilience to the challenges associated with the energy transition and identify political leeway to promote the resilience of the energy system based on a number of exemplary threat scenarios. The scenarios deal with six potential threats: shortage of raw materials for metals, shortage of raw materials for natural gas, loss of security, acceptance withdrawal, governance failures and weather extremes. The scenarios depict developments and events that are assessed from today's perspective as unlikely and unexpected or not (yet) seen as realistic. They serve as "substitutes for nasty surprises" with negative consequences especially for the security of energy supply. The paper will report about the outcomes of this national initiative and emphasize the repercussions and implications of the findings for foundational issues of risk and resilience studies.

W3-D.1 Restrepo, B; Schuttringer, E*; US Food and Drug Administration; ehren.schuttringer@fda.hhs.gov
A Retrospective Analysis of the Costs and Benefits of USDA's Meat HACCP Rule

In this analysis, we evaluate the effect of the meat and poultry Pathogen Reduction and Hazard Analysis and Critical Control Point (PR/HACCP) rule on foodborne illness. PR/HACCP, established by the United States Department of Agriculture (USDA) in 1996, specifies sanitation, process control, and testing procedures for specific foodborne pathogens in meat and poultry producing establishments. There are few existing empirical studies whose authors measure the relationship between food safety regulations and foodborne illness. In an effort to supplement this literature, we attempt to estimate the effect of PR/HACCP on foodborne illness using a difference-in-differences estimation strategy and national disease surveillance data. We evaluate the effect of the policy on overall foodborne illness and separately for *Escherichia coli* and *Salmonella*. Results indicate little evidence of a relationship between PR/HACCP and foodborne illness. However, we find suggestive evidence that trends in foodborne illness incidence rates decline prior to the implementation of the policy. This suggests that factors other than PR/HACCP, such as meat and poultry industry behavior, influenced the prevalence of these diseases prior to the rule taking effect.

P.169 Richter, BP*; Wilson, PH; Hawkins, BE; Winkel, DJ; Whittaker, IC; Gooding, RE; Bradley, DR; Cox, JA; Battelle Memorial Institute; richterb@battelle.org
Modeling Exposures in Municipal Water Contamination Scenarios using Synthetic Systems

The Chemical Terrorism Risk Assessment is a Department of Homeland Security Chemical Security Analysis Center program that assists in prioritizing mitigation strategies and assessing the risk of chemical terrorism attacks, including the intentional introduction of harmful chemicals into municipal water distribution systems (MWDS). A relative scarcity of consistently detailed, city-specific information, paired with the need to assess consequences to the wide variety of systems in the US represents a challenge to the current state of the art in hydraulic modeling, which requires explicit MWDS network information for each system considered. An innovative model involving the creation of synthetic MWDS networks based on the characteristics of real MWDS networks was developed to address this challenge. Synthetic MWDS network results were compared against industry-standard simulation results for real cities provided by USEPA. The exposures predicted were found to be consistent with USEPA-provided datasets, supporting the use of the synthetic model for the purposes of estimating mixing, dilution, and consumption.

M4-I.5 Rice, GE; US EPA National Center for Environmental Assessment; rice.glenn@epa.gov

Research Directions in Cumulative Risk Assessment

Cumulative risk assessment (CRA) has been defined as evaluating the combined risks from aggregate exposures to multiple stressors, potentially including chemical, psychosocial, physical or biological stressors. CRA development is intended to address multiple concerns: 1) risk managers' concerns that single chemical- or source-focused assessments might not comprehensively address risks experienced by populations that are exposed daily to dynamic mixes of stressors; 2) concerns about health outcomes among disadvantaged populations; 3) the multifactorial nature of many important health outcomes (e.g., incidence of cancer and heart disease are influenced by genetics, environmental factors, lifestyle, life history, occupational factors, and personal behaviors, among other factors; and, 4) concerns that risk management decisions ideally consider efficiency and equity and that risk assessment practices need to inform such decisions. This talk will focus on selected key research directions intended to aid the evolution of the state of the science and increase the capacity to conduct CRA. These research directions will include consideration of multiple disparate stressors in CRAs and incorporation of psychosocial stressors.

P.123 Rickard, LN; University of Maine; laura.rickard@maine.edu
Of sea lice and superfood: A comparison of regional and national news media coverage of aquaculture

As wild fisheries decline, aquaculture – the cultivation of aquatic organisms, such as fish, crustaceans, mollusks, and plants – will provide the majority of the seafood consumed in the U.S. Scientific and technological advances over the past three decades has made American aquaculture production increasingly environmentally sustainable and economically viable: a source of local jobs and affordable food. Yet, a legacy of environmental and human health concerns, and current controversy surrounding siting operations and the use of genetically modified species, suggest that perceived risks of aquaculture may loom large. As domestic aquaculture expands, knowing what U.S. publics think – in order to design strategic risk communication, and foster support for policy – will be increasingly critical to industry and government sectors alike. A news media content analysis can provide a critical first step toward gauging public opinion. The present study examines U.S. news media coverage of aquaculture over a ten-year period (2005-2015). To account for differences in aquaculture development and practices, we compare coverage (N = 493 articles) in four regional news outlets and four national newspapers for discussion of aquaculture risks, benefits, scientific issues, political/legal issues, and environmental sustainability, examining both prominence and co-occurrence of these themes over time. Following past research, for the majority of the study period, risk dominated the aquaculture discussion in both the regional and national newspapers. News media coverage of aquaculture during the last three years, however, has also included increasing attention to benefits and sustainability, a pattern that may be attributed, in part, to the growing distinction of shellfish aquaculture in the U.S. Comparing within and between regional and national newspapers revealed differences in thematic prominence that suggest that the conversation about aquaculture, rather than being monolithic, may vary geographically within the U.S. Implications and directions for future research are discussed.

M2-C.4 Ritchie, R*; Franco, LA; Loughborough University; r.a.ritchie@lboro.ac.uk

The effect of information format on police officer risk perceptions
In this presentation we examine the impact of different visual information formats on police officer's risk perceptions. We report on an experimental study in which 367 police officers across different ranks assessed their perceptions of risk based on information contained in six electronic briefing communications. The experiments manipulated information format through use of colour coding (red, amber, green), technical abbreviations versus plain text, and inclusion of uninformative data items. We tested whether viewing time pressure acts as a mediator or moderator in perception formation. The results show that neither the use of colour coding nor incremental inclusion of uninformative data items affects the perceptions of risk, whereas increasing the use of technical abbreviations does. In addition, it was found that viewing time pressure acts a moderator on perceptions, but only under extreme criteria. Analysis of respondents' characteristics also demonstrated a significant effect of the officer's rank on risk perception, where an increase in rank led to a consistent reduction in perceived risk for the same information. The research reported here contributes to further our understanding of the relationship between the type of visual information used by experts in dynamic environments and their perceptions of risk. Implications for the theory and practice of visual risk assessments will be discussed.

P.155 Roncancio, DJ*; Nardocci, AC; University of Sao Paulo. School of Public Health; djimenar@usp.br

Social vulnerability and the occurrence of gastrointestinal diseases associated with precipitation seasons in São Paulo, Brazil.
Hydro-meteorological extreme events can have an important impact on human health. Direct or indirect exposure to flood water can result in outbreaks of gastrointestinal diseases and respiratory infections among others. Climate change scenarios project an increase in extreme precipitation events in the Brazilian southeast region. Since improving risk management and adaptation strategies depends on knowing which areas and populations are most vulnerable to natural disasters and their health related problems, it is necessary to have clarity of the impacts on human health these events may have. The study aimed to compare the basin-level social vulnerability to natural hazards (SoVI) in the city of São Paulo against the spatial distribution of the public health care system registers of Diarrhea in the same area. Calculation and mapping of SoVI follows the Cutter et al (2003) methodology by processing social data from the 2010 census and using principal components analysis. Trends in spatial distribution of the proportions of authorization for hospitalizations (PAH) due to Diarrhea in 2 age groups (children and elderly) for the rainy and dry seasons of the years 2009 and 2010 assessed the effects of the city's seasonal precipitation on health. Results show 3 main components explaining the vulnerability of the city in different amounts: Demographic characteristics (43%), Urbanization and average family income (17%) and basic sanitation (16%). Additionally, 65% of the basins fell within the medium vulnerability level, 15% in medium-high level, 16% into the medium-low level and two percent 2% within the extremes (very high and very low). Clusters of basins with high proportions of PAHs overlapping basins with high social vulnerabilities and the opposite scenario were found. This shows how the principal components of social vulnerability contrast in each basin to trigger risk factors for the outbreak of infectious diseases and can differentiate the risk management strategies.

M3-I.2 Rivers, L*; Ligmann-Zielinska, A; Schmitt-Olabisi, L; Du, J; Marquart-Pyatt, S; North Carolina State University; livers@ncsu.edu

Participatory Ensemble Modeling to Study the Multiscale Social and Behavioral Dynamics of Food Security in Dryland West Africa
Despite recent gains in global agricultural productivity; sustained, equitable, and stable access to food continues to be a concern in the Sub-Saharan region. This issue is even more pressing when combined with climate change, reoccurring hunger, and volatile humanitarian relief that can undermine the vulnerable livelihood of affected people. Food security is a complex problem that involves many stakeholders (e.g., families, tribes, NGOs, farmers, and governments) across different spatial scales (e.g., individual, local, regional, and continental), and within different contexts (e.g., social, economic, political, cultural, and natural). Consequently, this project will use computer modeling: [1] to understand the key elements of the food system, [2] to explain food insecurity, and [3] to provide tools for long-term policy-making for improved food availability, access, and stability. This project will enhance understanding of the critical societal problem of food security and will communicate potential solutions to decision makers by developing tools that synthesize qualitative and quantitative information from geography, sociology, decision science, and sustainability science as well as cross-disciplinary knowledge on food insecurity. To this end, the investigators will develop and test a collection of small and independent computer models used to describe and understand different aspects of the food system. The investigators will use mental modeling (MM), multilevel structural equation modeling (MSEM), agent-based modeling embedded in a geographic information system (GIS-ABM), and system dynamics modeling (SDM) in an integrative, participatory, and iterative manner, to examine mechanisms affecting food security. Each model builds a progressively richer understanding of the problem. An overarching scenario study tool will encapsulate the models and offer a transdisciplinary platform for synthesizing information from the models through scenario generation and evaluation.

M3-I.3 Rose, KM*; Su, LY-F; Wirz, C; Brossard, D; Scheufele, DA; Xenos, MA; University of Wisconsin-Madison; kmrose@wisc.edu
Gut reactions to GMO foods: analyzing the interplay of attitudes, trust, and risk perceptions

In recent years, the growing prevalence of agricultural biotechnology and genetically modified (GM) crops have sparked debates in the U.S. and abroad. Due to the nature of this technology, concerns have been raised about the safety of food produced and it has become increasingly important to understand GM food related attitudes and risk perceptions. Particularly, it is important to understand if attitudinal dimensions, such as "gut reactions" (emotional responses, including disgust), are important factors in explaining risk perceptions. In this study, we explore what GMO (genetically modified organism) food related attitudes impact the risk perceptions that people have of these foods. Specifically, we examine how attitudes and gut responses to GMO foods predict public risk perceptions. In doing so, we also examine the interactive effects between these attitudes/gut responses and trust in food related organizations on GM food related risk perceptions. Data was gathered from a 2015 mailed survey of a Midwestern state (N=931) and was publicly representative. The mail survey design consisted of four waves and had a final response rate of 50.3%. We find that these attitudes and gut reactions have a large and overriding impact on risk perceptions compared to other predictors. The reliance on attitudes as cues for perceived risk, especially for those who have low trust in food related groups, is explored. This study will build upon these findings to provide a better understanding of GMO risk perceptions as a function of the interplay between attitudes and gut reactions to GMOs and trust in food systems.

P.55 Rosenstein, AB*; Collier, TK; Mori, C; Independent Consultant; envriskexpabr@aol.com
Extrapolation Strategies for Ecological Risk Assessment: Inhalation Toxicology in Cetaceans

There are often limited or no toxicity data for ecological receptors, and physiological information for many species is also similarly limited. In our recent research, we extrapolated laboratory animal inhalation toxic effect levels to marine mammals (cetaceans) by scaling, using body mass and lung volume. Other differences between terrestrial and marine mammals, some of which may derive from living and feeding in deep water versus in air, are not well understood. Examples include: physiological differences in lung structure and nasal filtration; environmental and chemical differences related to the possible impact of gas pressures at depth on toxicant uptake; and metabolic differences. These differences were not incorporated into the extrapolations we have conducted so far. Here we address the following question: what is the effect on the final exposure and risk estimates of leaving out these types of factors? We will present a summary of extrapolation approaches that have been used in ecological risk assessments in the past, and we will discuss promising methods currently being developed to take into account metabolic, physiological, and other species differences.

M3-J.12 Rosoff, HR*; John, RS; Guney, S; Nguyen, K; University of Southern California, Price School of Public Policy; rosoff@usc.edu

How framing, controllability, and aspiration influence communications and decision making about natural disaster early warning programs

Early warning is a critical element of disaster risk reduction. The selection of early warning programs is largely left to the decision making of government agencies. The challenge for policy makers is to identify programs that effectively prevent loss of life and reduce the economic impact of disasters. Furthermore, policy makers must select programs that allow for effective communication with communities at risk, such that the population heeds the warning and takes protective action. We study the challenge of selecting earthquake, tornado and flash flood early warning programs through a series of behavioral experiments in which various aspects of the context are manipulated that impact how program selection is perceived, interpreted and ultimately evaluated. In our experiments, participants' role play as policy makers and must decide between two different early warning programs for a given disaster type. Specifically, we study whether the participant selects the more risk-seeking or risk-averse program when the decision frame, control, and aspiration are manipulated. Framing consists of two contexts with same underlying outcomes described as either gains or losses. Control is defined as the perceived degree of influence that a policy maker has on the distribution and response to an early warning, and aspiration captures the degree to which a disaster outcome fulfills the goals of the policy maker. We anticipate that participants will have a tendency towards risk-aversion in gain frames and be more risk-seeking in loss frames – the classic gain-loss framing effect. We also hypothesize that the greater the aspiration level, the more risk-averse the decision maker because the outcome will be perceived as harder to attain. Lastly, we expect that when the policy maker experiences more control, she will be more risk-seeking because she perceives that she can manage the uncertainty associated with the decision.

WI-C.4 Rosoff, H*; Blythe, J; Kusumastuti, S; John, R; University of Southern California; rosoff@usc.edu
Behavioral Experimentation Of Cyber Attacker Deterrence With Deter Testbed

Deterrence is now being considered as a strategy to prevent and defend against cyber attacks. One part of implementing this strategy is having a powerful defense. If the defender's security can sufficiently make an attack exceedingly difficult, an attacker might choose not to attack. The challenges of enhanced security are that the number of potential attackers is numerous, there are limited barriers to entry and there is ample opportunity for concealment. In addition, unique to cyber space is the significant distance between attacker and defender at the time of attack, and the potential for attacker concealment. We study the complexities of cyber deterrence by conducting behavioral experiments with DETER (cyber defense technology experimental research interface) on the effects of enhanced security on attacker and defender decision making. By using DETER a more realistic exchange of the iterative process between the attacker and defender can be monitored allowing for collected data to more aptly represent their interactions when deterrence strategies are implemented. In our experiment, participants' role play as attackers confronted by different defense strategies. Specifically, we study the deterrent effect of layered security and monitoring, in the pursuit of various targets. Layered security is defined as either: (1) a series of moderately effective defense components where each covers the gaps in the other's protective capabilities or (2) a "best of breed" defense where one component of the integrated layers is implemented and extremely effective. Monitoring is defined as either: (1) a sophisticated monitoring system that when in operation detects all threats; however, this system is randomized and as such is only turned on at specific times, or (2) a less sophisticated monitoring system that is in operation all the time. We assess whether the attacker continues with the planned attack, is diverted to another target, or chooses not to attack after acquiring knowledge about the defensive security in place.

P.53 Rossmeis, CM*; Peck, C; Garber, K; U.S. Environmental Protection Agency; rossmeis.colleen@epa.gov
National-level evaluation of pesticide risks to endangered and threatened species

The United States Environmental Protection Agency (USEPA), the US Fish and Wildlife Service (USFWS) and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS), and the US Department of Agriculture are jointly developing a framework to address the risk from pesticide use to federally threatened and endangered species (listed species) and their designated critical habitats. This framework is intended to be applied on a national level to anywhere a pesticide may be applied as allowed on a label. The framework includes 3 steps, with the first two steps focused on risks to an individual of a listed species through a weight of evidence approach and the third step focused on risks to entire populations. The methodology is being developed by the agencies through the assessment of risks of three organophosphate insecticides: chlorpyrifos, diazinon and malathion. Draft results of the first two steps of the process have been completed for approximately 1780 species of plants and animals. USEPA, USFWS and NMFS are currently working to translate information used to identify risks for individuals, which are based on field and waterbody level scales, into information that is useful at the population, landscape and watershed scales. This presentation will give an overview of the methodology used in the individual level risk assessments used for the first two steps of the process and how this information could be integrated into a population level assessment.

M4-B.1 Rossmeisl, CM*; Panger, M; U.S. Environmental Protection Agency; *rossmeisl.colleen@epa.gov*

The use of incident data in assessing risks from pesticides

In assessing pesticide risk to non-target organisms in the environment, information on incidents (i.e., any reported exposure or effect from a pesticide's use that is not expected or intended) can be a useful tool. In the U.S. Environmental Protection Agency's Office of Pesticide Programs (USEPA OPP), human, ecological, and pet pesticide incidents are currently used in risk assessment as a line of evidence. The USEPA OPP is actively working to improve the reporting and use of incident data in assessing risk. Current activities include developing a team to quickly identify high priority incidents when reported to allow early and appropriate action, developing a portal to allow easier reporting of pesticide incidents to the agency, and fostering an outreach effort to improve communication and voluntary reporting of incidents in a manner that is most helpful for Agency consideration in risk assessment. Challenges exist in utilizing incident data, including verifying the association of a reported incident with a pesticide use and encouraging the active reporting of incidents. This discussion will expand on the USEPA OPP's efforts to improve incident data reporting and use and the challenges faced in using the data.

M4-B.4 Ryti, Randall; Neptune and Company, Inc.; *rryti@neptuneinc.org*

Are Population Ecology Concepts Routinely Applied to Ecological Risk Assessments?

Ecological risk assessments (ERAs) are used to support regulatory decisions and policy implementation. There are a variety of ERA methodologies, and some make extensive use of population ecological information, but others do not. For example in retrospective regulatory assessments of contaminated sites, generally little attention is paid to realistic spatial assessments of wildlife populations even though literature reviews and models to support such evaluations are available. This paper presents the results of a literature review of the current state of the practice for ERAs for contaminated sites, pesticide registration, monitoring media, and regional-scale assessments of introduced species. The use of population ecology for each of these ERA applications is reviewed as well as the potential limitations to their broader application to ERAs.

P.176 Royal, AY; Resources for the Future; *aroyal641@gmail.com*
Cognitive Sophistication and Learning about Risk from Experience

This study examines the relationship between cognitive sophistication, risk perception and risk mitigation when people learn about risk through experience. Findings are based on observations from a controlled laboratory experiment that had subjects make risk mitigation choices and report risk perceptions in response to a repeated low probability hazard. The experiment also contained tasks designed to independently evaluate each subjects' risk preferences and level of cognitive sophistication. Subjects possessing cognitive biases characterized by the representative heuristic were relatively more pessimistic about risk when unfavorable outcomes were frequently experienced, reflecting a possible over-reliance on small samples of outcomes (the hot-hand fallacy). Although reliance on the representative heuristic predicted patterns in subjects' reported beliefs, it was not significantly correlated with mitigation choices. However, subjects with greater cognitive ability, as measured by a cognitive reflection test, tended to make risk mitigation choices that more closely matched their risk preferences-- implying a lower degree of bias and inefficiency among more sophisticated subjects.

W3-E.2 Sahlin, U*; Aven, T; Lund University, Sweden and University of Stavanger, Norway; *ullrika.sahlin@cec.lu.se*
Robustness to uncertainty": What does it mean and how should we best deal with it in a risk management context?

In risk management, robustness is considered one of the fundamental strategies along with risk-informed and discursive strategies. Robustness relates here to the measures and arrangements considered and their ability to withstand risk sources, events and uncertainty. It is common to talk about "robustness to uncertainty", and considerable work has been carried out to develop appropriate strategies to establish this type of robustness. But what does this concept "robustness to uncertainty" really mean and how should it best be dealt with? The paper reviews common ways of understanding and using the concept in risk management, and provides new insights by building on current conceptualisations of risk, which highlight values at stake as well as uncertainties. Compared to earlier work on this topic we take a step back and perform a fundamental rethinking of the concept and its use. We ask: should not the aim rather be to ensure "robustness to risk" and not only "robustness to uncertainty"?

W1-E.4 Sahlin, U; Lund University, Sweden;
 ullrika.sahlin@cec.lu.se

Uncertainty According to EFSA

EFSA's new uncertainty Guidance published 2016 offer a comprehensive and broad uncertainty management from a risk assessment perspective. The Guidance seek to evaluate the impact of sources of uncertainty on the outcome of assessments. The Guidance open up for risk assessors to adapt the procedures and measures for uncertainty to the problem at hand. Uncertainty analyses are divided into standardised procedures and other procedures. Other procedures for uncertainty analysis are needed, not only in - what EFSA refer to as - emergency assessments, but also when standard procedures are missing or, when there is a need to include other types or sources of uncertainty, than those included in available standard procedures. The Guidance provide an overview of methods for uncertainty analysis and a guidance to evaluate a chosen procedure to treat uncertainty. A general aim of the Guidance is to better motivate and facilitate the use of quantitative measures of uncertainty in assessments. However, qualitative methods can be used in problems for which quantitative approaches are hard to motivate. By this Guidance, EFSA provide assessors a novel way to understand and manage the management of uncertainty, which can help risk assessors to motivate their choices on procedures of uncertainty analysis.

W3-B.4 SANAA, MS; French Agency for Food, Environmental and Occupational Health & Safety; moez.sanaa@anses.fr
Approaches for dealing with uncertainty and variability in decision analysis for food safety

Risk ranking is an important component of risk management due to the need for priority setting and resource allocation. Semi-quantitative scoring methodologies for risk ranking have been widely adopted because they are acknowledged to be practical and easy to use tools, which can help to promote discussion and present complex risk data in a concise fashion. Supporters of scoring methodologies argue that because of data gaps and time constraints it is not always possible to perform quantitative risk ranking. The scoring approaches, however, provide in general ranking with considerable differences in risk ranking compared with a quantitative stochastic model and more errors than the quantitative deterministic approaches. The objective of this presentation is to propose solutions that avoid using arbitrary scoring. Instead of using scores, our approach recommends the use of quantitative risk ranking models respecting the rules of probability calculation and describing correctly the main biological phenomena that determine the risk. Additionally, the generic risk ranking model is including both variability and uncertainty. In the absence of empirical data, the input parameters can be estimated using Expert Knowledge Elicitation (EKE) methods. EKE methods can be used to quantify expert knowledge and uncertainty by eliciting probability distributions or possibility distributions.

T2-F.1 Santos, JR; George Washington University; joost@gwu.edu
Interdependent Vulnerabilities of US Economic Systems to Disasters: an Input-Output Key Sector Analysis

This paper will utilize a series of US economic input-output (I-O) accounts for the last decade to track the interdependencies of economic systems and how they have evolved over the recent years. I-O analysis has been developed by Nobel Laureate Wassily Leontief and extensive I-O data are released by the US Bureau of Economic Analysis annually. We will investigate how simultaneous sector perturbations triggered by disasters will give rise to the concept of interdependent vulnerability. Dirichlet distributions will be implemented to model the uncertainty of the underlying time series of I-O data.

T4-J.5 Satterfield, TA*; Kaplan-Hallam, M; Tam, J; Wilson, N; Chan, K; Bennett, N; University of British Columbia; terre.satterfield@ires.ubc.ca

Measuring Resilience: Insights, Challenges and the Problem of Thresholds

At the heart of resilience thinking are efforts to understand when and under what circumstances change to a system can be reasonably absorbed or might instead result in regime-changing consequences. Yet, those who take seriously the social side of social-ecological systems have had a difficult time explaining what constitutes a regime change, or whether a change is negative or positive. The reasons for this are many including the capacity of individuals and communities to normalize change, the differences posed by how people adapt to slow versus fast change, and the question of what constitutes a threshold where outcomes exceed adaptive capacity, broadly stated. This paper analyses a set of case studies to demonstrate empirically and theoretically how to better characterize social thresholds as linked to the resilience of social systems. The insights derived from this include how we might approach resilience through a subjective 'risk' lens (i.e., when and why individuals perceive or react strongly to some changes as much worse than others), what kinds of shocks or stressors are particularly likely to challenge or defeat institutions closely aligned with adaptive capacity, and how we might come to understand social thresholds as tipping points where enduring regimes of identity might matter and are likely overturned. We conclude with some observations as to why a robust characterization of social resilience remains a fundamental challenge to social scientists and where further insights might be achieved.

T4-C.4 Sayes, CM; Baylor University; *christie_sayes@baylor.edu*
Utilizing the Adverse Outcome Pathway Model as a Tool for Elucidating Zinc Nanoparticle Toxicity

The use of adverse outcome pathway (AOP) models has become a sophisticated means to understand the mechanism(s) of action after exposure to chemicals, particles, biologics, or other substances. Here, we have developed an AOP describing possible toxicological mechanisms associated with zinc micro- or nanoparticle exposure. This AOP concludes that there are multiple pathways perturbed after exposure to zinc; the predominant adverse outcome is inhibition of normal copper-induced homeostasis in mammals. However, this adverse outcome is dependent on the zinc particle transformation that occurs before the molecular initiating event (termed pre-MIE), namely dissolution into Zn²⁺ ions. The MIE could be defined as Zn²⁺ complexing with the protein metallothionein. Further perturbations are presented in subsequent key events (KE) results from zinc's propensity to chelate copper resulting in copper deficiencies. At the onset, REDOX reactions impair mitochondrial damage on the cellular level and excessive inflammatory cytokines are produced in tissues. Morphological and biochemical changes progress in the organs, such as non-alcoholic fatty liver disease in the liver, peripheral neuropathy in the nerves, or anemia in the blood. Together, these diseases are labeled as the adverse outcomes (AO). This study demonstrates how nano-specific AOPs may add to the current knowledge base, as well as help identify voids where future development strategies may be developed.

T3-E.2 Scheele, R.; Stuttgart Research Center for Interdisciplinary Risk and Innovation Studies, University of Stuttgart ;
Ricarda.scheele@ziri.us.uni-stuttgart.de
Wolf in Sheep's Clothing? A Conceptual and Empirical Reconsideration of the Value of 'Plausibility' as Assessment Criterion in Scenario Planning

A key characteristic of scenarios as planning tools is that it distances itself explicitly from assigning probabilities to single futures. To account for its central objective of recognizing multiple forms of uncertainties and thus considering multiple futures, the concept of 'plausibility' has been widely established across the diverse scenario planning community as a key indicator in scenario development and assessment. Only a few scientific contributions have addressed plausibility, predominantly as social construction process that can only be coproduced by scenario producers and users. This study takes up plausibility as a cognitive mechanism in data evaluation—a perspective the scenario literature has mostly been silent on. It examines the way individuals process different scenario contents and formats and analyses how they subsequently perceive the plausibility of scenarios. The study is based on quanti. & quali. data from a semi-experimental design; participants were presented different scenario-sets on energy futures in the German energy transition debate. The methodological framework is derived from educational and cognitive psychology in which plausibility is conceptualized as a filter for information processing and precondition for conceptual enhancement and change. The approach allows for analyzing determining factors in scenario perception where there is to date only anecdotal evidence on how plausibility relates to probability, desirability or trust. Results indicate dynamic relationships involving, among others, perceived source credibility and scenarios' fit with individuals' prior knowledge and pre-conceptions. This gives rise to reconsidering the value of plausibility given scenarios' general objective of stretching people's mindsets and creativity. It also suggests plausibility as assessment and selection criterion can create illusions of certainty. The study proposes scenario plausibility research can be enriched by analogies to concepts and related findings on risk perception and communication.

T4-B.2 Schaffner, DW*; Igo, M; Miranda, R; Rutgers University;
schaffner@aesop.rutgers.edu

Modeling cross-contamination and survival of Norovirus in foodservice settings

Modeling Norovirus transmission in foodservice facilities poses a number of unique challenges that are different than many other types of microbial risk assessment. Norovirus may be introduced into a facility via a sick worker or customer. That individual may shed Norovirus via vomit or diarrhea. Norovirus may also enter the facility via a contaminated food item. Once Norovirus is in a facility, the means by which it can spread and infect others are complex. Traditional quantitative microbial risk assessment tools like @risk are not suitable for modeling these complexities. Agent-based modeling tools may offer an acceptable alternative. Any modeling approach will need to consider survival of Norovirus on surfaces, and means for disinfecting those surfaces. Other data required for a comprehensive QMRA for Norovirus include handwashing efficacy, and rates of cross-contamination from hands to food, food to hands, food to cutting boards, food to utensils, utensils to foods, as well as and to and from processing equipment like slicers. Finally any QMRA must use dose-response models to translate any predicted exposure to probability of illnesses. Data sources for such a QMRA and models of such data will be presented in this talk.

W3-J.3 Scheer, D*; Konrad, W; Class, H; Kissinger, A; Knopf, S;
 Noack, V; University Stuttgart - ZIRIUS;
dirk.scheer@sowi.uni-stuttgart.de

Expert involvement in science development: (re-)evaluation of an early screening tool for carbon storage site characterization

Carbon capture and storage (CCS) science development takes place in a highly contested and politicised environment and cannot be seen isolated from the public debate on energy policies. Early expert and decision-maker involvement in CCS science development thus is necessary for assessing the accountability and reliability of scientific methods and decision-tools. Relying on a participatory Group Delphi exercise with 14 experts involved, we carried out early expert involvement in science development with the evaluation of the so-called gravitational number (Gr) approach – an early screening tool for carbon storage site characterization. The aim was to elicit expert evaluations and judgments on the Gr approach and feeding back these judgments to method developers. Experts hinted to several Gr constraints, specifications and recommendations that served the method developers for re-designing and re-evaluating the screening tool. The expert assessment indicate an overall good understanding of the Gr approach with all but two items (far) beyond the scale midpoint of 3.5 on a seven point Likert scale. Evaluating reservoir characterization criteria, experts ranked safety related criteria more important than capacity related criteria. In a final evaluation of the Gr method, experts agreed unanimously to a very high degree that the Gr number approach alone is not meaningful and a review of Gr results by earth scientist is necessary. Oversimplification, therefore, seems to be the overarching downside aspect of the method that leads to the conclusion not to use the Gr results as a sole basis for decision making on site selection.

T3-A.1 Schell, KR*; Guikema, SD; University of Michigan; krschell@umich.edu

Incorporating renewable generation risk and reliability measures into electricity system planning

It has long been asserted that transmission system expansion is a key enabler of renewable energy integration, as the best renewable resources are often far from load centers. The permitting and siting of these new transmission lines, however, is often a contentious and heated process of public stakeholder engagement and NIMBY attitudes, similar to what is currently being seen in Germany's attempt to enable its ambitious Energiewende policy. Thus, this work seeks to optimally incorporate renewable energy with as little new transmission line investment as possible. To do so, we adapt a transmission system planning model to incorporate the generation supply risks inherent with renewable energy variability, while maintaining system reliability standards. Simultaneously, this model allows investment in flexible transmission system alternatives – such as energy storage and synchronous condensers – that allow for better use of the existing transmission system, and possibly preclude the need for new transmission line investment. We assess whether it is possible to bypass new transmission line investment at high renewable energy production, while maintaining system reliability.

M2-G.4 Schoeny, RS; Rita Schoeny LLC; ritas50@verizon.net
Strengths and Weaknesses Of Low-Dose Observations and Their Relevance to Human Exposures and Risk Assessment

The current risk assessment paradigm focuses on the concept of critical effect or critical target organ as a way of determining points of departure (PODs), extrapolation models, and/or uncertainty factor or safety factors that vary based on the underlying toxicology and epidemiology databases. These PODs, models, and factors in turn are used to determine either risk specific doses (RSDs) or Reference Doses (RfDs), or similar constructs of safe or virtually safe doses. Non-monotonic dose response curves are part of this paradigm and are usually considered in terms of essentiality, hormesis, or masking (where more severe effects mask lower severity effects). The challenge of current epigenetic findings is to determine where in the risk assessment spectrum these effects occur and whether current risk assessment methods are adequate to address them.

P.194 Schnatter, AR*; DeVilbiss, EA; Chen, M; ExxonMobil Biomedical Sciences, Inc. ;

A.R.SCHNATTER@EXXONMOBIL.COM

Meta-Analysis of Cancer in Petroleum Refinery Workers

Petroleum refineries are complex facilities that process crude oil into refined products such as motor gasoline. Workforces at these facilities involve many skilled positions, and there is relatively low turnover. This makes them an excellent candidate for epidemiologic study. Formal studies of these workers using modern statistical techniques began appearing in the 1970's. The International Agency for Research on Cancer has classified the petroleum refinery work environment as 'probably carcinogenic to humans'. This was based on findings regarding skin cancer and leukemia in 13 studies. The latest review of the epidemiologic literature on refinery workers was over 15 years ago, and was based on 21 studies. Since then, many studies have been added to the literature and/or updated with new mortality or cancer incidence information. The purpose of this project is to perform a meta-analysis of cancer occurrence in petroleum refinery workers. Guidelines that have emerged since the last review of refinery workers (such as PRISMA) are being employed to improve transparency. The present meta-analysis will be based on 66 studies, 203 abstracted tables within each study, and over 8000 measures of risk from the 203 tables. We will summarize the development of a 'construct' to define relevant data within the studies, the number of studies screened, and the development and justification of exclusion criteria being employed. We will also summarize the outcomes under investigation, statistical analyses being employed including the investigation of heterogeneity, and will present a funnel plot with summary results for one outcome. The database promises to be an excellent resource for new knowledge on cancer incidence and mortality patterns in this complex work environment and will serve to supplement health surveillance activities in the company.

P.26 Schuldt, JP*; Pearson, AR; Cornell University; jps56@cornell.edu

Race/ethnicity and climate change polarization: Evidence from a U.S. survey experiment

Social identities and group affiliations have been acknowledged to play an important role in public disagreements on climate change and other prominent scientific issues, perhaps none more so than political orientation (political ideology and party identification). Less research, however, has examined fundamental social identities besides politics that may matter just as much—if not more—in the ongoing debate over climate change. Drawing on research suggesting that concern about climate change is stronger among U.S. non-Whites relative to Whites, we explored whether the climate beliefs of U.S. racial and ethnic minorities would be less sensitive to political ideology and other known polarizing factors (labeling the phenomenon as “global warming” rather than “climate change”). Analyzing data from a large U.S. national survey experiment (n = 2,041), we found that political ideology (liberalism-conservatism) was a weaker predictor of non-Whites' (vs. Whites') beliefs for every climate change opinion metric we surveyed—namely, belief in its existence, perceptions of the scientific consensus, and support for climate mitigation policy. Additional analysis revealed that non-Whites were significantly less likely to personally identify as an “environmentalist” than were Whites—a variable that was less strongly correlated with political ideology among non-Whites—and that non-Whites were less likely to perceive a scientific consensus on climate change. Further, although Whites were less likely to report believing in the existence of “global warming” as compared to “climate change,” labeling did not influence the existence beliefs of non-Whites, a pattern that remained when controlling for key covariates (including political ideology and party identification). Our findings highlight a need to better understand how different social groups interpret environmental risks and respond to common climate-related messages, while offering insights into the dynamics of U.S. public opinion on climate change amid rapidly shifting demographics.

P.121 Schultdt, JP*; Rickard, LN; Yang, ZJ; Cornell University, University of Maine, and University at Buffalo (SUNY); jps56@cornell.edu

Bridging the gap: Exploring the role of situated distance cues in climate change visualization messaging

While communication research assumes that spatially proximal visual depictions of climate impacts (e.g., local flooding) are more effective than distal depictions (e.g., global sea level rise), psychological research complicates this view, pointing to additional context-dependent (“situated”) influences on distance perception. The extent to which any given climate-impact depiction feels near or far may depend on fleeting cues to spatial distance and the level of meta-cognitive fluency audiences experience when processing information about the location of depicted impacts. Such situated cues are relevant to climate change visualization efforts that are attracting increased attention as a means of portraying current or anticipated climate impacts to public audiences—depictions that routinely incorporate spatial-distance representations (e.g., maps) or fluency-relevant experiences (e.g., easy vs. difficult-to-pronounce place names). While understudied in this context, situated cues may alter the distance that audiences perceive between themselves and the impacted place or community, which in turn, may hold implications for key climate engagement outcomes (e.g., personal concern and climate policy support). To explore these concepts, we present U.S. participants with a map representing the distance between the U.S. and a region experiencing potentially catastrophic climate impacts (i.e., Republic of Maldives). Depending on condition, participants view a map that is designed to make the Maldives feel either relatively far or relatively close to the U.S. (e.g., depending on image size/resolution). All participants then watch the same video depicting climate change impacts in the Maldives, indicate their perception of climate change risk and support for climate change policy, and decide whether to donate money to a Maldivian environmental NGO. We will present key findings and discuss theoretical and practical implications for emerging climate visualization efforts and environmental risk communication more broadly.

M4-E.5 Schweizer, PJ; Stuttgart University; pia-johanna.schweizer@gmx.de

Inclusive Risk Governance: Lessons Learnt and Demand for Further Research

The German energy transformation can be regarded as one of the largest socio-technological innovations of our time. It involves the phase-out of nuclear energy by 2022 and a severe reduction of CO₂ emissions. The proportion of renewable energy in the energy mix is supposed to increase to 80 % of the total energy mix. A technological innovation on this scale necessarily entails social transformations. Therefore, the German energy transition requires the effective, efficient and socially compatible integration of technological development, organizational structure, behavioral adaptations, legal requirements and policy-making. In this regard, the German energy transformation can be framed as a systemic risk which affects various other social subsystems of society. Systemic risks call for systemic responses and new policy approaches and demand strategic interaction of social subsystems. The balanced integration of all kinds of knowledge (factual, experimental, local, anecdotal, etc.) in risk assessment is a fundamental challenge. Furthermore, values and societal preferences need to be taken into account in order to reach socially acceptable decisions. In addition, the demand for the inclusion of various stakeholders at an early stage in the governance process poses new challenges to institutionalized routines of decision making. Also, ethical issues such as intergenerational justice need to be taken into account. This presentation will investigate these topics, drawing on data from the research project Helmholtz Alliance ENERGY-TRANS. Special attention will be given to resilient governance processes which allow for social learning and correspond with pluralistic societies.

T4-A.1 Schultz, MT*; Smith, ER; US Army Corps of Engineers; Martin.T.Schultz@usace.army.mil

Assessing the Resilience of Coastal Systems: A Probabilistic Approach

Methods and tools to quantify resilience are needed to provide information that is useful for planning, designing, constructing, and managing coastal systems. This presentation describes how a probabilistic measure of resilience can be assessed for a coastal community using a Bayesian network and demonstrates the approach in Jamaica Bay, New York. The measure of resilience is the joint probability of meeting two management objectives, one with respect to the level of system performance and the other with respect to the length of time required to restore system performance. The method yields practical information about coastal system resilience to support decision making. The advantages, challenges, and limitations inherent in this approach are discussed, as is the feasibility of implementing this approach for operations. This approach to resilience assessment is well-suited for coastal planning contexts because it explicitly incorporates information about uncertainty in the severity of coastal storm events as well as uncertainty in how the system will perform when exposed to storm loads. The method challenges the community to establish explicit objectives for coastal resilience, helps clarify what data are needed to monitor progress toward objectives, and provides a platform from which to explore how those objectives might be achieved in practice.

M3-H.4 Schweizer, VJ*; Kurniawan, JH; University of Waterloo; vanessa.schweizer@uwaterloo.ca

Managing complexity in socio-technical transitions

Often economic development projects do not unfold quite as planned. Even in industrialized countries, the problems of delays or cost overruns are familiar. Nevertheless, what is important to retain is stakeholder buy-in. For major projects with long lead times – such as energy transitions that are currently under discussion in the face of climate change – scenarios are common communication tools for cultivating public support. Scenarios are effective because they provide a means for managing the uncertainty that comes from complex systems, which can evolve in unpredictable ways. Through exploratory scenarios, stakeholders and decision makers can consider and develop strategies that have the greatest likelihood of being robust in a variety of contexts. This presentation will touch on the ways that scenarios have been used to explore uncertainty and ‘manage’ complexity in multiple socio-technical examples: the future of urban transportation in Singapore and the future of energy decarbonization in Southern Ontario, a province in Canada. However, the presentation will also touch on the limitations of scenario analysis and stakeholder engagement by examining the challenges of reconciling stakeholder demands with scientific advice. The latter will be considered for a climate adaptation project in Jamaica and the application of the new Shared Socio-economic Pathways to the development trajectories of lower income countries. Remarks on these issues will be brief to foster discussion with the symposium audience on how risk perspectives can be better incorporated with stakeholder engagement – especially in the development settings of poorer countries.

P.17 Scott, RP; University of Washington; ryscott5@uw.edu
Pathways to learning in selecting voluntary risk management practices

Voluntary best management practices (BMPs) are a common framework for addressing diffuse risks and externalities in a manner that allows firm level flexibility in response and limited government coercion. However, use of BMPs in oil and gas risk management relies on firms baselining practices off of each other, adapting practices based on new knowledge and feedback, and selecting practices that do in fact minimize or mitigate risks. This project evaluates, 1) “what pressures firms to adopt new best management practices in response to new information from firms, residents, or agencies?” 2) “how do various pressures drive specific firm practice choices?” Based on 18 semi-structured interviews with drilling permit managers, this paper evaluates use of firm experiences, agency feedback, other-firm actions, and citizen involvement in firm choice of BMPs. The interviews were conducted in the state of Colorado in 2016 and were transcribed and coded using attribute and provisional coding followed by structural coding emphasizing differences between paired observations. The interviews are coded and analyzed in the software Dedoose, and each interview is analyzed alongside administrative data on firm and location characteristics gathered from the State of Colorado. The results highlight patterns that emerge as clear pathways to learning and adaptation based on the paired comparisons. I specifically characterize pathways through which specific pressures including normative pressure, coercive pressure, uncertainty, and economic motivations foster use of deliberation as part of the learning process. This work builds on the case to hypothesize about conditions under which a BMP systems may be most effective for risk management, emphasizes areas where regulatory agencies may be able to supplement private motivations, and provides new research questions for risk management research.

M2-G.3 Seed, J; Independent consultant (US EPA, retired);
jseed89770@aol.com

Determination of critical effect for risk assessment

The determination of a critical effect is a key concept in regulatory risk assessment. Decisions about which effects are suitable for regulatory risk assessment are frequently based on the results of standard rodent toxicology studies. As knowledge increases, a mode of action understanding may be developed, and it may become feasible to use critical key events in the mode of action for risk assessment instead of the more traditional apical effects from rodent toxicology studies. Some studies have suggested that exposures early in life may lead to epigenetic changes that become manifest later in life. Others have suggested that current study designs may be insufficient to characterize these effects. Several examples will be explored, current study designs will be reviewed in order to assure that such effects are addressed, or if not, how studies might be designed to do so.

P.183 Scott, RP*; Cullen, AC; University of Washington;
ryscott5@uw.edu

Guiding versus choosing: the role of Life Cycle Assessment in US state level policymaking

Life Cycle Assessment (LCA) is commonly proposed as a tool for assessing the complete environmental footprint of policy and infrastructure decisions. While its use in private and federal decision making has been characterized in previous research, we evaluate the characteristics of LCA that have either enhanced or limited the usefulness of the methodology in US state-level policy decisions. After selecting cases of state funded LCA via a systematic web search, we review 26 cases of states applying LCA as a method of assessing environmental impacts of policy alternatives. Each LCA is coded in light of their intended use while classifying the methods and data utilized. We pay particular attention to how the treatment of uncertainty in input data, impact categories, and potential alternatives. We find that data limitations and impact uncertainties are frequently cited as reasons for calling LCA results into question; however, such explanations are much more common when LCA results are not tied to a specific decision context. Interestingly, we find LCA is primarily used to explore potential alternatives, not as a method of comparing the relative merits of alternatives. This suggests that LCA may currently be useful as a method for suggesting alternatives and shaping proposals for the policy process, while methodological limitations and uncertainties appear to challenge its usefulness as a method for deciding among alternatives. Therefore we suggest that state-level practitioners be vigilant about emphasizing the usefulness of LCAs for future decisions while also producing analyses that could later be tailored for use within a specific decision context.

W3-J.4 Sellke, Piet, PS; Dialogik; sellke@dialogik-expert.de

Resilience and Terrorism: How to prepare the public

The threat western societies face through terrorist attacks became much more apparent than ever before through the attacks of 9/11 (New York and Washington 2001), 11-M (Madrid, March 11, 2004) and 7/7 (London, July 7, 2005). More recently, the attacks of Paris and Brussels continued this line. The new quality of those attacks comprised the deliberate attempt to cause as many fatalities as possible and to disrupt economic and social life. Not least the ruthlessness and sophistication of the attacks carried out made the use of radiological or biological substances for attacks conceivable, if not likely. Increasing the public's resilience as a response to a terrorist attack is, besides preventing the attack in the first place, an important part of minimizing the negative effects any attack will have. In this research, we are looking at how to learn about the public's behavioral intentions and information needs in case an attack happened, and how to prepare the public. How the public reacts terrorism will help to determine how extensive the attack's medical, economic and social impacts are. Yet our understanding of what the public is likely to do in case of an attack is limited, even more so if the attack involves biological or radiological components. Will they spontaneously evacuate affected areas? Are they willing to attend mass treatment centers? Will unaffected people demand treatment and monitoring? Will people avoid affected areas even after clean-up operations have been completed? A first step to preparing better plans to protect the public is to identify actions they intend to take in the event of one of these scenarios occurring, and to assess how prevalent such intentions are in society.

T3-E.3 Selvik, JT; University of Stavanger; jon.t.selvik@uis.no

On the uncertainty definition given in the new ISO 14224

A new edition of the ISO 14224 on reliability data collection and exchange for the petroleum industry is under development. The ballot for the final draft version started in April 2016, and the new edition is expected to be published later this year. The standard includes several definitions of key terms related to the collection of equipment failures and associated consequences. One of these is the new definition of uncertainty, which was not included in earlier editions of the standard. In this paper we study the uncertainty definition. A common understanding of the uncertainty term is important from an analysis perspective, as it strongly influences the way reliability and risk is assessed, managed and communicated. We give some clarification on what is the meaning of the definition, and also compare it with other uncertainty definitions, and in particular the one linked to the definition of risk in ISO 31000. Examples are used to illustrate different perspectives and interpretations. A main purpose of the paper is to discuss whether the definition is valid form both a frequentist and subjective probability perspective. The paper can be seen as a contribution to the foundational issues in reliability and risk analysis

P.113 Seo, K; Aoyama Gakuin University; kseo33jp@gmail.com

Associate professor

A catastrophic accident of Fukushima nuclear power plant in 2011 started argument about energy policy in Japan. Although many people agree to stop using nuclear power energy in the future, they were not necessarily agreed to withdrawing nuclear power generation immediately. This paper is about the results of students' survey that implemented in 2013-2014, when there were no active nuclear power plants in Japan. The question was "which do you think is more realistic option, restarting nuclear power generation or not restarting?". Students were also asked their risk perception related to each scenario. The questionnaires were not anonymous but open style, and the results were analyzed together with the students' academic performance in the class. The academic results of two groups were statistically different ($p=0.02$). Students with relatively high records expected restarting nuclear power plants, and those of relatively low records expected immediate withdrawing from nuclear energy use. This result reminds us that in the US relatively high educated people tend to support nuclear power generation. (1) Students who answered restarting nuclear power generation had negative perspective about feasibility of renewable energy use in near future. Those who answered that fading out of nuclear power generation was realistic worried about acceptability of neighboring residents of the power plants. Both groups were rather positive about improving safety technology but they were not quite positive about improving the management system of nuclear power plants. 1. Greenberg M and Truelove H. B. Energy Choices and Risk Beliefs: Is It Just Global Warming and Fear of a Nuclear Power Plant Accident? *Risk Analysis*. 2011; 31(5): 819-831.

P.99 Sentz, K*; Ferson, S; Los Alamos National Laboratory;

ksentz@lanl.gov

Computing Risks with Confidence

Confidence distributions encode frequentist confidence intervals for a parameter at any confidence level. They characterize inferential uncertainty about parameters estimated from sparse or imprecise sample data, just like bootstrap distributions or Bayesian posterior distributions, but they enjoy a frequentist guarantee of statistical performance that makes them useful in risk and uncertainty analyses. Although there is no confidence distribution for the inference problem of estimating a binomial probability from success/failure data, an imprecise generalization of confidence distributions, which we call a 'c-box' can be derived for this problem, and it can be propagated through mathematical expressions using the ordinary machinery of probability bounds analysis. Remarkably, the results also offer the same statistical guarantee. C-boxes allow analysts to literally as well as figuratively compute with confidence. We illustrate the application of binomial c-boxes to a risk assessment and describe numerical simulations that confirm the statistical coverage properties of c-boxes and computations derived from them.

W3-I.3 Severtson, DJ; Edgewood College;

LSevertson@edgewood.edu

Testing Methods for Conveying Uncertainty on Maps: A Synthesis of Five Studies

This presentation will provide a synthesis of findings from five studies that tested methods for conveying uncertainty using maps. Four studies pertained to sample size uncertainty and the fifth pertained to uncertainty inherent in the use of models to estimate cancer risk from environmental hazards. Study methods included cognitive interviews, randomized control trials with surveys to measure outcomes, or mixed methods using both approaches. Study samples consisted of university students or people who had a private well as their source of drinking water. Methods of visualizing uncertainty included: directly illustrating the uncertainty of hazard data on dot maps, using hatch marks to illustrate spatial areas with no data on choropleth maps, using a combination of color saturation and transparency to convey the uncertainty of data on choropleth maps, and using visual fuzziness to display the uncertainty of estimated cancer risk from air pollution on contour maps. All studies used factorial designs that included methods of visualizing uncertainty and risk level. Some studies used other factorial variables such as color, how risk was defined in the legend, supplementary numerical information, and interactivity. Outcomes included judging the chance of having a hazard or a health problem for a given map location, confidence in these judgements, and intentions to monitor for the presence of the hazard. Results across these studies will be synthesized to discuss methods that were more and less effective for conveying uncertainty, the influence of judgments and confidence on monitoring intentions, and characteristics of participants (e.g. numeracy) that moderated these influences. Key themes from this synthesis will be reported in this presentation.

W2-I.1 Severtson, DJ*; Roth, RE; Sack, CM; Edgewood College; LSevertson@edgewood.edu

The Influence of Interactivity and Uncertainty on Reasoning with Maps that Depict an Environmental Hazard

Interactivity is proposed to enhance reasoning with uncertain information. We explored this proposed influence with maps depicting test results for a fictitious drinking water hazard in private residential wells. Using interactive features to see more details about certain or uncertain information was hypothesized to influence judgements about two outcomes, (1) the chance of having unsafe amounts of the hazard, and (2) confidence in those judgements. Interactive features were 'zooming' to view hazard information for smaller map units and 'retrieving' numerical details about the hazard for a given unit. An incomplete $2 \times 2 \times 2 \times 2 \times 2$ factorial study design was used to create maps that varied by: interactivity (static, interactive); uncertainty (insufficient, sufficient hazard data); map unit (large, small), numerical details (without, with), and hazard level (low, high). We controlled for sex, numeracy, and prior beliefs about drinking water. Color saturation and transparency were used concurrently to symbolize data sufficiency. More and less saturation/transparency signified less and more data sufficiency, respectively. University students ($n = 436$ participants, $n = 1673$ map observations) participated in the online survey by answering questions as each viewed a set of four study maps for an assigned map location. Hierarchical regression models were used to examine the influences of the five factorial variables on outcomes, and how each variable moderated the influence of other variables on outcomes. Interactivity, map unit, numerical details, and hazard level moderated the influences of uncertainty on outcomes. Map unit moderated the influences of numerical details and hazard level on outcomes. Study results suggest that interacting with maps may enhance reasoning with maps that represent uncertainty. These and other results and conclusions will be shared in this presentation.

P.29 Shan, X*; Zhuang, J; Rao, N; University of Houston - Clear Lake and State University of New York at Buffalo and Oak Ridge National Laboratory; xshan@buffalo.edu
Game-theoretic model for attack and defense of smart grids at three levels

As the society relies more on electric technologies, efficient generation and delivery of electric power becomes increasingly important. Smart grids provide a promising solution to the increasing electricity needs. Whereas smart grids have a number of advantages over traditional grids, one of their main disadvantages is the susceptibility to cyber attacks, which have not been the focus of studies on smart grids. In this paper, a game-theoretic model is developed to identify optimal defenses and attacks at three different levels (i.e., electric generation plants, transmission, and distribution systems). We define parent and child networks. For example, electricity generation network is the parent network of transmission network, which is in turn the parent network of distribution network. Network failure could be due to either direct attacks, cascading failure caused by intense attacks on its parent network, or inadequate maintenance. We identify the best responses and equilibrium strategies of both the attacker and the defender, who interact at three system levels: distribution, transmission, and electricity generation. The results show that the best response of the defender is not only a function of direct attacks but also of the spread from connected networks. Furthermore, we also conduct sensitivity analyses of the equilibrium strategies. Results show that if the probability of a successful attack against electricity generation plants is above a certain level, the defender enhances efforts in protecting electricity generation plants. On the other hand, the efforts of attacking at any of the three levels is not influenced by such a probability. This paper yields some interesting insights to modeling and analyzing the strategic interactions between the attacker and the defender of smart grid networks, which plays an increasingly important role in modern societies.

P.106 Sexton, KR*; Bhojani, FA; Shell ; krystal.sexton@shell.com
Health Risk Communication to a Non-Technical Workforce

In manufacturing operational settings, where the workforce is largely non-technical and perceived risks are frequent, the seven principles of risk communication defined by the EPA should be carefully and appropriately applied. Recently, employees in a manufacturing site voiced concern over a potential health risk. Company physicians and scientists worked together to assess the risk and then tendered the results to local Health, Safety, and Environment (HSE) and medical staff to deliver to the employees. In the first presentations to the workforce, the presenters failed to build a high level of trust and credibility, recognize the emotional reaction from the audience, and collaborate with credible sources, thus violating several key risk communication principles. Mistrust was instantly evident as employees noted a potential weakness in the risk assessment and were suspicious of the methodology and results. They felt their concerns were not sufficiently addressed, so a second stage of risk assessment was undertaken. Restoring the relationship between the healthcare professionals and the workforce required many steps. First, Health staff was invited to all subsequent presentations in order to meet the employees and answer any questions over the methodology used to assess risk. Second, relationships were developed between site leadership, the local medical team, and the corporate scientists to deliver a unified message to the workforce, with all present for each discussion with employees. Finally, a collaboration between the scientists and an academic partner addressed the limitations of the initial risk assessment, and the final results presented to the workforce included this new partnership. This presentation will focus on what went wrong, how we corrected it, and how trust and credibility were re-established in a workforce initially skeptical of the corporate environment.

P.150 Shao, W*; Xian, S; Lin, N; Lee, TM; Auburn University Montgomery; wshao@aum.edu
Global Attitudes Towards Climate Change: Evidence From 15 Countries

An international survey data set, supplemented with contextual data such as GDP per capita, carbon emission per capita, local weather and climate, and local climate plans/policies etc., is used to examine how people from 15 countries perceive risks of climate change and how willing they are to reduce the adverse impact of climate change. We first estimate multi-level models explaining variations in risk perceptions of climate change and willingness to address this issue across countries. Then, we select a list of mega-cities from each country and investigate into the key factors that determine one's risk perceptions of climate change and willingness to address this issue among these cities. Results of this study are believed to provide policy makers from international to local levels with important information that can serve as useful guide for effective climate change strategy formulation.

T3-G.1 Shao, K; Indiana University Bloomington;
kshao@indiana.edu

Can short-term toxicity studies inform BMD estimation of long-term studies?

Although toxicological data generated from two-year bioassay studies are preferred for dose-response modeling in human health risk assessment, such data are relatively limited because of the high cost and long duration of conducting such toxicological testing studies. The lack of appropriate dose-response data is always a challenge faced by risk assessors at regulatory agencies for one important reason that such insufficient data can result in substantial uncertainties in model fitting and benchmark dose (BMD) estimation. Therefore, it is not only practically useful but also theoretically plausible if the BMD for a particular endpoint (estimated from a long-term study) can be reliably estimated using toxicity data generated from short-term studies or at least adequately informed by such data. The noncarcinogenic endpoints caused by chemicals that have been tested in both short-term and long-term National Toxicology Program (NTP) studies serve as the basis of toxicological data for comparing the BMD estimates. The study will first compare the BMD (and BMDL) estimates calculated from short-term study data and long-term study data respectively to determine the correlation between the two sets of estimates. Then, this study will focus on discussing Bayesian dose-response modeling approaches (such as the power prior method) to integrating toxicity data to improve the reliability of BMD estimation.

M2-H.5 Shiroiyama, H*; Taniguchi, T; the University of Tokyo;
siroyama@j.u-tokyo.ac.jp

Governing interconnectedness of multiple risks

The Great Eastern Japan Earthquake proved the fact that a single risk (earthquake)'s interaction with the risks in other sectors (nuclear power plant) can develop into the so-called NaTech event and can bring about an amplified consequence (community evacuation and food contamination etc.). Such catastrophe has brought to the fore the importance of studying the interconnectedness of risks. However, the scope of existing studies are focused on the interaction between "physical/visible" events that has once happened, rather than future events that are "unexpected" or "unthinkable". It is also necessary to focus on the interaction involving "cognitive/intangible" risks caused through human behavior and on interaction involving future risk events. As the organizer of the symposium, the authors defined the purpose of the session as follows; (1) identify different patterns of interconnectedness through the case studies in different area (namely, global public health, space and cyber, and natural disaster and nuclear power) using an analytical approach based on hazard-medium-consequence loop; (2) explore the ways and approaches for addressing such complex interconnected nature of risks; and (3) consider a framework that enables cross-sectoral response. Drawing on the findings from the presentations of the case studies in different area and analytical methods, we will explore the challenges and possible framework for governing future interconnectedness of risks with the invited discussant.

M3-G.1 Sheehan, P*; Kalmes, R; Exponent;
psheehan@exponent.com

Assessing Exposure from Consumer Product Use: Methods that Have Been Developed to Address Manufacturer, Consumer and Agency Concerns

Consumer Product Safety Commission (CPSC) and California's Proposition 65 regulations, as well as legal suits against manufacturers, have necessitated the development of product testing and exposure assessment methods to address potential consumer exposure to various types and uses of products. However, there are no standardized exposure assessment procedures for most types of consumer products even though consumer protections have been in place for decades. This presentation provides an overview of the testing and methods that have been developed and are currently being used to assess consumer exposures to the variety of everyday products, and data gaps and uncertainties with current approaches. Exposures to chemicals released from consumer products may occur via various routes including, ingestion, inhalation, and/or dermal uptake. Examples include direct ingestion of contaminant chemicals in packaged foods and dietary supplements, incidental ingestion of chemicals transferred from product via hand to mouth contact, inhalation of volatile chemicals released from products, dermal uptake of chemicals directly transferred to skin from handled products, absorbed from topically-applied products, or leached from electronic wearable devices into sweat and water on the skin. Data to support exposure assessment from published literature are often unavailable. When data are available in the literature, statistical models of uptake have been developed to support exposure estimation. When no or few relevant data are available in the published literature, simulation is a popular testing option where the product is used as intended by a volunteer, and chemical release from the product is sampled. For unique products such as electronic wearable devices where production are worn continuously during exercise and showering, new test methods have been developed to assess dermal loading and allergic contact dermatitis risk. Example assessment methods for the various plausible routes of consumer exposure to different types of products are discussed.

M2-F.3 Siegrist, M; ETH Zurich, Switzerland; msiegrist@ethz.ch

Intuitive Toxicology: Lay People's Risk Perception

Synthetic chemicals in the environment and in foods are objects of many health concerns. Past research suggests that lay people are more concerned about synthetic chemicals compared with other chemicals. Little is known, however, what heuristics people use in making decisions regarding the risks of chemicals. If results of risk assessments and risk perceptions substantially differ, this may result in non-optimal decisions. Consumers may substitute less risky options by more risky options. Regulations may also be influenced through a biased risk perception. I will present results that suggest that people use perceived naturalness of the substance or the product name for their risk evaluations. Furthermore, I will present results of a study that examined lay people's and experts' risk perception of various household cleaning and washing products. Results suggest that consumers have a more or less accurate understanding of the dangerousness of different cleaning products, but exhibit misconceptions related to the risk of eco-labeled cleaning products. Risk regulators and communicators should focus on biases in lay people's risk perception, in order to ensure safe handling of chemicals.

W2-J.4 Simis Wilkinson, M; University of Wisconsin-Madison; simis.wilkinson@gmail.com

Risk, media, and licorice: Stakeholders' perceptions of and involvement in media coverage of the 2014 West Virginia water crisis

In January of 2014, a licorice-scented chemical contaminated the Elk River and a downstream water treatment facility, causing a health and environmental crisis in south central West Virginia. Three hundred thousand people were issued with a do-not-use order for days, and the state and federal governments declared the area to be in a state of emergency. People and organizations in positions of authority—from the West Virginia Governor to the Center for Disease Control and Prevention—presented conflicting information on the risks involved and the proper protection measures citizens should. Some experts have called the crisis and emergency risk communication around this event a total failure. Previous research explicates the cultural and regulatory context that allowed this crisis to occur, as well as the complex role that social and news media played in communicating risks and building (dis)trust. Yet unexplored, however, is an evaluation of stakeholders' responses to and involvement in communication about the crisis. The present research draws from interviews with stakeholders in five sectors—government, university research, activist groups, chemical industry, and the public—and from a news media analysis grounded in the psychometric paradigm of risk. The semantic network analysis of interview transcripts elucidates the underlying mental models that different stakeholders groups employ when thinking about the quality and extent of news media coverage. The news media analysis evaluates the extent to which risk dimensions that are known to influence risk perceptions are incorporated into news media coverage of the crisis, as well as what stakeholder groups are associated with communicating about those risk dimensions. This research analyzes how different groups of stakeholders implicitly and disparately respond to news media about a health and environmental crisis, and the extent to which those groups are likely to affect audiences' risk perceptions through their media presence.

P.58 Sjöstrand, K*; Rosén, L; Kärrman, E; Blom, L; Lindkvist, J; Ivarsson, M; Lång, LO; Lindhe, A; (1,3) SP Technical Research Institute of Sweden, (1,2,8) Chalmers University of Technology, (4) City of Gothenburg, (5) Gothenburg Region, (6) Enveco Environmental Economics Consultancy, (7) Geological Survey of Sweden; karin.sjostrand@sp.se

Combining cost benefit analysis with multi criteria analysis for sustainability assessment of regional water supply policies

The provision of safe drinking water is of primary importance in society and a prerequisite for public health and economic development. This provision is however threatened by a variety of risks due to e.g. climate change and societal development. To manage these risks the water utilities are facing complex decision situations. Today, decisions on costly investments are being made with limited knowledge of which choices are the most sustainable. In order to achieve a safe and sustainable water supply, a regional perspective on the environmental, social and economic effects of the decisions is increasingly promoted in Sweden. There are, however, few decision support tools adapted to the regional level. Hence, this study focuses on the development of a decision support framework for assessing the sustainability of risk reducing measures by adapting Cost-Benefit Analysis (CBA) and Multi Criteria Analysis (MCA) to a regional perspective. The Gothenburg region serves as a case study for which five measures are evaluated: (1) centralization of water supply production; (2) centralization of water supply organization; (3) shift of the main raw water source (4) maximization of groundwater usage; and (5) use of additional raw water sources. All measures aim to enhance safety by reducing risks. Uncertainties concerning the net present values are analyzed using statistical simulation (Monte Carlo). The CBA results are complemented with environmental and social effects in an MCA, including criteria such as intrinsic values, equity and health. The case study results are then used to design a decision support framework that allows for non-market valuations and economic and ecological tradeoffs under uncertainty, a novelty on the regional scale. In conclusion, it is expected that the results of this study will provide decision makers with a framework that can improve their ability to make well-informed decisions and ensure the society a safe water supply for generations to come.

P.88 Singhal, A*; Renee, K; Sheehan, P; EXPONENT, INC.; asinghal@exponent.com

Using Diffusive Samplers to Measure Formaldehyde in Residential Indoor Air

Starting in early 2015, due to claims of elevated formaldehyde emissions from laminate flooring, there was a need to determine laminate-specific formaldehyde contribution to indoor air. This study focuses on the first part of the evaluation, which was used as a screening tool to measure total formaldehyde levels in homes. Homes that requested an evaluation (n>40,000) were provided with diffusive samplers (or passive badge monitors) to measure aggregate indoor air formaldehyde concentrations. Passive badges however are designed for occupational settings where concentrations may be 10 – 100 times greater than residential indoor air and few data are available on their ability to measure formaldehyde at low levels typical in homes. Therefore, we conducted experimental studies in which badges from three different manufacturers were placed in chambers with known concentration of 13 or 14 µg/m³ for 24 hours. These badges were subsequently analyzed by two or more of the participating labs to determine inter-badge and inter-lab differences. Badge A appeared to provide the most accurate results while badges B and C tended to under-report them. Preliminary indoor air data from actual houses (n~8,000) confirmed these results. No statistically significant differences were noted between labs in the experimental studies. Results of our analysis suggest that not all badges perform equally well at low concentrations. While some badges may have lower sensitivity and therefore higher detection limits, others report accurate levels at low formaldehyde concentrations. Our findings suggest that badges, after a pilot study calibration at concentrations of interest, can be very effective and inexpensive screening tools for measuring residential indoor air formaldehyde concentrations.

W2-F.2 Smith, MT; Guyton, KZ; Gibbons, CF; Fritz, JM; Portier, CJ; Rusyn, I; DeMarini, DM; Caldwell, JC; Kavlock, RJ; Coglian, VJ*; United States Environmental Protection Agency; cogliano.vincent@epa.gov

Key Characteristics of Carcinogens as a Basis for Organizing Data on Mechanisms of Carcinogenesis

A recent review by the International Agency for Research on Cancer (IARC) updated the assessments of the more than 100 agents classified as Group 1, carcinogenic to humans (IARC Monographs Volume 100, parts A-F). This exercise was complicated by the absence of a broadly accepted, systematic method for evaluating mechanistic data to support conclusions regarding human hazard from exposure to carcinogens. IARC therefore convened two workshops in which an international Working Group of experts identified 10 key characteristics, one or more of which are commonly exhibited by established human carcinogens. These characteristics provide the basis for an objective approach to identifying and organizing results from pertinent mechanistic studies. The ten characteristics are the abilities of an agent to: (1) act as an electrophile either directly or after metabolic activation; (2) be genotoxic; (3) alter DNA repair or cause genomic instability; (4) induce epigenetic alterations; (5) induce oxidative stress; (6) induce chronic inflammation; (7) be immunosuppressive; (8) modulate receptor-mediated effects; (9) cause immortalization; and (10) alter cell proliferation, cell death, or nutrient supply. The use of the 10 key characteristics to conduct a systematic literature search focused on relevant endpoints and construct a graphical representation of the identified mechanistic information will be presented using benzene and polychlorinated biphenyls as examples to illustrate how this approach may work in practice. The approach described is similar in many respects to those currently being implemented by the U.S. EPA's IRIS Program and the U.S. National Toxicology Program. Specific applications of systemic review principles in the EPA's IRIS program will be discussed.

W3-F.1 Smith, AE; NERA Economic Consulting;
anne.smith@nera.com

Rebuilding consistency between the health risk analyses for a NAAQS review and the rationale for the NAAQS decision

Over the past two decades, the policy judgments expressed by the EPA Administrator when setting the NAAQS for PM2.5 and ozone have become increasingly separated from the assumptions used by EPA staff in making quantitative estimates of health risk that are provided to the Administrator to support the decision. This presentation will trace this separation to a growing avoidance of subjective judgments regarding non-statistical sources of uncertainty in the risk analyses (particularly regarding the shape of the concentration-response function). It will show that subjective judgment in setting the NAAQS has not diminished, but has instead shifted solely to the policy maker, rendering the risk analysis increasingly irrelevant to the process. A recommendation is made for how the risk analysis process might be revised so that it can incorporate a range of views on important non-statistical uncertainties in a policy-informative manner without undermining the ability of the Administrator to make the ultimate policy judgment, and without tying the analysis to a potentially controversial "expert elicitation".

T4-A.4 Snell, M*; Seager, TP; Arizona State University;
marcus.lsnell@gmail.com

Utilizing Resilient Processes to Combat Catastrophic Events

Levees are failing at successively larger flood water volumes causing unsustainable repair costs. Without immediate action, levee breaches in floodplain cities will reach the level of catastrophic events. Instead of allowing breaches to happen randomly policy makers and levee managers must be empowered to intentionally breach levees. Intentional breaching will grant policy makers and managers the foreknowledge of when and where the damage will occur allowing them to minimize the cost to life and property.

P.197 Snell, ML*; Eisenberg, DA; Arizona State University;
marcus.lsnell@gmail.com

A Model for Coupled Population and Infrastructure Growth

The last few years have seen a rash of "One in a Thousand Year" storm events. South Carolina, Colorado, Arizona, and most recently West Virginia have all suffered the consequence of extreme precipitation. However the States have not suffered equally. In these storm effected areas Colorado, affluent with relatively lower population density, saw rapid renewal of services but has yet to see complete reconstruction. Arizona, affluent with relatively higher population density, saw lower levels of infrastructure destruction with near complete reconstruction. South Carolina, less affluent than the Phoenix region but a similar population density, witnessed more infrastructure destruction. West Virginia, lower level of both affluence and population density, saw infrastructure destruction on a level rarely evidenced in modern society. The consequence of the storm events with similar return periods was different in each region due to the relationship between population and supportive infrastructure. We propose the adoption of a new coupled population and infrastructure model to understand the differences in regional flood consequence with future work centered around modelling adaption to these consequential differences.

P.181 Soden, R*; Balog, S; Deparday, V; World Bank;
robert.soden@gmail.com

The Open Data for Resilience Initiative: Approaches for Making Risk Analysis More Transparent, Inclusive, and Effective

The World Bank's Global Facility for Disaster Reduction and Recovery (GFDRR) launched the Open Data for Resilience Initiative (OpenDRI) in 2011 to make disaster and climate risk assessment more inclusive, transparent, and effective. Since then OpenDRI has worked in over 30 countries to bring the philosophy and practices of the open data movement to the challenge of building a more resilient future. Central to our approach has been the understanding of risk analysis as a situated, socio-technical process where the landscape of human capacities, social networks, and institutional arrangements are as important as the data and models that are produced. This understanding has led us to explore a variety of tactics outside the traditional toolbox of risk modelers, including exploration of the opportunities offered by serious games, involving non-traditional actors in peer review processes, investment in the development of open source software communities, and working with participatory mapping techniques in order to develop asset inventories. Through five years of work, OpenDRI has drawn from diverse fields of practice and scholarship to craft a bespoke approach to risk analysis and communication. We are currently launching a research project aimed at: 1) assessing the efficacy of our work with our in-country partners and its contribution to the wider community of practice in which we participate; 2) more clearly frame our activities as they sit within research areas of risk communication and civic technology; and 3) chart a path forward for the next steps of our program. The project will provide both a framework for assessing this work as well as clear and practical guidance for those seeking to implement similar efforts. We will also include case studies from projects developed by the OpenDRI team and other organizations. Our presentation will describe this work as well as solicit feedback and partnership from attendees.

W2-E.4 Soerskaar, LIK*; Abrahamsen, EB; Selvik, JT; University of Stavanger (UiS); leif.i.sorskar@uis.no

Vision Zero and the ALARP principle: can they be unified?

Vision Zero and the ALARP principle are two different principles in risk management. One main difference is how they weights on a time scale. While Vision Zero strongly focuses on a point in distant future, implementation of the ALARP principle is performed at one or several given points in time. Vision Zero, as a principle for continuous improvement, cultivates for development and innovation over time, seeking alternative ideas and solutions for risk reduction – but does not adequately consider cost-benefit aspects when prioritizing between such alternatives. In contrast, we argue that the ALARP principle is more able to balance concerns such as risk reduction and cost, and thereby better in providing a dynamic and pragmatic decision support. Meanwhile, the ALARP principle often focuses on one measure at a time, and it is not clear whether the principle reduces risk over time. We question if it is rational to unify these principles, and discuss whether we can achieve potential synergies in continuously reducing risk. We conclude that such a unification between principles may be beneficial in a context of fatality risk and environmental risk. However, in a context of sole economic concerns, we conclude that it is not rational to apply Vision Zero - but rather a mindset of continuous improvement.

P.49 Sommerville, DR*; Channel, SR; US Army Edgewood Chemical Biological Center and Leidos; douglas.r.sommerville.civ@mail.mil

Review and Assessment of Phosgene Mammalian Lethality Data and the Development of a Human Estimate

New human estimates for the lethal effects of phosgene inhalation were derived from a review and statistical analysis of existing mammalian lethality data. The estimates are expressed as a function of exposure duration for healthy subpopulations and the general population. Median lethal dosages and quantal response data were analyzed for 10 species: mouse, rat, guinea pig, rabbit, cat, goat, sheep, swine, horse, dog and monkey. A total of 155 median lethal dosages and 31 probit slopes were compiled from some 42 studies/sources dating back to World War I. Resulting human estimates were expressed via the toxic load model, $L(C^n t)50 = k$, where $n = 1$ with C in mg/m^3 and t in minutes (thus following Haber's Rule). The $LCt50$ equals 1,500 and 1,100 $mg\text{-min}/m^3$ for military (healthy subpopulation) and general populations, respectively. The revised healthy subpopulation estimate is lower than WWII era military estimates but in exact agreement with more recent analyzes by the United States and the United Kingdom. The general population estimate is lower than previous estimates reflecting a more robust estimate with inclusion of non-human primate data that was generally unavailable to non-military organizations. The base 10 probit slope (concentration) is estimated at 9.5 (healthy subpopulation) and 7.0 (general populations).

P.149 Song, H; Cornell University; hs672@cornell.edu

Trust shaped through knowledge and elaboration: Considering the attitude strength properties of trust

Theories of trust in risk communication often characterize trust as a cognitively effortless judgment based on heuristics such as value similarity or affect. Although research has well demonstrated that trust enables individuals to make judgments about environmental hazards without undertaking complex risk analyses, this should not be confused as meaning that judgments about trust are intrinsically shaped through heuristic information processing. Individuals who find themselves incapable of dealing with technical complexities may nevertheless invest considerable effort in making accurate judgments about risk managers, provided that they are sufficiently motivated. It is important to consider cognitively effortful forms of trust because research suggests that attitudes rooted in substantial knowledge and elaboration tend to be stronger. Stronger attitudes, by definition, are more persistent over time, resistant to counter-attitudinal persuasion, and impactful on subsequent cognitive and behavioral states. When trust is weak, in contrast, the public may easily withdraw their trust or be reluctant to act upon the trust to express support. To address this gap, researchers can focus on risk communication processes that enhance knowledge and elaboration about risk managers. People can acquire rich knowledge about their risk managers through direct face-to-face interactions such as public meetings. Mass-mediated news stories can also convey considerable knowledge about important risk managers. Knowledge about risk managers can be further solidified through elaboration processes when individuals are involved in discussions or perceive high personal relevance regarding certain risk issues. Empirical support for these processes will yield implications showing how sincere commitment to engage the public that go beyond appeals to heuristics can build strong forms of trust.

P.124 Spence, EM*; Pidgeon, NF; Pearson, PN; Cardiff University and Understanding Risk Group; spencee@cardiff.ac.uk
Communicating the unfamiliar risk of ocean acidification to members of the public

The effects of climate change on the marine environment are becoming more prevalent, including the novel risk of ocean acidification (OA). The absorption of anthropogenic carbon dioxide by the ocean and the changes in ocean pH has already affected shellfish hatcheries and fisheries, which are vital livelihoods for some communities. As there has been little research conducted to examine public risk perceptions of this risk, we aimed to explore this through a mental models approach. We compared expert and public risk perceptions of OA, in order to highlight areas of agreement, important knowledge gaps, and key misunderstandings. Through comparison of the different mental models constructed, we found low awareness of this risk with many attributing pollution and dumping waste as being the main causes of OA. Despite this, many identified that it would impact on numerous organisms resulting in marine ecosystems being altered. More generally, OA was perceived as a highly negative issue. A survey was conducted to establish whether these findings were confirmed in a wider population as well as exploring numerous psychological factors including concern, psychological distancing and affect. We will also discuss why public perceptions and understanding of climate risks such as OA are relevant. These findings will be discussed as to how they may be implicated in future risk communications for members of the public.

P.14 Sridharan, S; Mangalam, S*; Wiersma, R; Ravindran, K; Reid, D; Larez, J; Technical Standards and Safety Authority; ssridharan@tssa.org
Estimation and Management of risks of injury at institutions due to fuel burning appliances

This paper will outline a novel methodology used by the Technical Standards and Safety Authority for the estimation and management of risk of injury or fatality to residents at these locations due to the fuel burning appliances such as boilers, water heaters and furnaces.

P.158 Sridharan, S; Mangalam, S*; Technical Standards & Safety Authority; ssridharan@tssa.org

Application of the Averted Disability-Adjusted Life Year Metric for Proactive Decision-Making in a Regulatory Environment

This paper focuses on the characterization of the Technical Standard and Safety Authority's (TSSA's) impact on compliance via regulatory inspections conducted on operating plants in Ontario, Canada. The use of regulatory inspection programs to identify non-compliances, often with underlying failures in the regulated system, can be used to support a proactive decision-making framework. The paper will detail the development and implementation of the novel Averted Fatality Equivalent (AFE) metric, predicated on the Averted Disability-Adjusted Life Year (DALY), in measuring the impact of regulatory inspections. The novel application of this metric is of significance to a public safety regulator in quantifying the value of inspections in preventing or averting risks when non-compliances are identified and corrected prior to their manifestation into an occurrence with potentially deleterious health impacts. This innovative indicator is of significant value to regulators in clearly demonstrating the effect of actions of the regulator and regulated parties on the overall state of compliance and its ultimate impact on safety.

M2-A.1 Staid, A*; Watson, JP; Sandia National Labs; astaid@sandia.gov

Smart scenario generation for power system resilience

There is increasing interest in designing more resilient infrastructure systems. The ability to better withstand and recover from adverse events will result in fewer service disruptions and lower costs over the long run. In order to improve system resilience, we must first understand the critical threats and resulting consequences. From there, we can work to mitigate these consequences through better planning and operational decision-making. Here, we focus on the electric power transmission system of one utility company. We use historical outage data to develop realistic scenarios that can be used for planning in a stochastic optimization context to increase resilience for both near and far time horizons. Stochastic optimization seeks to find the best solution to an operational problem given that uncertainty exists about the future. We use real data, and scenarios represent plausible future outcomes based on adverse events experienced by the system. We first identify the probability of failure for each line in the transmission system from the historical data. We can do this either overall across all data, or for specific types of weather events (i.e., for a thunderstorm or an ice storm.) We then randomly sample from these probability distributions to determine which lines fail in a given scenario. These baseline scenarios can also be augmented to represent extreme weather events, which result in much higher numbers of failures. We show that this type of scenario generation is needed to get trusted results from optimization models, as the scenarios are linked to the actual data from the customer. We also highlight the many challenges of data availability and of working with historical power system data. The level of detail at which the data is collected directly determines the rigor of the scenarios and the confidence with which they can be used for decision-making.

T4-I.4 Steentjes, K*; Pidgeon, N; Poortinga, W; Corner, A; Cardiff University; steentjesk@cardiff.ac.uk

The role of social processes in shaping perceptions of climate change: A comparison across four European countries

The European Perception of Climate Change (EPCC) project offers a unique opportunity to gain insights into the social processes that shape public perceptions of climate change and support for related policies. The cross-national survey, conducted in Germany, France, Norway and the United Kingdom allows us to examine social constructs as individual level predictors and as predictors of between-country differences. For this project, we chose to focus on two psychological constructs, social norms and (national) social identity. A vast body of literature established that individual beliefs and actions are influenced by what the social environment approves of (injunctive norms) and by what others are doing (descriptive norms). In addition to using these two traditional measures of social norms (Cialdini, 1990), we ask respondents about their willingness to enforce these norms (interpersonal activism). This willingness to confront others about their actions is a reflection of underlying norms and also a process of change. Confrontation has been extensively researched in other domains but only few researchers considered this process in relation to environmental issues (Swim, 2013). The additional measure of interpersonal activism will help us to capture multiple facets of social norms and thereby broaden our understanding of how norms shape public perceptions of climate change. Furthermore, based the preparatory analysis of the four EPCC countries and stakeholder input, we consider social identity as another relevant social context variable. We expect that the degree to which environmental issues play a central role to each national identity will affect how respondents evaluate proposals for national action on climate change. Through providing high quality, cross-national data on two relevant social context variables, the EPCC survey will contribute to the ongoing efforts to identify and capture social processes that affect how climate change is perceived and responded to.

M2-F.4 Steinhardt, JS; Michigan State University; jsteinh@gmail.com

Low-income adult smoker attitudes and beliefs about cheaper smoking alternatives

A better understanding of how smokers make decisions about what they smoke may ultimately help in more effective cessation campaigns and messaging. Adult smokers with an annual household income of less than \$35,000 may be especially sensitive to the price of cigarettes when it comes to determining what to smoke. However, while the results of a discrete choice experiment suggested that this population may be likely to smoke cheaper brands of cigarettes, most would not consider switching to alternative smoking products such as e-cigarettes and little cigars/cigarillos that can cost almost a fifth as much per pack equivalent. Through qualitative interviews with low-income adult smokers (N=20) this paper explores the reasons why they do not switch to cheaper alternatives. We report that many adult smokers hold affective beliefs and attitudes about cigarettes, little cigars/cigarillos, and e-cigarettes that result in smoking cigarettes over cheaper alternatives. For example, fears about e-cigarettes exploding or the liquid being smoked containing unknown chemicals. We also report that many low-income cigarette smokers who have never tried e-cigarettes believe that they may be too complicated for them to understand. In the case of little cigars, many make affective associations with more traditional cigars and thus tend not to want to smoke them. In addition to affective beliefs, we report that cost is still a major factor in decision making for low-income smokers. While the price-per pack equivalent drops significantly with e-cigarette usage, the startup costs are prohibitive to some of the lowest income smokers. These findings provide a deeper understanding how low-income smokers make decisions about smoking. How these findings can be used in messaging and future research are discussed.

M4-H.2 Stevens, YA; Arizona State University; ydstevens@asu.edu
Implementing Resilience in Regulatory Law: Procedural Provisions

Resilience provides a new (or at least revised) paradigm for structuring regulatory programs that seek to reduce or manage risks. While a risk-based program attempts to minimize harm by preventing a harmful act, activity or product from causing injury, a resilience-based program attempts to minimize harm after an injurious act, activity or product has occurred. A resilience-based approach must have both a substantive and procedural component – this presentation will focus on procedural requirements. A key procedural component of a resilience-based regulatory program would be to build-in an ongoing monitoring and assessment process that would periodically evaluate whether the regulatory program is effectively addressing the risk it is trying to prevent or manage, and to permit a reconfiguration of the regulatory program if improvements are needed. Such an “adaptive management” system presents administrative law challenges under the Administrative Procedure Act, which must be anticipated and addressed to the extent possible upfront in the regulatory design. A more extreme form of procedural resilience-planning would be to grant a regulatory agency authority for “regulatory forbearance” to stop implementing an ineffective regulatory program and substituting a different type of program in an emergency situation, such as a major accident or serious harm. Finally, a procedural resilience approach would need to put in place up front some type of process for treating injuries and remediating harm in an efficient manner if injury does occur. The recent water contamination debacle in Flint, Michigan provides a useful lesson for designing such a remedial program.

P.168 Stene, LK*; Olsen, OE; University of Stavanger; lillian.k.stene@uis.no

Military coalition's organizational challenges in complex emergencies.

Violent conflicts and complex emergencies such as in Afghanistan, Somalia, Syria and Iraq expose the local population and communities to great suffering. The international response has proven to be exigent and hazardous. The security dimensions of these conflict emergencies and new wars calls for an appropriate response that often include military forces to establish and maintain stability and prepare the ground for political solutions. New concepts and ways of organizing multinational military interventions has been worked out to deal with challenges and interdependencies characterizing today's new wars and complex emergencies. Starting with a discussion of complex emergencies and new wars, this paper undertakes to discuss organizational aspects of multinational military coalition working under vague mandates and exit strategies to gain security in a complex emergency, and how this influence crisis management. The paper draws on studies of the NATO-led International Security Assistance Force (ISAF) in North-Afghanistan, as well as recent developments in ongoing complex emergencies and on experiences gained by the authors during missions and fieldworks in Afghanistan, Somalia and Iraq.

W3-I.4 Stewart, RN*; Morton, AM; Dolislager, FG; Oak Ridge National Laboratory; stewartrn@ornl.gov

Representing Uncertainty in Environmental Decision Support Models: Progress and Illustrative Case Study in Risk Based Decisionmaking

Environmental decision support tools translate complex physical processes such as contamination, geology, exposure, and toxicology into the language and modality of decision analysis where the tools like cost-benefit tradeoffs and decision risk estimation are brought to bear on choosing among a set of restoration alternatives. These methods can be particularly useful when uncertainty, propagated through these models, is present and well-articulated in the decision products themselves. This benefit can be easily mishandled and lost without clear communication about the meaning and implications of the specific uncertainty. Communicating and representing uncertainty clearly is a challenging problem largely because the term itself provides umbrella coverage for a wide range of qualitative, quantitative, and logically nuanced meanings. The problem may be further compounded by stakeholders with widely varying familiarity and expectations about what uncertainty means. Some may even harbor concerns about whether uncertainty quantification is empowering or discrediting to the process. In this presentation we a) discuss challenges and progress in articulating uncertainty particularly to non-statistical decision makers, b) showcase visual and cartographic methods for representing uncertainty in spatial decision support products, and c) demonstrate how decision making processes are empowered rather than troubled by uncertainty delineation. We demonstrate these principles through illustrative decision support tools available in the Spatial Analysis and Decision Assistance (SADA) freeware program. We also report on progress in extending SADA to track and visualize contributions to uncertainty from various links in the process chain such as measurement uncertainty, geospatial modeling, human health risk modeling, and the final decision support products.

P.89 Stewart, DJ*; Galloway, LD; Dolislager, FG; Smith, S; Frame, AM; Gaines, LG; The University of Tennessee, Knoxville, TN; US Environmental Protection Agency, Washington, DC; dstewart@utk.edu

Presentation of new EPA online Vapor Intrusion Screening Level (VISL) tool

The U.S. Environmental Protection Agency (EPA), Office of Superfund Remediation and Technology Innovation (OSRTI), through an interagency agreement with the Oak Ridge National Laboratory, developed an online calculator for vapor intrusion screening levels (VISL) that will be linked to the EPA Regional Screening Levels (RSL) database. This tool provides screening level concentrations for groundwater, soil gas (sub-slab and exterior), and indoor air to help risk assessors, risk managers, and concerned citizens determine risks from vapor intrusion. Vapor intrusion is the general term for migration of hazardous vapors from any subsurface vapor source, such as contaminated soil or groundwater, through the soil and into an overlying building or structure. Chemicals must be sufficiently volatile and toxic to pose inhalation risk via vapor intrusion from soil and groundwater sources. This is determined by calculating the chemical's pure phase vapor concentration and the groundwater vapor concentration. The soil gas vapor concentration and the groundwater vapor concentration must be greater than the air screening level to determine a VISL. The VISLs for groundwater and soil gas (either sub-slab or soil gas collected below or adjacent to buildings) are calculated from the target indoor air concentrations using empirically-based, conservative attenuation factors that reflect reasonable worst-case conditions, as described in EPA's draft vapor intrusion guidance (EPA, 2002), and default exposure parameters and factors that represent Reasonable Maximum Exposure (RME) conditions for chronic exposures. In addition to calculating screening levels, this tool can calculate indoor air concentrations and risks from soil gas and groundwater concentrations entered by the user. The online VISL tool will be available soon.

P.156 Stringari, D*; Pinheiro, EG; Schneider, GX; Zamarchi, K; Disaster Research Center of Parana State - Brazil; danystringari@gmail.com

Structuring, Implementation and Management of a Specialized Basis in the Wildlife Oiled Rescue in the Event of Environmental Accidents in Estuarine Complex Area of Paranaguá, Paraná State, Brazil

The city of Paranaguá and its estuarine zone are located in a high environmental fragility susceptible area to the occurrence of environmental disasters caused by the presence of the largest grain port in Latin America, especially for instance of oil products spills. In the last decade, two major disasters in the port of Paranaguá showed great disarticulation and lack of coordination with respect to the wildlife rescue actions that led to the death of almost all rescued animals. Therefore, the creation of an Oiled Wildlife Rescue unit (OWR) to act in the area of the Estuarine Complex Paranaguá (ECP) is presented as an unprecedented initiative in the state of Paraná and Brazil, even as the creation of a Brigade Voluntary specialized and trained for this purpose. Installing structure and an office for the management of the Voluntary Brigade that will act in the rescue and rehabilitation of oiled wildlife in the estuarine zone of Paranaguá, is one of the project objectives. In addition, we intend to further empower the academic community and local actors for the role in the ECP risk areas, strengthening the culture of prevention and risk perception in the city in connection with the local civil defense and emergency foundations. It is expected this project obtains a large number of volunteers trained to act in the rescue, rehabilitation and restoration of coastal and marine species; and strengthen the integration of the local fishing and academic community together to port activities of APPA (Paranaguá and Antonina Ports Administration).

P.177 Stoycheva, S; Ca' Foscari University of Venice, Italy; stoycheva.stella@gmail.com

Opening the Black Boxes of Sustainability Management: How Metrics Frame Decisions?

Despite the ongoing debate regarding the meaning of sustainability in the business context, there is a common understanding that to account for how a corporation is doing with respect to sustainability, this performance should be measurable. No matter the existing ways of corporate sustainability operationalization, any measurement generally implies the identification of quantitative indicators to represent properties and relations. It could be argued that such processes of measurement (data construction, analysis and final presentation) and the construction of metrics imply tacit assumptions and informal practices that affect the process of decision making. If not challenged on these instances, metrics and indicators may fall in the trap of being "black boxed", which makes their use smoother but hampers their ability to adapt to changing contexts and be a valid representation of reality. The reliance on quantitative based measurement of organizational performance as a common means for informed decision making is then not exempt from undesired outcomes if guided by a naïve approach to measurement. To this date, however, the available body of knowledge on sustainability measurement fails to address the issue of how numbers are constructed, given meaning and enacted in organizational practices. The aim of this study is exactly to explore the impact of corporate sustainability measurement in framing organizational decisions through challenging the construction, interpretation and display of metrics produced by organizations by the means of ethnostatistical analysis. The latter will imply three stages of research, resorting to different methodologies: a) an ethnography of metrics construction and application, focusing on the informal practices and tacit assumptions involved in the production of numbers; b) a computer-based simulation of the possible diverging results that different assumptions would imply; c) a literary and textual analysis of the rhetoric use made of the resulting numbers, and of their impact on decisions.

M3-E.4 Sue Wing, I; Wei, D*; Rose, A; Wein, A; University of Southern California; dxw217@gmail.com

Economic Consequences of a Silicon Valley Earthquake

A major earthquake in the Silicon Valley has profound consequences for both the regional and US economies. We model the consequences of a catastrophic earthquake on the Hayward Fault affecting the San Francisco Bay Area and the surrounding region. This scenario has been developed by the US Geological Survey and is referred to as the Haywired Scenario. It begins with analyses of geologists and engineers in translating ground shaking into direct physical damages. Our research first translates property damage into business interruption. The linkages between the earthquake and the electricity system, cyber network, and manufacturing sector are then explored in the context of a multi-regional computable general equilibrium model. Special emphasis will be placed on rapid recovery of the Cyber system via several resilience strategies.

P.8 Sullivan, KS*; Dodge, DG; Lewandowski, TA; Gradient Corporation; kssullivan.73@gmail.com

Screening for Developmental and Reproductive Toxicity Hazards in the Workplace

We have conducted conservative screening level analyses aimed at protecting workers from reproductive and developmental toxicity (DART) for over 10 years. These DART assessments are for inhalation exposures only and help occupational physicians decide whether workplace activities should be restricted to protect mothers and the developing child. The assessment uses a three part process: exposure assessment, DART hazard identification, and risk characterization. Exposure assessments identify workplace chemicals of concern (CoC) and quantify exposure duration and frequency. Toxicological data for the CoC is identified and captured during the DART hazard identification phase using sources such as: on-line databases (TOXNET, IRIS, IUCLID, ATSDR, Prop65), occupational exposure limits (OELs) and their documentation, and MSDSs. Chemicals are categorized as known, suspect, or not suspect based on the toxicological review. If no suitable information is found, insufficient data is assigned. Risk characterization includes calculating a DART reference dose (DRD) and worker dose (WD). The DRD is derived from OELs that account for DART effects or animal or human data with applied safety factors. A DART-specific hazard quotient (HQ; $HQ=WD/DRD$) is established and serves as the assessment product. The assessment results are provided to the occupational medicine team and employee. Using this process, we evaluated over 1500 individual chemicals and/or products. Eighteen percent were classified as known or suspect DART agents. Fifty percent of the individual chemicals evaluated did not have an established OEL (for any health effect); among these substances 8% were known or suspect DART agents. These results suggest a need to consider DART effects regardless of whether a chemical has an existing OEL. Based on our experience, this screening process is a useful tool to rapidly inform risk managers whether or not there are DART concerns so that appropriate interventions are considered.

W1-G.4 Swartout, JS; US Environmental Protection Agency; Swartout.Jeff@EPA.gov

Low-dose extrapolation of the harmonic mean method for dose addition in mixtures risk assessment

The "harmonic mean" method (HMM) for dose addition in mixtures risk assessment is an alternative to the standard index chemical/relative potency factor (IC/RPF) model. The HMM is particularly useful for cases in which dose-response curve (DRC) shapes are different among mixture components that otherwise have the same fundamental mechanism of action. In these cases the predicted mixture risk, when using the IC/RPF model, will be dependent on the choice of IC. The HMM involves a modification of the mixture isobole equation, which is independent of DRC shape, yielding an estimate of the total mixture dose at any arbitrary risk level; the mixture risk can then be derived by optimizing on the actual exposure levels. However, extrapolation of the HMM much below the observed response range is highly uncertain because the mixture risk is rapidly dominated by the component with the steepest low-dose slope, irrespective of its nominal RPF; the relative potency of that component is increasing without bound at lower and lower response levels, which may be unrealistic or implausible at low exposure levels. This phenomenon results implicitly in a mixture DRC shape that is not a fixed parameter over the entire dose range. Assuming that the DRC shape differences are due to differential nonlinearities in the toxicokinetics prior to the key dose-additive process, the mixture DRC shape will be constant at lower doses. Several extrapolation methods for the HMM are demonstrated with published data, including low-dose-only modeling of the component data and two approaches for predicting the low-dose mixture DRC shape. Each of these methods has limitations and none is a clear preference. Together, however, they are offered as a pragmatic solution to the HMM low-dose extrapolation problem for more plausible predictions of mixture risk at environmental exposure levels. The views expressed here are those of the author and do not necessarily reflect the views and policies of the U.S. EPA.

P.65 Sundell, J*; Rosén, L; Chalmers University of Technology; jonas.sundell@chalmers.se

Risk assessment of groundwater drawdown in subsidence sensitive areas

Groundwater drawdown induced subsidence in soft soil is a severe problem in many regions around the world. One common cause for drawdown and subsidence is leakage of groundwater into sub-surface constructions. When planning for future sub-surface projects in areas with risk for subsidence, potential damage costs need to be estimated. This is of utmost importance in cities where the risk objects (buildings and other constructions) are many and of high value. To reduce the risk for costly damages, safety measures and additional investigations can be planned for. Since groundwater drawdown and subsidence is a transient process, a time space for implementation of safety measures exists. In this study, we present a novel method that recognizes the whole cause- and effect chain of groundwater drawdown induced subsidence, the large spatial scale of the problem, its spatial variability and the transient process. Applied on a case study in Sweden, the method combines three probabilistic models for spatial estimation of: (1) soil- and bedrock stratification, (2) groundwater drawdown, and (3) subsidence. The combined result of these three models gives probability density functions for subsidence magnitudes at certain time steps and locations. The risk for damages and its associated cost is estimated by combining this result with the sensitivity for subsidence of individual risk objects. By means of cost-benefit analysis, the benefit of a safety measure is compared to the cost for implementing the measure. Possible risk reduction measures can be ranked with respect to profitability. If a measure holds a positive net benefit at a certain location, the measure is recommended to be implemented. When mapping the result, the method provides a clear and communicative decision support for planning of safety measures, monitoring and additional investigations.

W2-C.4 Tailor, J; LaVictoire, P; Critch, A*; Machine Intelligence Research Institute; critch@intelligence.org

Value alignment for advanced machine learning systems as an existential priority

I will present some arguments that value alignment research for advanced machine learning systems should be considered a top priority for mitigating existential risks, and that such research is possible and actionable today. I will also give some overview of technical problems that I believe are currently tractable and relevant to mitigating existential risks from highly capable and autonomous AGI systems, and some progress that has been on tackling them.

P.50 Takeshita, J*; Oki, H; Yoshinari, K; 1) National Institute of Advanced Industrial Science and Technology, and 2), 3) University of Shizuoka; jun-takeshita@aist.go.jp

Prediction of hepatotoxicity in rats by statistical approaches

Today, hazard and risk assessments of chemical substances are mainly carried out based on the results of animal experiments. On the other hand, in terms of time and cost efficiencies and the animal welfare, there is an increasing demand for alternatives to animal experiments in the world. The development of alternatives, however, has not progressed enough, especially for "repeated-dose toxicity (RDT)," which is one of the most important toxicities in a hazard assessment of chemical substances. As alternatives to animal experiments, we suggest two statistical ways to predict in vivo hepatotoxicity using three different data: a) existing data of in vivo hepatotoxicity in rats, b) data of in vitro nuclear receptor assays, and c) molecular descriptors (in silico data). First, we obtained in vivo RDT data from "Hazard Evaluation Support System Integrate Platform (HESS)," which had been developed in Japan. There were 365 endpoints and 606 compounds in the HESS data as of September, 2014. Then, we conducted several kinds of in vitro nuclear receptor assays for 190 compounds out of the 606. We also calculated various molecular descriptors of the 190 compounds using Dragon 6. Thus we constructed a training dataset for this study. Then, we took two ways to predict in vivo toxicity: 1) We selected "Hepatocellular Hypertrophy (Centrilobular)" as an endpoint of hepatotoxicity to be studied. We then predicted the presence or absence of the toxicity, as well as its strength, using the in vitro and in silico data. 2) We grouped the 190 compounds based on the in vitro and in silico data. We then filled the missing information of potential hazards of compounds whose in vivo hepatotoxicity had not been obtained, based on our assumption of their similarity to the compounds in the training dataset. In this talk, we will show you the summary of the training dataset and the results of the two approaches to predict in vivo hepatotoxicity in rats.

M3-A.1 Thacker, S; Hall, J W; Pant, R*; University of Oxford; scott.thacker@ouce.ox.ac.uk

Understanding risks in global infrastructure systems

Infrastructure network systems support society and economy by facilitating the distribution of goods and services across broad spatial extents at a range of scales. In recent years, technological innovation and rapidly increasing levels of globalization has extended these networked systems beyond the borders of individual countries – resulting in interconnectivity and interdependence at the global scale. In addition to providing opportunities for growth, this interconnectivity has large implications for risk: not only for individual countries embedded within global networks, but also for organisations whose operations may transcend countries and continents. A number of historic events have highlighted how cascading-failure related risks manifest at this scale, this includes through exposure to global climate and natural hazard events, political instability and conflict. Despite its significant importance, the lack of data, methods and tools has ensured that the characterization of infrastructure risks at the global scale remains poorly understood. Within this research we address the need for understanding in this area. This is achieved by providing new methodology that integrates recent developments from the study of infrastructure systems, spatial risk analysis and complexity science. These methods are used alongside sophisticated data processing techniques to assimilate emerging global datasets to enable understanding of interconnectivity and the quantification of flows and transactions. Criticality is calculated at the asset and country scale based on global access to services through underlying infrastructures. Risks are computed by exposing global interdependent networks to spatially coherent hazard events and to realistic 'what-if' national and continental failure scenarios. This research offers new methodology and analysis for the quantification of risk in global infrastructure network systems.

M3-F.3 Taylor, CL; National Institutes of Health; TaylorCL3@ods.nih.gov

Nutrient risk assessment: context, development and evolution

The field of nutrition incorporated risk assessment in the early 1990s in response to the expanded paradigms needed for nutrient reference values, known as Dietary Reference Intakes (DRIs). DRIs have been established for more than 60 years by committees convened by the National Academy of Sciences. These reference values reflect human requirements – and, more recently tolerable upper levels – for nutrients and related food substances based on systematic reviews of the literature and, at times, scientific judgment. The application of risk assessment to DRIs was based on the framework articulated in the 1980s for use with analysis of contaminants, toxins, microbiological hazards, and food additives. However, because nutrients – unlike substances such as contaminants – are also essential in the diet and characterized by special metabolic processes, the risk assessment model has required adaptation for use with nutrients and food substances. The use of a risk assessment framework within the field of nutrition has been a learning curve with a number of challenges and often very limited data. Examples of challenges include inability to use large safety factors; appropriateness of endpoint; limited application of lifetime exposures given relevance of amount per kg body weight; and differences by life stage, gender and age complicating extrapolation to unstudied groups. The lack of data has resulted in a different evidentiary standard for benefit versus adverse effect, while terminology has caused some confusions and misunderstandings. As research increasingly uncovers the complexity of diet-health relationships, the use of nutrient risk assessment continues to be both important and in need of further refinement coupled with guidance for its application.

WI-D.2 Thierer, AD; George Mason University; athierer@mercatus.gmu.edu

As Software Eats the World, What Happens to Risk Regulation?

As a noted venture capitalist recently quipped, "software is eating the world," and that includes the world of food, drugs, medical devices and their regulation. The underlying drivers of the modern computing and Internet revolution—microprocessors, software, sensors, networked technologies, wireless geolocation, and other digital devices and applications—are poised to upend the health sector and its regulation. Smartphones, fitness tracking devices, 3D printers, and virtual reality technologies are just some of the specific applications that consumers are already using in a decentralized—and sometimes largely unregulated fashion—to better their health or improve their capabilities. How should policymakers account for the risks associated with this bold new world of highly personalized health, where medical treatment decision-making is increasingly democratized and decontrolled? Traditional approaches to risk regulation may no longer work in light of new technological realities. This paper will consider how the FDA and other medical experts could reorient their focus away from strict preemptive risk controls and toward improved risk education and health literacy instead of, or in addition to, traditional regulatory efforts. The goal would be to better inform a citizenry that is empowered to make many of their own health decisions to ensure that they better understand the relative risk trade-offs associated with their newly-acquired technological capabilities and opportunities. The paper will also explore how over time this approach might improve resiliency among citizens as they increasingly engage in "learning by doing"—even with the risk that potentially entails.

W4-J.4 Thompson, KM; Kid Risk, Inc.; kimt@aorm.com

Will the World Eradicate Measles and Rubella Next?

With the polio endgame now progressing and all World Health Organization regions working toward their regional measles elimination targets of 2020 or earlier as part of the Global Vaccine Action Plan, the opportunity to globally eradicate measles continues to emerge as a topic of global importance. With the use of combination vaccines for measles that also contain rubella, discussions about measles eradication lead to discussions about possibly also eradicating rubella. Models of measles and rubella transmission demonstrate the importance of achieving and maintaining high population immunity using vaccines to stop and prevent transmission and manage the risks of viral spread and reintroduction. As for polio, this requires focusing on under-vaccinated subpopulations. This talk will discuss the economics of potential measles and rubella eradication and challenges associated with reaching under-vaccinated subpopulations. In contrast to polio, measles and/or rubella eradication lack a global commitment from all key stakeholders, and thus this presentation will ask the question: will global measles and/or rubella eradication be next on the global health agenda?

M2-E.1 Thorisson, H*; Lambert, JH; University of Virginia;

ht3jt@virginia.edu

Requirements Analysis and Canonical Formulation of a Risk, Safety, Resilience, or Security Program

Organizations increasingly follow comprehensive guidelines and standards when implementing programs for the assessment and management of risk, safety, resilience or security. Programs often involve the coordination of multiple systems of stakeholders and organizational units and require balancing of different needs and missions, as well as being flexible and having the ability to withstand and adjust to emerging conditions of economics, policies, military conflict, environment and other factors. This paper suggests three canonical questions as the mission of such a program: (i) what sources of risks are to be managed by the program, (ii) how should multiple risk assessment, risk management, and risk communication activities be administered and coordinated, and what should be the basis for resource allocation to these activities, and (iii) how will the performance of the program be monitored and evaluated. An approach to evaluate how different tasks of the program comply with guidelines and withstand disruptions is demonstrated. Thus, it emphasizes the need for programs whose priorities adjust to emergent conditions of technology, environment, demographics, markets, regulations, organizations, geography, etc. The methods presented are useful to organizations and agencies implementing risk and safety guidelines for security, infrastructure, finance, and others.

T4-F.3 Thorisson, H*; Almutairi, A; Collier, ZA; Slutzky, DL;

Wheeler, JP; Lambert, JH; University of Virginia;

lambert@virginia.edu

Risk Analysis and Systems Integration of Fleet Electric Vehicles with the Power Grid

Programmatic risk analysis for business plans, technology commercialization, and systems integration is a topic of wide current interest. Integration of electric vehicle fleets and power grids, or vehicle-to-grid (V2G) technology, is the utilization of electric vehicle batteries to balance fluctuations of the grid. Electric vehicle batteries are able to interact with the grid and provide frequency regulation when they are neither recharging nor powering the vehicles. Since many fleet vehicles operate on a predictable schedule, a V2G aggregator has the ability to optimize both the grid interactions and the logistics schedules of the vehicles by implementing the technology efficiently. This presentation contributes a programmatic risk analysis of schedule, cost, and obstacles in the commercialization of V2G. It demonstrates computer simulations developed to understand the resource constraints of the logistics systems. Recommendations to address sources of risk are formulated to meet the goals of various stakeholders in industry, government, and technology development. The methods that deploy risk analysis, systems engineering, and scenario-based preferences analysis are broadly transferable to infrastructure development and technology commercialization.

M4-G.5 Toccalino, PL*; Belitz, K; U.S. Geological Survey;

ptocca@usgs.gov

Pharmaceuticals and hormones in groundwater of the United States

For the first time, the U.S. Geological Survey's National Water-Quality Assessment (NAWQA) Project is measuring the occurrence of hormones and pharmaceuticals in groundwater across large areas of the United States. Groundwater samples were collected during 2013–2015 from about 1,100 wells. The wells are located in 23 principal aquifers that are nationally distributed across 46 states. Seventy-nine percent of the wells are public-supply wells with a median depth of 340 feet, 15 percent are domestic wells with a median depth of 150 feet, and the remaining wells are observation wells with a median depth of 100 feet. Each well was sampled once and the samples were analyzed using new analytical methods for as many as 21 hormones and 108 pharmaceutical compounds. Because the analytical methods are new, and because the NAWQA Project has not previously conducted large-scale studies of hormones and pharmaceuticals in groundwater, extensive quality-control analyses are being performed to ensure data quality. Preliminary results on the occurrence of hormones and pharmaceuticals in groundwater will be presented, including the frequency, magnitude, and potential human-health relevance of detections.

P.152 Todd, AL; Howard, PM*; ABS Consulting;
atodd@absconsulting.com

Implementing Geographic Information Systems to Support Coast Guard Operational Decision Making

Under the United States Coast Guard's (USCG) Ports, Waterways, and Coastal Security (PWCS) mission, the ultimate goal is to prevent and respond to terrorism risk within the maritime domain. Efficient resource allocation and operational planning is crucial to the success of the mission. With a limited set of available assets and a vast area to protect, optimizing resource allocation and prioritizing Coast Guard actions is the smartest way to aim for success. The Maritime Security Risk Analysis Model (MSRAM) is a terrorism risk management tool that enables the USCG to understand and mitigate the risk of terrorist attacks on targets in the U.S. maritime domain. USCG analysts in each major port perform a detailed risk analysis for all significant targets operating within their area of responsibility, ultimately resulting in a dataset that can inform a wide variety of risk management decisions. MSRAM is an application developed in MS Access, with a complementary GIS tool called the Risk Management Workspace (RMW). The RMW is most often used to as a means to more clearly communicate risk to USCG officials and decision makers. Additionally, its built-in tools and capabilities allow for the generation of location-specific analyses, providing defensible and repeatable results that provide a clear picture of the U.S.'s maritime risk nationally. By combining census data with built-in calculators that estimate and display consequences associated with explosions, chemical releases, and IED-style attacks on a map, the RMW allows for consistent analyses for maritime targets and simplified communication of those results. This presentation will provide an overview of the available GIS functionalities developed to assist the Coast Guard in best allocating its available assets and resources to maximize mission success. It will demonstrate how fast-paced geospatial tools can inform real-life U.S. policies, decision making and security efforts in a timely and reliable manner that can be implemented simply, by an analyst without a specific scientific background.

P.92 Toledo, MC*; Nardocci, AC; University of Sao Paulo;
michele.toledo@gmail.com

Risk assessment for non carcinogenic health effects for people living in a contaminated area by chemicals in Sao Paulo, Brazil.

The contamination of urban areas is a reason of concern, because these areas, that are very populated, represents risks to the human health. Vila Carioca, located in São Paulo city, is considered critical because of the high levels of contamination in the soil and groundwater leading to the exposure of the resident population. The contamination started in 1960 due industrial activities. Risks studies have already been conducted, however, there is still much uncertainty and controversy about the health risks of the population. The investigations also included some preliminary clinical tests (blood, urine and hair) and the results suggested alteration in leukocytes, hepatic system and hematologic system. This study proposes a risk assessment of non carcinogenic health effects for the people living in the residential area contaminated by dangerous chemicals. The exposure occurred by groundwater ingestion for 25 years, and by soil ingestion over the entire life (70 years). It were followed the methods recommended by the United States Environmental Protection Agency. It was selected 15 compounds for the groundwater assessment and 20 for soil. The Hazard Quotient was considered not tolerable in relation to water ingestion for the cis-1,2-dichloroethylene which can be associated to problems to urinary system.

M3-B.4 Todd-Searle, J*; Danyluk, MD; Schaffner, DW; Rutgers University; jlt182@scarletmail.rutgers.edu

Farm to fork quantitative microbial risk assessment of Salmonella on tomatoes

Fresh tomatoes have been linked to Salmonella outbreaks in the US. A quantitative microbial risk assessment (QMRA) was developed to predict illness from tomatoes contaminated with Salmonella in the field. The model was built in Excel using the Monte Carlo modeling software @Risk add-in. The QMRA was composed of five modules: in field, packinghouse processing, retail storage, home storage, and dose response. The field contamination module contained data on transfer of Salmonella from soil, plastic mulch, and agricultural waters to tomatoes. The literature greatly differs regarding Salmonella survival and decline on tomatoes, suggesting multiple factors such as temperature, RH, and Salmonella serovar play a role. Even when these factors were consistent, different researchers report different responses. The model simulated growth or reduction of Salmonella on tomatoes in accordance with the variability and uncertainty seen in the published literature. The literature data used for modeling indicates increases could be as great as 1.8 log CFU/day, or declines as great as 0.7 log CFU/day. Current research shows Salmonella levels on tomatoes do not exceed 7 log CFU/tomato, so this was assumed to be the maximum concentration which could occur in the simulation. Peroxyacetic acid in a spray bar and roller application and chlorine in a dump tank were considered for packinghouse wash treatments since they are the most common methods for tomato washing. Research has shown chlorine is not very effective at reducing Salmonella concentration (~1 log CFU reduction/tomato), so the focus of chlorine usage was on reducing cross-contamination. Peroxyacetic acid has been shown to have similar effects on Salmonella on tomatoes and was assumed to display similar protection against cross-contamination as chlorine dioxide. The model predicted that reducing cross-contamination was important in reducing Salmonella illnesses due to contaminated tomatoes.

WI-1.3 Toy, V; US Technical Advisory Group to ISO 45001; formally with IBM; vtoy@insystohts.com

Risk in ISO 45001:xxxx – Occupational Health and Safety Management

Over the past several years, ISO developed an occupational health and safety management system (OHSMS) standard; this standard is called ISO 45001. The 45001 development effort had built on existing OHSMS consensus standards. This presentation will review the risk-related requirements of 45001 and highlight unique aspects of them from other standards.

P.119 Trumbo, CW*; Peek, LA; Laituri, M; Schumacher, RS; Mokry, M; Colorado State University; ctrumbo@mac.com
“Weather Whiplash” — An analysis of alternating hydrologic events 1960 to 2014 and the associated representation of risk.

Due to climate change areas of the world will be undergoing a more frequent “weather whiplash” between drought and flood. In this pilot study we use a database of natural disaster property loss claims to examine the co-occurrence of drought and flood disasters. The goals of the project include a historical examination of how risk and other disaster-relevant concepts were represented in public reports. Using the Spatial Hazard Events and Losses Database for the United States we accessed some 87,000 county-level records for financial losses from natural hazards over the period 1960-2014. The data were parsed to isolate floods and droughts, and a summary metric was computed to identify the cases in the top 80th and 95th percentiles for total losses (both crop and property damage, in 2000 dollars). By parsing the data by geographic area we were able to sort cases by date to select specific circumstances in which losses from floods and droughts occurred in spatial-temporal proximity. The continuation of the analysis is proceeding to transform the original dataset into a time-series of approximately 650 months, with multiple events represented in each month, and the inclusion of temporal and spatial metrics that may be used to calculate proximities. Once complete, these data may be analyzed using techniques such as geographically-weighted modeling, and visualized in GIS. Importantly, a more fluid time window may be examined. The final phase of this project will examine historical records such as news sources to gain insight into the risk-related social responses and consequences of these past events. Specifically, the socio-historical analysis will allow us to understand how individuals, households, policy makers and elected officials, and the private sector, for instance, responded to alternating weather extremes. Moreover, this analysis will allow for further investigation into the myriad consequences—environmental, economic, social, and political—of these events.

M4-H.5 Trump, BD; University of Michigan; bdt2011@gmail.com
Qualitative Methods for Early Stage Regulation of Synthetic Biology

The maturation of synthetic biology may produce dramatic improvements to medicine and public health in a rapid and systems-wide fashion. Similar to other emerging technologies like nanotechnology, however, synthetic biology may also pose environmental and human health risks if not developed and implemented responsibly. Research is needed that underpins evidence-based and proactive approaches to the development of synthetic biology applications if future environmental health risks are to be minimized, and benefits to population health and well-being realized. One possible approach to such research may include the use of qualitative research, where qualitative methods may provide context-rich information to assist regulators with early stage regulation of synthetic biology products. Such an approach may provide insight into regulatory questions that are inherently difficult to quantify while also providing expert opinion regarding the hazard, exposure, and consequences that may arise within the process of synthetic biology development. This talk describes how one qualitative approach – narrative analysis via subject expert interviews – may be utilized for the application of synthetic biology pharmaceutical development.

P.195 Trumbo, CW; Colorado State University; ctrumbo@mac.com
Influence of Risk Perception on Attitudes and Norms Regarding Electronic Cigarettes.

A hallmark of the reduction in tobacco use has been the shift in social norms concerning smoking in public. Research has shown there to be significantly greater tolerance of public electronic cigarette use than for public smoking. Related concerns about public views on electronic cigarettes reside in the attitudes that individuals hold toward the potential for electronic cigarettes to be used in smoking cessation, and the addictive potential of the devices. Such attitudes may drive views on acceptability of public electronic cigarette use. Understanding normative acceptability of electronic cigarette use in public spaces is critical for effective formulation of relevant policy and regulations. While the literature on social dimensions of electronic cigarettes is expanding, little attention has been given to the role of risk perception. This study undertakes such an effort. In spring 2015 an online survey was conducted on attitudes towards electronic cigarettes among a sample of students at a Western university (a convenience sample of students invited from several large lecture courses, 395 participants). Measures included scales for the acceptability of public electronic cigarette use, level of nicotine use from a range of sources, belief that electronic cigarettes are useful for tobacco cessation, beliefs about the addictiveness of electronic cigarettes, and the perception of risk for electronic cigarettes. All measures present good to excellent reliabilities, and strong correlations. Path analysis demonstrates a model in which risk perception predicts attitudes towards addictiveness and cessation, which subsequently predict public acceptability for electronic cigarette use (sub-model R-squares of .35 and .38, $p < .001$). Elaboration of this analysis will be designed to further explore the relative effects of cognitive versus affective risk perception.

P.185 Tsaïoun, K*; Stephens, ML; Hoffmann, S; Maertens, A; Busquet, F; Hartung, T; EBTC and CAAT Johns Hopkins Bloomberg School of Public Health; ktsaiou1@jhu.edu
The role of systematic review in risk assessment – the missing link between the objectivity and transparency of scientific evidence and confidence of regulatory decisions.

The public demanded transparent and objective assessment of effectiveness and safety of medicines and other chemicals for humans and the environment for quite some time. In clinical research such approaches, termed evidence-based (EB), brought the needed objectivity, consistency and transparency to the field and have brought strict design and publication standards to clinical trials. This allows clinicians and educated public to quickly compare the effectiveness of different treatments in systematic reviews. EB approaches include inter alia the establishment of a common ontology, improved and consistently structured reporting of evidence, probabilistic uncertainty and risk assessment, development of data integration and synthesis methodology. However, these approaches are not yet adopted in chemicals risk assessment. As a result, there are many published studies, but their number does not guarantee quality or consistency, and does not lead to clear conclusions, which causes public confusion and lack of confidence in policy. Confidence is further compromised by lack of transparency in a priori determination of specific primary and secondary endpoints, declaration of pre-specified approaches to data analysis, lack of transparency in post-hoc statistical analyses, and lack of availability of the primary data, allowing an alternative analysis. EB methods are set out to assemble, assess, integrate, analyze and summarize different streams of evidence (animal, epidemiological, mechanistic, in vitro, in silico) in a transparent and objective manner. EB methods, adopted by industry, regulators and understood by public, can bridge the gap between evidence generation and regulatory decisions. This approach holds great promise to become a standard that informs confident regulatory decisions. The theory and principles of evidence-based methodologies will be described and examples of application of this approach to safety test methods assessment and will be described.

P.135 Tsuchida, S; Kansai University; tsuchida@kansai-u.ac.jp
Investigating risk communications at Fukushima-Daiichi NPP accident

Risk communications, that is, crisis communication, care communication, consensus communication, conducted mainly by Japanese governments were investigated. A) Crisis communication: At the crisis most of the evacuees from the contaminated area around Fukushima-Daiichi NPP did not have sufficient information about the evacuation. They did not know how and where to go. No information about the distribution of radioactive contaminants was provided by the government on the first and second days of the accident. Results of a mail survey to the evacuees showed that 26.0% of them obtained no information of the evacuation at that time. Many people of Minami-Soma city and Namie town failed to choose their evacuation route and they headed and stay at Iidate or Kawamata which were ones of the highest radioactive areas. TEPCO was banned to have independent press conferences by the national government at the end of April and it lost its position of primarily responsible risk communicator. The government and TEPCO made no communication with the public to seek supports to overcome the accident. B) Care communication accompanied by medical check with tens thousands of evacuees was needed from the beginning of the accident. National Institutes of Radiological Sciences (NIRS) and Japan Atomic Energy Agency (JAEA) did it. A year after the accident the Japanese government organized a committee of government officials from all the ministries to make plans of care communication with the victims. The chief of it was Minister of Environment. Children and parents were their main communication targets. They wanted teachers, local government workers, and medical staffs to be the care communicators. C) No reports of official consensus communication concerning NPP by the government was found after the Fukushima-Daiichi NPP accident. However, re-running of Sendai NPP, Takahama NPP, and Ikata NPP were officially accepted by each local government.

P.94 Turley, AT*; Burch, DF; Henning, CC; ICF International; audrey.turley@icfi.com

Evidence Integration Facilitated by DRAGON ONLINE

What strengthens our conclusion on whether a chemical exposure poses a health risk? More evidence? Higher quality evidence? Evidence from more than one data stream? The answer varies based on the decision context (e.g., regulatory, problem formulation) and the decision framework (e.g., traditional risk assessment paradigm, 21st century paradigm), but having well-organized, well-annotated data facilitates evaluation and development of our conclusion. DRAGON ONLINE is a tool for risk assessors that enables the organization, evaluation, and annotation of toxicology and epidemiology data to support risk assessment decisions. By standardizing the data elements evaluated across scientific studies, we can more easily reach conclusions because it is easier to understand data across studies and even evidence streams. On this poster, we demonstrate the utility of DRAGON ONLINE for the organization and evaluation of epidemiologic and toxicologic data identified through a comprehensive literature search. We show the flexibility of DRAGON ONLINE for the evaluation of individual studies and the visualization capabilities available to the risk assessor. Over the course of developing DRAGON ONLINE, we have extracted data from more than 2,000 toxicology and epidemiology studies and evaluated the quality and potential for bias of more than 1,000 studies. We share the lessons learned through this experience regarding standardization of text, clearly defined extraction fields, and quality control procedures and explain how each of these elements impacts our ability to integrate data across evidence streams.

P.109 Tsunemi, K*; Kato, E; Kawamoto, A; Kihara, T; Saburi, T; National Institute of Advanced Industrial Science and Technology; k-tsunemi@aist.go.jp

Risk estimation on hydrogen fueling station and surrounding area
The aim of this study is to identify and quantify the human risk related to hydrogen explosions during the operation of a hydrogen fueling station. First, five types of accident was identified by the volume of leakage of hydrogen from high-pressure hydrogen storage tank and event tree method was applied for estimation of probability of explosion accident. Next, maximum pressure and maximum impulse on the hydrogen fueling station and surrounding area were estimated using FLACS software developed by GEXCON. Then, consequence and risk of explosion were estimated using existed fragility curves of damage to hearing, whole body displacement effect and impact of the head. As the result, the maximum pressure was estimated 6.9 kPa on the station by the rupture type of the accident, 6.0 kPa by the major type and 1.3 kPa by the medium type. The maximum pressure gradually decreased from the station toward the surrounding area and the maximum pressure at 50 m distance area from the explosion point was less than half of that at the explosion point. The rate of damage to hearing was up to 81%, the mortality rate by whole body displacement was up to 2.3 x 10⁻¹²% and the mortality rate by impact of the head was up to 0.017%. Individual risk of damage of hearing was up to 2.5 x 10⁻² year⁻¹, mortality risk by whole body displacement effect was up to 1.1 x 10⁻¹⁶ year⁻¹ and mortality risk by impact of the head was up to 3.7 x 10⁻⁷ year⁻¹. Thus, the space of explosion effect was within 200-300 m radius and mortality risk by explosion was under 10⁻⁶ year⁻¹ which is a negligible risk level of concern.

T4-I.5 Tvinneim, E; Uni Research Rokkan Center for Social Studies; endre.tvinneim@uni.no

Death or taxes? Explaining what people associate with climate change in four countries

Climate change is a multifaceted issue, associated with geophysics, jobs, taxes, and ethics to name but a few. Studies of public perceptions and attitudes in relation to climate change touch on these issues and more, but rarely permit participants to draw attention to the aspect they themselves find the most important. Recent advances in quantitative text analysis have made open-ended survey questions a more useful tool in overcoming this problem. This study analyses open-ended responses to the question "What comes to mind when you hear the words 'climate change'?" in four countries: Germany, France, the UK and Norway. We use structural topic modelling of word frequencies from verbatim textual responses to induce topics such as melting ice, future generations and carbon taxes. Models will be run both on the individual languages and one common model for all four countries using machine translation of the most frequent terms. Based on earlier work, we hypothesise that what people associate with climate change relates to demographic factors (notably age and gender), political/ideological placement and recent events. Notably, we expect that younger people will emphasise effects on humans, all else equal, whereas older people will emphasise the physical aspects of climate change (glaciers, ice melt, sea-level rise). Given that the four countries display great variation in their electricity production systems, we also hypothesise that respondents in countries with high emissions from the power sector (Germany, UK), will emphasise electricity emissions and coal more than those in countries with lower emissions from the same sector (France, Norway).

P.59 Vaishnav, PT; Carnegie Mellon University ; parthv@cmu.edu
The long and winding road: controlling CO2 emissions from international aviation

In 2013, International Civil Aviation Organization (ICAO), the UN agency charged with regulating CO2 emissions from international aviation, declared that it would implement a market-based mechanism (MBM) that would require airlines to buy credits to offset any growth in their carbon dioxide emissions after 2020. In March 2014, ICAO published a “strawman” proposal for the MBM, which was revised in March 2016. The revised draft was the subject of a high-level meeting (HLM) in May. The meeting ended in an impasse on whether and how to phase the MBM in, as well as on how to account each country’s contributions to global emissions. The proposed research analysis will trace the development of the fledgling mechanism, thru to the final version that emerges from the meeting of ICAO’s Assembly in 2016, where the mechanism will be voted upon. The proposed research will evaluate the impacts – many of them arguably unintended – of the different iterations of the mechanism for different types of airlines. Drawing on the documentation that ICAO provides of its Global Aviation Dialogues (GLADs), the analysis will attempt to correlate changes in the mechanism to positions taken by individual, or groups of, states. One of the big unresolved issues in the design of the MBM is the standard that any carbon dioxide offset purchased to meet its requirements must meet. The proposed analysis will draw on the literature in management sciences to argue that there is a considerable risk that this standard will not have high integrity. As the first mechanism that will address CO2 emissions from an entire sector of the global economy, ICAO’s MBM may serve as a template for other sectors, for example, ocean shipping. Understanding what it gets right, and what it does not, may be important to the design of other global mechanisms.

W2-B.3 Vieglais, CM*; Rappaport, KL; Jones, MJ; U.S. Department of Agriculture, Animal and Plant Health Inspection Service;
christina.m.vieglais@aphis.usda.gov

USDA Regulation of Confined Field Releases of Genetically Engineered Organisms Expressing Pharmaceuticals

The Animal and Plant Health Inspection Service (APHIS) is the regulatory agency of the United States Department of Agriculture (USDA) charged with setting and enforcing standards necessary to protect our nation’s food, agriculture, and natural resources from pests and diseases. One of APHIS’ diverse protection responsibilities is to ensure the safe development of genetically engineered (GE) organisms using a science-based regulatory framework. During the past 20 years, USDA APHIS Biotechnology Regulatory Services has authorized over 20 institutions to conduct confined field releases of eight species of plants genetically engineered to contain over 500 genetic constructs expressing pharmaceutical proteins, distributed over 10,000 acres across 160 locations in 17 States and U.S. Territories. GE pharmaceutical field releases are highly confined, with strict procedures around reproductive isolation, volunteer monitoring, dedicated equipment, equipment cleaning, GE plant devitalization, post-trial planting restrictions, record keeping, reporting, and inspections. We will describe risk assessments that are conducted prior to release to formulate permit conditions designed to ensure confinement of the field tests; to prevent dissemination or persistence of the GE organism, the transgenic DNA, or the expressed GE pharmaceutical proteins into the environment; and to prevent adverse exposures to non-target organisms.

T4-B.1 Van Abel, NA*; Schoen, ME; Meschke, JS; (1) US Environmental Protection Agency, (2) Soller Environmental, and (3) University of Washington; VanAbel.Nicole@epa.gov

Norovirus dose-response modeling: use of multiple models in QMRA to describe uncertainty

Norovirus is a major public health problem leading to numerous global food and waterborne outbreaks, so Quantitative Microbial Risk Assessments (QMRAs) are increasingly being developed for norovirus. A key component of QMRA is the dose-response analysis and currently there are numerous, proposed norovirus dose-response models available for use in QMRA. This work reviewed the norovirus dose-response models used in QMRA and discussed the model considerations such as secretor status, infectivity, and aggregation. A comparison between dose-response models was performed and differences in predicted risk estimates among dose-response models was found to be largest for small doses. In conclusion, QMRA is sensitive to the choice of dose-response model and no one model is best. Thus, in the absence of one best norovirus dose-response model, multiple models should be used to provide a range of predicted outcomes for probability of infection and to describe the uncertainty. Additionally, future research needs were identified including more information on norovirus viral aggregation, more low dose human challenge data, and studies on genogroup differences in immunity mechanisms and dose-response among immune and non-immune individuals.

T4-A.3 Villalba , NA*; Ocampo, FA; Muñoz , F; Universidad de Los Andes; na.villalba340@uniandes.edu.co

Quantitative risk assessment of Natech scenarios triggered by different types of floods

Natural events impacting on chemical plants may cause severe accidents triggering the release of hazardous materials. An example of this type of events was witnessed when hurricane Katrina landed in the coasts of Louisiana in 2005, where water from the storm surge flooded several tank batteries and around 800.000 gallons of oil were released to the water. The released material floated through the community staining almost 1.8000 homes. Despite this, scarce attention is devoted to the assessment of the risk related to this type of accidents. The present study focuses on the development of a framework to perform a quantitative risk assessment addressing major accidents triggered by different types of floods. This approach presents different steps to carry on the assessment. Among these a more reliable estimation of the damage probability of storage tanks threatened by floods using probit functions. This functions were developed based on mechanical models representing the flood water striking the tanks and estimating the probabilities for each scenario using montecarlo simulations. Once the probabilities are estimated a fitting method is applied to determine the mathematical equation to calculate the damage probability as a function of the impact vector (flood velocity, flood height). Also generic event trees were built specifically using data of past events involving different types of floods damaging storage tanks followed by a loss of containment, in order to estimate the final scenario probability. All this tools were implemented in the methodology so a more reliable calculation of the individual and societal risks related to this type of incident could be carried out. The framework was applied to a case of study so a comparison between a quantitative risk analysis not considering a Natech event triggered by floods and the presented approach results can be assessed.

M4-J.5 Visschers, V; Shi, J; Siegrist, M; Arvai, J*; ETH Zurich, Institute for Environmental Decisions, Consumer Behavior; University of Michigan, Erb Institute, School of Natural Resources & Environment and Ross School of Business; and Decision Research ; vvisschers@ethz.ch

Public support for solar radiation management depends on concern about climate change and nationality

Solar radiation management (SRM) aims to counteract the negative consequences of global warming. Because SRM is a new technology, research on the public perception of this technology is needed and should be done in countries with various cultural and political backgrounds. Previous studies have shown that laypeople know very little about SRM. They thus need to be informed about it to be able to form an opinion on it. Moreover, people more concerned about climate change were found to be more in favour of SRM. This relation may however disappear or become negative after people receive balanced information about SRM. We conducted an online study in Canada, China, Germany, Switzerland, the UK, and the US (N = 2,327) to investigate the effect of informing people about SRM on their support and perception of it using a pre-post test design. First, respondents' concern about climate change was measured. Before and after reading a neutrally framed text about the risks, benefits and uncertainties of SRM, they answered questions to assess their support, affect, and perceived usefulness and risks of technologies that aim to reduce the temperature on earth (i.e., SRM). The information about SRM resulted in lower support for and a more negative perception of SRM in all countries but China, where support remained high. Regression analysis showed that in each country, post-information support for SRM was positively related to their concern about climate change, the pre-information level of support and their perceived usefulness of SRM, whereas it was negatively related to the perceived risk of SRM. According to a mediation analysis, concern about climate change appeared to influence post-information support for SRM both directly and indirectly, through the pre-information support for SRM. Thus, if communicators wish to counteract the negative effect of informing the public about SRM on support for the technology, they should emphasize the worrisome consequences of climate change.

T3-J.4 Volken, S*; Hanus, N; Trutnevyte, E; Swiss Federal Institute of Technology Zurich and Carnegie Mellon University; sandra.volken@usys.ethz.ch

Building informed and stable preferences in communities affected by new energy developments: The role of Fact Sheets and deliberation

Many countries aim to expand and diversify their portfolios of low-carbon electricity generation technologies. This development gradually demands that power plants, such as wind, deep geothermal or hydropower, are sited in areas, where no power plants existed before. Laypeople are rarely familiar, but at times highly concerned, about comparatively new technologies and their impacts and risks to the local community, such as induced earthquakes or accident risks. Thus, lay preferences for or against the new developments might neither be well-informed nor stable, posing uncertainty to the electricity project developers. We study (1) how providing balanced information about electricity generation technologies and their impacts and risks to local communities shape laypeople's preferences for these technologies, and (2) whether stable preferences can be achieved. First, we develop and test informational material (referred to as Fact Sheets) that aims to educate the public about electricity generation technologies and their associated impacts and risks to the local communities. Second, we use these Fact Sheets to observe how laypeople form their informed preferences individually as well as in a group deliberation setting. We organize 6 workshops with N=60 participants in total in urban and rural communities in the German-speaking part of Switzerland. We apply a mixed-methods approach, comprised of a statistical analysis of pre- and post-deliberation surveys and qualitative analysis of recorded discussions. A delayed, follow-up survey allows us to study the longer-term stability of the preferences informed by Fact Sheets and the deliberation process. Our study thus contributes to a better understanding of how preferences on new low-carbon generation technologies are formed, especially with a focus on communities affected by new energy developments.

P.62 Volchko, Y*; Karlfeldt Fedje, K; Norrman, J; Rosén, L; Chalmers University of Technology; volchko@chalmers.se

Cost-Benefit Analysis of Copper Recycling in Remediation Projects

Soil contamination is a worldwide problem. Only in Sweden there are more than 80 000 potentially contaminated sites. Remediation in Sweden is usually performed using conventional "excavation and disposal" method because of the low disposal fees and time constrains for remedial actions. To assist this most common remediation method, a metal recycling technology can be used for extraction of valuable metals, e.g. copper, from excavated masses at contaminated sites and thus returning these metals into the societal cycle instead of landfilling. In order to assess economic competitiveness of metal recycling in remediation projects with conventional "excavation and disposal" methods, five alternative remedial actions were assessed for the Köpmannebro site in Sweden by means of a Cost-Benefit Analysis (CBA). Uncertainties in the analysis results were handled with Monte Carlo simulations. All studied alternatives assumed excavation and disposal of the masses heavily contaminated with copper, however differed in distances to the disposal sites, transport means and treatment of excavated masses before landfilling. The CBA had resulted in the negative net present values (NPVs) for all five remediation alternatives, because the remedial action itself was associated with very high costs and low benefits. Project risks (i.e. 12.5% of the costs for remedial action), copper prices, efficiency of copper recycling and costs for the increased health risks due to remedial action contributed most to the uncertainties in the NPVs for the alternatives assuming metal recycling. The simulated mean of NPV for one of these remediation alternatives was slightly lower than for direct disposal of contaminated masses because of the metal recycling opportunity and disposal of the excavated and treated materials at the local landfill. If copper prices were increased at least twice, all the metal recycling alternatives for the Köpmannebro site could be competitive with the conventional "excavation and disposal" method.

M2-C.5 von Winterfeldt, D*; Siebert, J; John, R; University of Southern California; detlof@aol.com

Identifying, Structuring, and Comparing Objectives of Terrorists

A key question of terrorism risk analysis is: What do terrorists want? To answer this question, we developed a methodology using principles of decision analysis to identify, structure, and compare objectives of terrorists from publically available materials. We applied this methodology to identify and structure the objectives of Al Qaeda, ISIL and Hezbollah and, in the process, found interesting similarities and differences. The results of this work was used in two real-time simulations to develop messages to counter ISIL and its followers.

P.146 Vos, SC*; Sutton, JN; Olson, MK; University of Kentucky; sarah.vos@uky.edu

Communicating visual risk: Threat, efficacy, and emotion in SNS messages about Zika

Existing empirical evidence suggest that images can communicate risk information as effectively as text and, in some cases, more effectively (Chang, 2013). However, little empirically based guidance exists as to how visual risk messages should be constructed even though researchers (e.g., Bostrom, Anselin, & Fairris, 2008; Lipkus & Hollands, 1999) have repeatedly called for more research and theory development. These calls came before the advent of visual risk communication on social networking sites (SNS), like Facebook and Twitter. These relatively new platforms facilitate the sharing of visual risk messages. The sharing of messages, or amplification, is a key measure of message success on social media as each time a message is shared, it is exposed to a new group of users. The growing use of images in SNS risk communication raises questions about which visual message elements are more effective for increasing message retransmission. Previously we have found that including an image increases the amplification Ebola risk messages. However, this work focused on the type of visual communication and did not examine the message communicated by the image. In this poster, we draw on the extended parallel process model (EPPM) to examine how risk is communicated visually by public health organizations on SNS during a public health crisis. We use the current Zika crisis to examine visual risk messages distributed during a six-month period in 2016 by 536 Twitter accounts that represent federal, state, and local public health agencies. We conduct a content analysis of the types of visual elements used to communicate risk. We code for the visual communication of threat, efficacy, and emotional appeals. We analyze the effect of these variables on amplification, using negative binomial regression to model how these message elements contribute to message retransmission. We use the results to build on previous research and begin theorizing the visual communication of risk.

P.174 Walia, AB; Centre For Disaster Management, LBSNAA; waliaabhi@gmail.com

Futuristic Risk Assessment For Coastal Flooding in Changing Climate Era: A case of Ernakulam, India

The Ernakulam district of India possesses a coastal belt of 46 Kms along with 12 coastal villages on western coast. District have high population density with huge infrastructure of high importance i.e big harbour of high importance, major Navel base, governmental infrastructure, Tourism hotspot etc. Transportation through water is one of the major way of commuting. City have many water channels, some of them being used by ships to enter harbour and naval base. But in the changing climate scenario city is at high risk for storm surges and Tsunami as preparedness level in not up to the mark. In view to the high vulnerability of the city, Risk Assessment exercise has been carried out by considering futuristic climate change consequences along with suggestive framework to deal with the worst scenario.

P.175 Walia, A; Ardalan, A*; Patrick, V; Singh, S; 1. CDM ,LBSNAA 2. TUMS 3. HHI, Harvard 4. UNICEF ; waliaabhi@gmail.com

Disaster Risk Management in India and Iran : Conceptual Framework for Disable Sensitive DRM Planning

Disasters have severe impact on people, property and environment. Disasters can happen as result from natural hazards i.e. earthquakes, floods, cyclones, etc. or from human-influenced causes like climate change, accidents and conflicts, and can lead to a catastrophic situation. During every disaster situation, people with disabilities suffer most because of their physical and mental condition. It is crucial to consult and involve people with disabilities in disaster risk reduction, response and recovery planning to ensure that the capabilities and contributions of disabled and older people are recognized and utilized. People with disabilities are the people who are differently able but have many abilities. Appropriate needs assessments are critical to address specific needs of people with disabilities during disasters and to ensure that mainstream services and facilities are accessible to people with disabilities. Disaster Management Planning at all levels need to be inline with the needs of the people with disability.

P.138 Walpole, HD*; Wilson, RS; The Ohio State University; walpole.23@osu.edu

The Role of Risk Attitudes in the Reception of Risk Information for Risk Mitigation Strategies in Wildfire

Although evacuation is the preferred method in the US for preserving public safety in wildfire, alternatives such as "staying and defending" have garnered interest due to their increased rates of structure survivability and reduced strain on public safety resources and evacuation routes. While interest has grown in why some people choose to evacuate and other prefer to stay and defend, little research examines whether or when communication interventions can be effective at altering a person's intentions in this context. We investigated the effects of providing information about the benefits of different strategies on intended evacuation behavior. Using an online sample (n=274) we conducted an experiment aimed at assessing the effects of information detailing the benefits of different strategies on intended evacuation behavior and associated perceptions of the risks and benefits of different strategies. Drawing on previous research exploring the role of domain specific risk attitudes in evacuation decision making, we hypothesized that the effectiveness of information would be conditional on the domain specific risk attitudes of the participants. Specifically, we hypothesized that more tolerant attitudes towards a domain of risk would reduce the effectiveness of information at altering risk and benefit perceptions and ultimately behavioral intentions to engage in a strategy that reduces risks in that risk domain. Our results indicated that pro-evacuation information had no effect altering perceptions or intended behavior regardless of risk attitude, however pro-defense information had an effect on behavior through increased perceived benefits of defense. This effect was only present for those with lower tolerance for property risks. Understanding how a resident's risk attitude contributes to the effectiveness of risk messages can help us understand why some communications fail and help us to craft messages with broader appeal to those at risk from wildfire.

P.172 Wang, TW; University at Buffalo and Industrial and Systems Engineering; wtscholar@163.com

The True Meaning of Terrorism and Response to Terrorism

This research mainly focuses on the divergences and controversies over defining terrorism and how to define, understand and deal with terrorism. Based on the systematic survey and study of previous definitions about terrorism and fully referring to other relevant information and data, this article is devoted to exploring the main characteristics and nature of terrorism, then putting forward a clear, pragmatic and widely accepted definition of terrorism from a relatively unique perspective, and then not only tries to use it as a tool to explain, clarify and solve the problems relating to terrorism in reality, but also deepen the battle against the intangible conception of terrorism by proposing some suggestions to strike at the tangible entity of terrorist organizations and terrorists.

M3-J.10 Wang, BW*; Zhuang, JZ; University at Buffalo, The State University of New York; baiongw@buffalo.edu

A case study on the use of Twitter for crisis communication during Hurricane Sandy

Twitter has gained an increasing popularity in crisis communication and been used by official agents for information distribution. This study focuses on crisis communication effectiveness of official users and studies how re-tweet and mention can improve crisis information impression. In this study, tweets posted during Hurricane Sandy are sampled. A content analysis method is used. Results show that time-gap between re-tweet time and original time is power law distributed and 75 percent of re-tweet occurs within 1.5 hours, which is efficient for information distribution. Re-tweet rate based on mentioned users is 0.21, which is significantly higher than the corresponding rate of 0.0001 based on regular followers. Also, tweets from governmental official (GO) and non-governmental official (NGO) users are more likely re-tweeted by both mentioned users and regular followers than tweets from news-agent users. On average, one re-tweet can contribute 5,688 times of impression. Interestingly, we find that the second impression consists of only 10% of the total number of impressions. And neither the first or second impression is significantly different among three types of users, but results show that tweets from news agent users can gain a larger number of impressions than governmental and non-governmental account users.

W3-A.3 Wang, D*; Davidson, RA; Trainor, J; Nozick, LK; Kruse, J; University of Delaware, Cornell University, and East Carolina University; derawang@udel.edu

Modeling homeowner hurricane insurance purchasing behavior

Insurance coverage for flood damage is typically excluded from standard homeowner policies. It can be purchased instead through the National Flood Insurance Program (NFIP) which is managed by the Federal Emergency Management Agency (FEMA). Although wind loss is generally covered in standard homeowner policies, in many of the coastal areas most at risk of hurricane-related damage, it is excluded. In those cases, homeowners can either remain uninsured against that peril, or purchase a separate wind-only policy from a private insurer or more commonly from a state-run catastrophe insurance pool created to augment the market. Despite efforts over the years, low penetration rates and potential solvency concerns persist in these markets. Understanding how homeowners make insurance purchase decisions is critical to maximizing penetration rates and creating an effective insurance market for hurricane wind and flood loss. This presentation contributes to the empirical literature on the subject through an analysis of survey data for homeowners in North Carolina. We develop separate mixed logit models for flood insurance and wind insurance homeowner purchasing decisions as a function of premium, deductible, and selected attributes of the homeowner and insured property. Most of the literature focuses on flood insurance and uses revealed preference data. The data in this study addresses both wind and flood insurance in parallel, and includes discrete choice experiment questions asking whether homeowners would purchase insurance under different hypothetical premium and deductible combinations. We focus on: (1) developing statistical models that can be used to predict insurance penetration rates for a region under different premium levels, (2) understanding the influence of certain factors on homeowner insurance purchasing decisions—in particular, premium, deductible, previous hazard experience, risk, and previous retrofit actions, and (3) comparing the insurance purchasing decisions for flood and wind perils.

P.22 Ward, L*; LaBarre, D; Duverna, R; Muniz Ortiz, JG; Kishore, R; Kause, J; Catlin, MC; USDA FSIS Office of Public Health Science; lindsay.ward@fsis.usda.gov

Prioritizing Chemical Residue Testing in Meat, Poultry, and Egg Products

As the public health agency of the United States Department of Agriculture, the Food Safety and Inspection Service (USDA-FSIS) is responsible for ensuring that the nation's commercial supply of meat, poultry, and eggs products is safe, wholesome, and correctly labeled and packaged. The interagency National Residue Program (NRP), which is organized and administered primarily within FSIS, is responsible for identifying and prioritizing chemical hazards of concern for FSIS-regulated product classes, for collecting FSIS laboratory data describing residues detected in meat and poultry samples, and for analyzing and reporting those data to ensure that permissible levels of hazardous compounds are not exceeded. Recent audits of the NRP have highlighted a need for a more transparent prioritization strategy for chemical residues than its prior reliance on expert judgement. FSIS is shifting toward a more systematic, transparent, and public health-focused risk ranking scheme. FSIS—in collaboration with the Environmental Protection Agency and the Food and Drug Administration—is currently evaluating two risk ranking approaches. One, the Public Health-Based model (PH) is a straightforward combination of exposure and toxicity characteristics with a relative public health risk score being generated for each evaluated chemical. The other, the Latent Variable model (LV), incorporates the same chemical characteristics or parameters used in the PH model, but inputs them into a more complex statistical model that approximates the probability of an adverse event occurring with exposure to observed chemical residue levels. Despite their many differences in construction, the PH and LV methods generate highly similar relative public health risk rankings. A comparison of the two approaches and their outputs will be presented.

P.144 Wardman, J K; University of Nottingham;
jamie.wardman@nottingham.ac.uk

Digital risk perception and communication unplugged: Twenty years of data processing

Digital advances in information and communication technologies have markedly expanded the repertoire of risk management tools and resources that are contemporarily available to researchers and practitioners. Yet, with few notable exceptions (e.g. Bostrom 2003), the transition from 'analogue' to 'digital' risk management over the past twenty years has passed by with surprisingly little critical examination. Following Fischhoff's (1995) and Leiss's (1996) respective works outlining key developmental stages traditionally associated with risk management learning and practice, this paper offers a timely assessment of current advances and trends which I term 'digital risk perception and communication' (DRPC). The paper identifies a series of focal DRPC strategies that researchers and practitioners now 'hope will do the trick', and further argues that DRPC characteristically marks a 'Fourth Phase' in the evolution of risk communication as contrasted with the three preceding phases previously specified by Leiss (1996). Current progress in the consolidation of DRPC skills and capacities is discussed along with early lessons learned about how far each focal strategy will go when confronting risk management problems in the information age. It is concluded that DRPC has unquestionably increased the various capacities of organisations to responsibly manage risk with exacting levels of detail, powerful means of social persuasion, and unprecedented public engagement. However, this is yet to widely translate into the execution of sound and ethical risk communication as a matter of good practice, and innovations in DRPC may prove in certain instances to be disruptive to societal expectations for the conduct of risk management to empower citizens.

WI-J.2 Way, D*; Evensen, D; Boudier, F; Lofstedt, R; King's College London; dominic.way@kcl.ac.uk

Medicines transparency and trust in Europe: Results from 6 member state surveys

The overriding goal of enhancing transparency in the scientific data that underpins the European pharmaceutical evaluation system is to build public trust in medicines. Past studies consistently show that the European public are acutely unfamiliar with how medicines are evaluated and have not heard of the concrete entities that regulate them at the national or supranational level. Rather, public trust in medicines centres on various sources of advice that communicate the regulators' scientific opinions (e.g. GPs, pharmacists, brand-specific websites, patient groups etc.). This study examines the relation between the public's perceived trustworthiness of these actors and its consequences for their medicine-taking and information seeking behaviour. A representative 2015 survey (N=6,001) was conducted with adults from 6 EU countries (GB, France, Germany, Denmark, Italy, Poland). Respondents consistently rated medical actors (GP, pharmacist, local hospital, emergency services) as significantly more trustworthy than societal (the Internet, friends/relatives, patient groups, and the mass media) and especially industry (pharmaceutical companies and brand specific websites) actors. A structural equation model revealed various strong relations between perceived trustworthiness of different actors and the public's behavioural intentions. Notably, when receiving information pointing to potential safety problems with a medicine, a particularly strong positive relation was found between perceived trustworthiness of medical actors and intentions to continue taking their medicine as usual (rather than stop) whilst seeking additional advice – a behaviour most healthcare professionals would recommend. Significant and substantial national variations were also found in the public's medicine-taking and information seeking intentions as well as their opinions on when safety information should be conveyed to the public in the first place. Implications for the regulators are discussed.

M2-A.5 Watson, JP*; Staid, A; Silva-Monroy, CA; Bynum, M; Arguello, B; Singh, B; Pierre, B; Sandia National Laboratories; jwatson@sandia.gov

Proactive and reactive operations paradigms for improving power system resilience to extreme weather events

Electricity is one of the three components of the energy sector, one of sixteen critical infrastructure sectors defined by U.S. Presidential Policy Directive 21. Resilience of the electricity grid is vital for both the economy and public safety and health. Economic operation of power systems alone is difficult. Improving the resilience of the system to a wide range of scenarios (i.e., potential future events) is even more challenging due to the inherent uncertainty in the problem. Additionally, extreme events that disable many system components must be considered as opposed to the traditional N-1 contingency analysis where the system loses one transmission line per scenario. Nominal systems operations, where the primary manipulated variables are generator setpoints, is generally insufficient to make systems resilient to such events. Other operational and planning decisions, such as transmission switching or physical protection of critical components, must be considered, adding even more complexity to the problem. In this work, we present two-stage stochastic programming formulations for minimizing the consequence of extreme weather events to the electricity grid. While the second stage decisions are made in response to a particular event, the number and flexibility of options for recourse are limited. Therefore, the first stage decisions must be made carefully to make the system resilient to all scenarios. We utilize generator dispatch, transmission switching, and physical protection of transmission lines in the first stage, and compare the effectiveness of each, along with their combinations. The optimization problem is formulated with Pyomo, a flexible, python-based optimization modeling language. The analysis is performed on a real system with thousands of buses and transmission lines, and the scenarios used for the stochastic programming problem are generated with historical outage data.

WI-I.4 Wecker-Seipke, D; BSI;

Denise.Wecker-Seipke@bsigroup.com

A Registrar's Perspective on EHS Risk Management within the ISO Paradigm

A related issue to ISO standards is certification to them by a third-party. Certification to standards is an activity within a larger enterprise that is called conformity assessment. Third-party certification is done by organizations that are called registrars. Registrars are in a unique position to see how companies implement standards, and conform to them. This presentation will present an impartial review of ISO's Annex SL capability to manage risk, with consideration of its intent to assess risk through business planning processes, exploration of how Annex SL links EHS management to business processes to ensure risk is considered in decision-making, and a look at the keys to effective use of Annex SL.

W4-G.2 Weir, MH*; Borine, M; Division of Environmental Health Sciences, College of Public Health, The Ohio State University; weirmarkh@gmail.com

Development of an Air Pollutant Dose Response Model for Asthma Incidents Specific to Philadelphia for Triple Bottom Line Modeling

There is a further interest and development of green infrastructure for urban areas in America to advance their stormwater management practices. However with this is the need to critically analyze the benefits as well as the risks of such projects, especially considering their costs. To further the ability to model all three of the triple bottom lines (TBL) innovative modeling solutions are required. TBL models consist of means of quantifying the benefits from environmental, social and economic areas. The environmental bottom line is often referring to public health benefits that can be expected throughout the city. In order to accomplish this environmental model we have developed a dose response model specific to Philadelphia, but with the potential for expansion to other cities. The dose response models accounts for ozone (O₃), PM_{2.5}, PM₅, sulfur oxides (SO_x) and nitrous oxides (NO_x). The dose response model was developed as a multiple nonlinear regression with interaction for the air pollutants of interest and using hospital admittance data that was time coded. Therefore, correlating the asthma emergency room (ER) admittance with remote sensing data for the air pollutants of interest, we were able to develop a projective model of asthma ER admittance based on air pollutant concentrations. This model can be considered a dose response model in most circumstances and will be immediately used in the development of an innovative TBL model for Philadelphia. There are a broad range of future uses of this model as it demonstrates how to develop such specific models for different cities as needed.

P.196 Williams, AD; Jones, KA*; Osborn, D; Kalinina, E; Mohagheghi, A; Parks, J; Sandia National Laboratories; kajones@sandia.gov

Investigating a System-Theoretic Framework for Mitigating Complex Risks in International Transport of Spent Nuclear Fuel

New analytical approaches are desired to effectively manage the growing complexity of safety, security and safeguards (3S) threats to the nuclear fuel cycle (NFC). As NFC global infrastructure expands within this dynamic environment, increasingly complex risks emerge—a risk space captured in the 3S challenges of transporting spent nuclear fuel (SNF) via multimodal and international transportation routes. This research hypothesizes that an integrated 3S approach to SNF transportation risk results in design, implementation and evaluation benefits. Given that the extant 3S literature is primarily conceptual, this research develops a scientific and technically rigorous 3S approach to assessing, managing and mitigating the complex risks of SNF transportation. Traditional SNF evaluation methods for 3S are challenged by uncertainties related to ignoring interdependencies, stochastic assumptions of environmental factors and time independent domain risk mitigation strategies. In contrast, this research utilizes system-theoretic frameworks to model SNF transportation and demonstrates how to assess, manage and mitigate complex risks of SNF transportation with a time dependent, dynamic control theoretic complex system model. Leveraging the growing applications of the system theoretic process analysis (STPA) and dynamic probabilistic risk assessment (DPRA) methods, this research investigates the gaps, interdependencies, conflicts and leverage points often overlooked by traditional methods that rely on analyzing each ‘S’ in isolation. Preliminary results indicate that a system-theoretic, 3S analytical framework is better able to manage the risk complexity of SNF transportation in international environments. Sandia National Laboratories is a multi-mission laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy’s National Nuclear Security Administration under contract DE-AC04-94AL85000.

W4-E.6 Wiersma, RP*; Mangalam, S; Technical Standards and Safety Authority; rwiersma@tssa.org

Risk Based Scheduling of Safety Performance Audits - a regulatory approach to reviewing and influencing safety behaviours

Risk-informed methods are often used to schedule inspections of devices, facilities, or products. Such methods allow resources to be allocated where they can avert the greatest public safety risk. Applying similar methods to sectors where the inspection/auditing of people is required is less straightforward. The purpose of the audit is to affect behaviour that, if left uncorrected, presents a risk to public safety. Contracting companies can vary as to the number of staff they employ, the number of customers they serve, and the types of technologies they maintain. These factors differentiate an inspection scheduling method from inspection scheduling of devices, and must therefore be accounted for. We present a risk-informed scheduling method for the auditing of maintenance contractors. The method limits the risk to a threshold value above which the contractor is subject to an audit, resulting in an efficient and fair regulatory instrument.

P.110 Williams, PRD*; Maier, A; E Risk Sciences, LLP; pwilliams@erisksciences.com

Cumulative Risk Assessment for Occupational Health: Challenges and Solutions

Novel methods, such cumulative risk assessment (CRA), have received growing attention in environmental and community settings. However, CRAs conducted to date have generally not included the occupational domain and occupational health assessments have typically not adopted a CRA approach. In the current analysis, we explore some of the key challenges and data gaps hindering the wider use of occupationally-based CRAs, and present a range of existing methods and tools that can be used to advance this approach in the near term. Specifically, we discuss methodological shortcomings and data limitations related to development of a uniform CRA framework, identification and inclusion of non-chemical stressors, establishment of a “common currency” for assessing the combined effects of stressor co-exposures, and creation of a clearinghouse or central database for exposure and effects data. We also highlight important regulatory, public policy, social, and ethical issues that may arise from performing CRAs in occupational settings. Additionally, we present several examples where existing tools can be used or modified for occupationally-based CRAs: 1) using mode-of-action hypotheses to identify potential stressor interactions, 2) using auditing checklist tools or worker surveys to document potential combinations of stressors for hazard identification, 3) adjusting occupational exposure limits in the dose-response assessment to incorporate scenario and population specific susceptibility factors, 4) modifying acceptability criteria in the hazard quotient as a refinement to the risk characterization, and 5) working with occupational health care providers and wellness teams to address combined effects of stressors. These approaches can be applied in a qualitative or quantitative way to begin to address the effects of occupational risk factors, coupled with stressors arising from non-occupational domains (e.g., personal factors, community exposures), on worker health.

W2-G.2 Williams, PRD; E Risk Sciences, LLP;
 pwilliams@erisksciences.com

Assessing Benzene Exposures and Risk Among Vehicle Mechanics in the U.S. and Abroad

In this study, benzene exposures were characterized among vehicle mechanics exposed to gasoline and other petroleum-derived products. Specifically, time-weighted-average (TWA) and task-based benzene concentrations were summarized based on published air sampling data from two dozen studies. Statistical analyses were conducted to compare benzene exposure concentrations by region, season, and job task and to predict benzene exposures from total hydrocarbon data. A mathematical model was used to estimate task-based benzene concentrations under several hundred different product scenarios. Based on the available data, TWA airborne concentrations of benzene for vehicle mechanics in the United States averaged 0.01–0.05 ppm since at least the late 1970s, with maximal TWA concentrations ranging from 0.03–0.38 ppm. Benzene exposures were notably lower in the summer than winter and in the Southwest compared to other geographic regions, but significantly higher during known gasoline-related tasks such as changing fuel pump or filter. Measured benzene concentrations were greater for vehicle mechanics in other countries due to the higher benzene content of gasoline (5% vs. 1-2%). Short-term airborne concentrations frequently exceeded 1 ppm during gasoline-related tasks, but remained below 0.2 ppm for tasks involving other petroleum products. Model predicted benzene concentrations were found to be similar to those measured when using reasonable input values from the literature. Dermal exposures were found to contribute little to total exposure. When assessing mechanics with varying work histories, cumulative benzene exposure estimates ranged from 0.5 to 1.5 ppm-years after the late 1970s, and 3.5 to 4.5 ppm-years for work that included 10 years prior to the late 1970s. Overall, the available data suggest that vehicle mechanics have not experienced significant exposures to benzene in the workplace, except perhaps during short-duration gasoline-related tasks.

T2-C.3 Wilson, PH; Hawkins, BE; Winkel, DJ; Whittaker, IC; Gooding, RE; Bradley, DR; Cox, JA; Hauser, K*; Battelle Memorial Institute; wilsonph@battelle.org

Modeling Exposures in Chemical Release in Indoor Building Scenarios Using a 3 Zone Concept

The Chemical Terrorism Risk Assessment is a Department of Homeland Security Chemical Security Analysis Center program that assists in prioritizing mitigation strategies and assessing the risk of chemical terrorism attacks, including the release of harmful chemicals in indoor building spaces. Modeling aerosol dispersion of hazardous chemicals in populated buildings that are sufficiently broad in physical aspects and dynamic behavior as to encompass the diverse nature of any building within the US represents a challenge to the current state of the art in dispersion modeling, which requires explicit indoor building information for each building. An innovative model involving the creation of 3 zones consisting of a zone of release and zone of interest which are adjacent and of equal sized, as well as a lumped zone which represents the remainder of the building all fed by a single HVAC system with a common re-circulation was developed to address this challenge. The 3 zone modeling concept results were compared against field study data provided by USEPA. The concentrations predicted were found to be consistent with USEPA-provided data sets, supporting the use of the 3 zone model for the purposes of estimating concentration and exposures.

W4-I.4 Wilson, RS*; Zhang, W; Irwin, E; Aloysius, N; Martin, J; The Ohio State University; wilson.1376@osu.edu

Modeling the effectiveness of outreach as a risk management tool

Non-point source runoff from agricultural production is impairing coastal ecosystems and related services across the globe. This degradation is projected to worsen with climate change, as more intense rains transport more nutrients downstream. In the upper Midwest, these changes are already resulting in harmful algal blooms that pose great economic and public health risks in the region. To combat these problems, agricultural best management practices (BMPs) have been advocated, but policymakers have been reluctant to mandate these and voluntary farmer adoption has proven insufficient. Using the western Lake Erie Basin as a model ecosystem, we conducted a mail survey of conventional corn-soybean farmers in a largely agricultural watershed to develop a farmer decision-making model as part of a larger coupled human-natural system. Preliminary results indicate that adoption of recommended best practices increases with greater response efficacy, a belief that can be targeted through ongoing education and outreach efforts. For example, just a 20% increase in perceived response efficacy increases the probability of adoption for a given individual by approximately 15%. We use a spatially-explicit coupled human-natural systems model to evaluate the effectiveness of outreach and education efforts focused on increasing adoption. Namely we evaluate to what extent an individual farmer on the landscape will experience an increase in perceived efficacy as a result of local outreach efforts, to what extent that increase in efficacy leads to a change in behavior, and to what extent those aggregated changes in behavior across the landscape decrease the nutrient loss contributing to harmful algal blooms in western Lake Erie. We model the effectiveness of such policies under a variety of future climate change scenarios, addressing the extent to which future climate change risks can be offset through voluntary changes in human behavior.

P.145 Winter, PL*; Milburn, LA; Li, W; Padgett, PE; USFS, Pacific Southwest Research Station; pwinter@fs.fed.us

Urban Parks as the Nexus for Neighborhood Vulnerability and Resilience

Urban parks serve as the nexus for this ongoing inquiry into neighborhood vulnerability and resilience. A number of environmental and social effects are anticipated from climate change. Urban parks, home to urban forests, offer myriad ecological, social and economic benefits to surrounding neighborhoods, including benefits that will help buffer impacts from climate change. Four communities, two affluent and two disadvantaged across a number of socioeconomic dimensions, are the focus of our analysis. For this study, neighborhood is defined as those street segments lying within a half mile radius of two urban parks within each community. California EnviroScreen data show the dramatic difference in pollution burden for the eight neighborhoods. Observations of park use paired with assessments of ozone exposure further highlight issues surrounding community well-being. To render a more complete picture of neighborhood condition the physical environment was rated through an application of Google Earth Pro and Street view. Independent raters assessed street segments using the Active Neighborhood Checklist. Typically applied to inquiries in community health and active living, the ratings reflect the mix of land uses in a neighborhood (e.g., residential or commercial structures), non-residential uses (e.g., markets or educational facilities), visible street characteristics, and environmental quality (e.g., presence of public art or litter). In sum findings inform a greater understanding of current community condition as well as areas where interventions are most needed. More broadly, the neighborhood context offers a framing that is meaningful to community members, NGOs, and policy makers capitalizing on advances in climate change communication science.

M3-J.11 Wirz, CD*; Chung, JH; Rose, KM; Brossard, D; Scheufele, DA; Xenos, MA; Massarani, L; Maynard, A; University of Wisconsin-Madison; cwirz@wisc.edu

Zika outbreak: a multilingual analysis of social media discourse surrounding the Zika virus and genetically engineered mosquitoes

The recent outbreak of the Zika virus has received a great deal of international press attention. Last year, as the virus began to spread through South America and concerns over the link between the Zika virus and microcephaly were growing, the conversation turned to genetically engineered (GE) mosquitoes. The mosquitoes were discussed as a potential way to limit the spread of the virus. However, the technology has proven to be controversial with increasing conversation on social media surrounding the risks associated with genetically engineered mosquitoes. This study performs an in-depth analysis of these conversations on two prominent social media platforms, Facebook and Twitter. In addition, we also performed our analysis in English, Spanish, and Portuguese. The use of a multilingual, multiplatform approach provides a more robust and comprehensive analysis of the conversations by including data from countries more affected by the Zika virus. We are specifically analyzing trends in volume and sentiment surrounding the Zika virus and GE mosquitoes to see the impact of key events on social media discussions. Additionally, we are interested in whether posts focus on problems and risks associated with Zika or potential solutions. We also look at the types of strategies that are presented to combat the virus. Lastly, we determine the proportion of posts that explicitly assign blame for the broader problems associated the Zika virus. We then compare each of these factors in terms of differences between the platforms and languages to determine how the type of discussion and proximity to the problem affect social media discourse. Preliminary sentiment results show that the conversation on Twitter is more neutral, while the conversation on Facebook appears more polarized and negative.

M4-F.4 Wood, MD*; Larkin, S; Linkov, I; US Army Engineer Research & Development Center; Contractor to US Army Engineer Research & Development Center; US Army Engineer Research & Development Center; matthew.d.wood@usace.army.mil

High Throughput Screening Tool for Evaluating Chemical Toxicity Risk Based on Chemical Properties and Human Factors

The amount and variety of chemicals manufactured has been steadily rising [1]. Gaps still exist in toxicity data, and efforts focused on assessing those chemicals believed to pose the greatest threat based on production quantity and other properties are limited [2]. Resource limitations for chemical assessment, along with the increasing number of manufactured chemicals, has produced a need for prioritizing chemical assessment. Common chemicals used in everyday products (e.g., cleaning agents, fragrances, pesticides) have limited data available concerning human exposure potential based on common usage. The US EPA has been making efforts to include risk though exposure as a criteria to consider when choosing chemicals to prioritize. Recently they have identified 83 chemicals from a larger data set of 1235 chemicals on which to prioritize research over the next several years. Those chemicals were selected by first filtering to remove “data poor” chemicals, before the remaining chemicals were evaluated by their Exposure Potential, Hazard, Persistence and Bioaccumulation. In order address the much needed ability for chemical prioritization on data poor chemicals, the EPA’s Office of Research and Development launched the ExpoCast [3] program to advance development of novel methodologies for evaluating chemicals based on their biologically relevant potential for human exposure. Combined with toxicity information from ToxCast [4], a complementary program, the EPA will be able to screen and prioritize chemicals based on cutting-edge experimental and computational methodologies. The Exposure Challenge [5] was organized, challenging several scientists to develop their own exposure based prioritization methods on a small set of well-characterized chemicals. In addition, as a high level, initial screening tool, a team from US Army Engineer Research & Development Center (ERDC) was asked to develop a prioritization tool using methods from the field of Decision Analysis, drawing upon parameters used in the other Exposure Challenge models.

M4-F.3 Wong, J; California Department of Toxic Substances Control; Jeff.Wong@dtsc.ca.gov

California’s Safer Consumer Products Regulations: A Regulatory Framework That Includes Nanomaterials

The California Safer Consumer Products Regulations (SCPR) provides a continuous, science-based, iterative process to identify safer consumer product alternatives. Nanomaterials can be subject to these regulations either as chemicals or products. There are various features of the SCPR that allow for a more precautionary approach to the regulation of new or emerging products and chemicals, such as nanomaterials and nanomaterial enabled products, than that found in past regulatory frameworks. Manufacturers and others who are involved in the lifecycle of a nanomaterial will want to develop or obtain safety and other relevant data prior to introduction of a nanomaterial or nanomaterial enabled product to the marketplace.

P.38 Wood, MD*; Foran, CM; US Army Engineer Research & Development Center; matthew.d.wood@usace.army.mil

Portfolio Analysis for Research Prioritization: Application to NOAA Fisheries

NOAA Fisheries is responsible for understanding and monitoring the wellbeing of species and ecosystems in the Nation’s continental waters while considering priorities of the organization, the federal government, and the regional economies that rely on commercial fishing, tourism, and other activities. Every year, NOAA Fisheries develops and executes a portfolio of cruises for each of its six Fisheries Science Centers. These cruise portfolios must maximize scientific understanding and stakeholder requirements while maintaining flexibility to changing organizational, scientific, and budgetary conditions. We present a portfolio analysis tool developed for NOAA Fisheries that uses leadership preferences expressed as weights from structured interviews, and historic information from past year’s cruise prioritization expressed as optimized weights derived through a genetic algorithm. The result was a prioritized list of cruises for each of the Fisheries Science Centers and the Nation as a whole that were successfully used to inform which cruises were approved for allocated NOAA Fisheries funding in FY17. Additional findings and lessons learned to be discussed.

P.127 Wooten, EK*; Rivers, L; North Carolina State University; ekwooten@ncsu.edu

Effects of climate change on Malian farmers

Food security in Africa has become increasingly unstable in recent years. The lack of it threatens the capacities and developmental abilities of individuals, households, communities, and states. Seventy-five percent of African nations are classified as extreme or high risk for food insecurity. Reasons for such high risk are war, disease, poverty, and climate change. In Mali, a largely agrarian country, the risk of food insecurity is severe. One reason for this risk, which will be the focus of our project, is climate change's effects on the region. Climate change in Mali is being seen through the Sahelian climate of the north shifting into the Sudanian climate zone located in the south. This southern region located in the Sudan is where most of the country's agriculture takes place. In this area the climate shift has led to increased rainfall variability and made predicting the start of the rainy season difficult for Malian farmers. These changes are leading to farmers facing uncertainty in their planting decisions, and are critical for farmers as agriculture in Mali is 93% rain fed. Overall this is leading to yield reductions. With most agriculture in the country being subsistence farming, crops are used to feed farmers' large polygamous families that can exceed a hundred people. Trying to feed large families with decreasing yields has made farmers' food security more precarious. Our objective is to look at how climate change, by making food security more uncertain, is affecting farmers' lives. To do this 42 individual open-ended interviews were conducted with farmers in the Koutiala area of Mali. We will use these to look at how farmer's lives are being altered by climate change and its effects on their food security by qualitatively coding the interviews. Our work will contribute to the food security literature on the link between climate change and food security in the context of Malian Farming.

W2-J.3 Wu, F*; Hallman, WK; Rutgers University; fanfan31@gmail.com

Improving food safety crisis communications: an experimental study on public perception

This study tests the applicability of Situational Crisis Communication Theory (SCCT) to the unique circumstances posed by food safety crises. The study uses a factorial repeated-measures experimental design with a representative sample of 743 online participants. The experiment investigates the effects of different types of food safety crises (accidental, omission preventable, and commission preventable) and different initial crisis communication strategies (deny responsibility without recalling the affected food, denial with recall, and accept responsibility with recall) on public responses to an unfolding food safety crisis (time 1 - breakout of crisis, time 2 - confirmation of whether the company is involved, and time 3 - identification of the cause). The results show that different initial communication strategies generate different public perceptions at different stages of the food safety crisis. At time 1, the "denial with recall" and "accept with recall" strategies led to better public perceptions (i.e. post-crisis attitude and purchase intentions) than the "denial without recall" strategy. The same pattern was observed at time 2, even when the company turned out not to be linked to the outbreak. No such pattern was observed at time 3, when the cause of the outbreak was discovered. The results also show that different types of food safety crises generate different public perceptions. In general, omission preventable and commission preventable crises led to more negative responses (e.g. post-crisis attitudes, emotions, purchase intentions, perception of legal responsibility), with commission preventable crises yielding the most negative responses. The results of this study extend the SCCT theory and provide practical recommendations regarding how to effectively communicate about food contamination incidents. In particular, these results highlight the importance of a recall at the early stage of crisis and of identifying the type of crisis involved.

P.90 Wu, CH*; Shih, IT; Chuang, YC; Wu, KY; National Taiwan University; charlenehwu@gmail.com

Health Risk Assessment of maleic and fumaric acid in Taiwanese adult population via LC-MS/MS and Bayesian Statistic Markov chain Monte Carlo Simulation

Maleic anhydride (MAH) was used purposefully as a food adulterant in a variety of starch-based local Taiwanese delicacies such as tapioca and vermicelli. MAH is mainly used in the manufacturing of polyester resins for boats, autos, piping, and electrical goods. Consumed and hydrolyzed, maleic acid (MA) may cause renal impairment such as tubular injury and necrosis in the proximal tubules. On the other hand, fumaric acid, an isomer of maleic acid, has been used as an acidity regulator in foods since 1946. The aims of this study are to 1) determine the total amount of maleic acid and fumaric acid in foods with liquid chromatography coupled with tandem mass spectrometry (LC-MS/MS) and 2) assess the exposure in adults in Taiwan via Bayesian Statistics and Markov Chain Monte Carlo Simulation (BSMCMC). Of the 66 food samples collected, some of which include instant coffee, tapioca starch and rice cake, 60 samples contained quantifiable concentrations of MA and 39 samples contained quantifiable residue of fumaric acid. The aforementioned data, combined intake rates collected from National Food Consumption Database, life average daily dose (LADD) and hazard index (HI) were calculated as follows: LADD of MA and MAH for adult males and females is 0.63 μg/kg/day and 0.56 μg/kg/day respectively, with a 95% upper limit of 1.14 μg/kg/day and 0.97 μg/kg/day respectively. The average exposure dose for fumaric acid is 3.55 μg/kg/day and 3.63 μg/kg/day respectively, with a 95% upper limit of 10.14 μg/kg/day and 10.01 μg/kg/day respectively. The HI value of MA for adult males and females is 0.01137 and 0.00972 respectively, while the HI value of fumaric acid is 0.00169 and 0.00167 respectively. Even though the HI value of maleic acid for adults is higher, the individual HQ of maleic acid and fumaric acid is far lower than 1. Our results indicate that the current amount of exposure of maleic acid and fumaric acid is unlikely to induce adverse health effect in humans.

P.137 Wu, CY; Huang, SZ*; Wu, HC; Wu, KY; National Taiwan University; d04841012@ntu.edu.tw

The Relationship Between Stigma and Public Acceptance of Food Products- An Example of Chewy Starch in Taiwan

In 2013, a prohibited food additive (maleic anhydride) was found in chewy starch, a commonly used ingredient for several Taiwanese cuisines, causing a widespread panic after media coverage in Taiwan. The objective of this study was to investigate whether the food safety incident had stigmatized food products that contained chewy starch, and explore how stigma, risk and benefit perceptions, trust toward government and food industries, and dose-response sensitivity affected the acceptance of the food products. A total of 714 Taiwanese participants aging from 16 to 45 were recruited for a questionnaire survey. Path analysis using LISREL was employed to analyze the direct and indirect relationships in this model. The risk and benefit perceptions were defined as mediators to predict the level of food acceptance. The result showed that stigmatization had a significant effect on both mediators: a positive effect for risk perception (β= 0.51), and a negative effect for benefit perception (β= -0.341). Dose-response sensitivity had a negative association with risk perception (β= -0.15). The trust towards the food industry had a negative association with risk perception (β=-0.07) and a positive association with benefit perception (β=0.25). The direct association between risk perception and food acceptance was not significant, suggesting its effect needed to be mediated by benefit perception. The study showed that two major influential factors were stigmatization and benefit perception. Stigmatization posed both direct and indirect effects on food acceptance, whereas benefit perception posed a direct effect to acceptance. Trust had little impact on the level of acceptance through mediations of perceptions. These findings suggested that management of such crises should consider strategies that acknowledge and address the potential cost of stigmatization, and minimize its impact through other means such as increasing perceived benefits of stigmatized food.

M3-J.3 Xian, SY*; Shao, WY; Lin, N; Kunreuther, H; Goidel, K; Princeton University; Auburn University Montgomery; Princeton University; Wharton Business School; Texas A&M University; sxian@princeton.edu

Understanding Individual's Voluntary Flood Insurance Purchase from Flood Risk Perspective

Over the past several decades, economic damage from flooding has increased dramatically due to rapid coastal development and climate change. While coastal residents could take preventative measures, such as purchasing flood insurance, to mitigate against any negative impacts, only a minority of coastal residents have purchased flood insurance. Drawing on the theory of environmentally significant behaviors and using a survey database for the entire U.S. Gulf Coast (with sample size of 3800 respondents), we examine how external influences and perceptions of flood-related risks together with socio-demographic factors affect individuals' voluntary decisions to purchase flood insurance. We find that external influences related to flood risks conveyed through flood maps by FEMA, intensities and consequences of past storm and flooding events, as well as perceived flood-related risks significantly affect individuals' voluntary flood insurance purchase behaviors. Voluntary purchasing decisions are also influenced by home ownership, trust in local government, education and income. These findings have several important implications. First, FEMA's flood maps have been effective in conveying local flood risks to coastal residents and correspondingly influencing their decisions to voluntarily seek flood insurance. Second, policy makers should design strategies to enhance homeowners' trust in local government and better communicate flood risks and to address affordability issues for low income and low education homeowners. Future studies should examine the impact on individuals' perceptions and behaviors of external forces embodied in policy makers' estimates of future flood risks affected by climate change.

P.9 Yamaguchi, H*; Matsumoto, M; Kato, H; Hirose, A; National Institute of Health Sciences; h-yamaguchi@nihs.go.jp
Uncertainty analysis with the assessment processes in the screening hazard assessment of human health under Japan's Chemical Substances Control Law

Hazard classes of human health in a screening assessment under Japan's Chemical Substances Control Law (CSCL) had already been established about 450 chemical substances from the 2010 to the 2014 fiscal year. However, chemical substances targeted in the screening assessment are about 10,000 substances, those with the manufactured/imported amount of more than 10 tons are about 7,500 substances. Several contracted institutions had conducted the pre-screening assessment of thousands of substances, and estimated hazard assessment values. However, the information and data collected by these institutions were required to refine in order to apply the governmental screening assessment, because their assessment procedures were inconsistent with each other. Therefore, many resources for the refinement have been spent for the data evaluation. Toward the establishment of an effective procedure of the hazard screening assessment, this study aimed to quantitatively evaluate the uncertainty with the processes of hazard screening assessment and to identify its sources by comparing the hazard assessment values, the assessment procedures and the sources of hazard information adopted by several authorities. Then, we discuss the improvement of the procedure to help the efficient screening assessment in CSCL.

P.36 Xian, SY*; Small, MJ; Lin, N; Princeton University; Carnegie Mellon University; Princeton University; sxian@princeton.edu
Should we design for 100 year flood?

Flood adaptation measures are imperative to deal with increasing flood risk. However, current flood adaptation strategies may be far from optimal. First, estimates of future flood hazards are often made assuming stationary mean sea level or a uniform global rate of increase, without consideration of local variations. Second, flood adaptations are based on design storms with specified current or future flood return levels rather than using the full distribution of flood hazards. In this study, we provide a framework to integrate the estimation of flood hazards under local uncertain sea level and the calculation of flood return levels and optimal protection levels for the future. Optimal mitigation level is defined as the level that minimizes the combined cost of mitigation and future expected losses (net present value). We first estimate the annual probability of flooding and the storm surge and damage associated with the full range of flood return levels (e.g. 50 and 100 years). The optimal mitigation level is then determined for a future assessment period corresponding to the next 30 years. Alternative realizations of flooding (using Monte Carlo simulation) are used to evaluate the return period design and the optimal mitigation design across the multiple simulations. However, each realization of future floods generates an amount of regret or absolute losses associated with over-mitigation or under-mitigation. The distribution of the regret and absolute loss are obtained for the two approaches of protection design: i) mitigate for a design storm; and ii) choose optimal mitigation across the distribution of storm events. We apply this framework to two properties in NYC and Florida as an illustration and comparison. The results show that economically optimal design is more favorable than the commonly-used flood return levels. The study suggests that decision makers should take into account the uncertainty of local sea level increase and the economical optimum when flood adaptation is prescribed.

P.148 Yamaguchi, H*; Shintani, K; Hamada, NS; National Institute of Health Sciences; h-yamaguchi@nihs.go.jp
The chronological change of consumer anxieties and concerns related with radioactive contamination of foods in Japan: applying the text mining approach

Since the accident at the Fukushima Daiichi nuclear plant, the anxieties and concerns of Japanese consumers related with radioactive contamination of foods has increased. The purpose of this study is to analyze the chronological change of the anxieties and concerns of consumers about radioactive contamination of foods by applying the text mining approach. We used the text data that were inquired from consumer in "Hitokoe Seikyo". "Hitokoe Seikyo" is the two-way communication system of Consumer Co-operative, and provided by the Tohto Co-operative. First, we performed the frequency analysis, the cluster analysis and the co-occurrence network of the text data on annual basis by text mining approach. We then conducted the syntax analysis, and identified the main anxieties or concerns of consumer. As a results, three consumer anxieties or concerns were extracted: (i) the safety of provisional reference values in Japan, (ii) the need for voluntary efforts of Co-operative, and (iii) requests for origin labeling of food. It suggested that the main topics of the anxieties and concerns were not changed by years, although the number of data reduced after two years of the accident to one-tenth.

W2-C.5 Yampolskiy, RV; University of Louisville;
roman.yampolskiy@louisville.edu

Artificial General Intelligence Risk Analysis

Many scientists, futurologists and philosophers have predicted that humanity will achieve a technological breakthrough and create Artificial General Intelligence (AGI). It has been suggested that AGI may be a positive or negative factor in the global catastrophic risk. In order to mitigate a dangerous AGI system it is important to understand how the system came to be in such a state. In this talk, I will survey, classify and analyze a number of pathways, which might lead to arrival of dangerous AGI.

W1-B.4 Yang, H*; Chada, K; Huang, Y; Forshee, RA; Anderson, SA; US Food and Drug Administration; hong.yang@fda.hhs.gov
Risk Assessment for Transfusion-Transmission of ZIKA Virus (TTZIKV) in Puerto Rico

The Puerto Rico health department reported 785 confirmed ZIKA virus cases, as of April 21, 2016. Blood collection on the island was temporarily suspended due to the concern of possible transfusion-transmission of ZIKA virus (TTZIKV) observed in other countries with Zika. There is an urgent need for risk mitigations. We conducted a quantitative risk assessment to estimate the residual risk of TTZIKV from blood units collected in Puerto Rico and screened using a ZIKA virus detection assay. The risk assessment model inputs are monthly disease incidence, asymptomatic infection proportion, window period and sensitivity of screening assay, and TTZIKV rate. The model outputs are estimated infectious blood units/100,000 donations, monthly infectious blood units and monthly TTZIKV cases. An importance analysis identified major risk drivers among model inputs. The Puerto Rico monthly incidence rate has the largest impact on the risk outcomes. The blood units collected during the peak outbreak period may result in more TTZIKV cases. Blood screening may yield a 60 -90% risk reduction depending on disease incidence. The incidence rate of reported cases in Puerto Rico is higher for pregnant women than the general population. It is unknown whether pregnant women are more susceptible. Higher incidence in pregnant population may be due to increased surveillance for ZIKA infections among pregnant women, in association with microcephaly in infants. This may imply a potential underreporting of confirmed ZIKA cases among the general population. Results of the importance analysis also indicate that the rate of underreporting may have a significant effect on the precision of risk prediction. The model can be used to estimate the TTZIKA risk in Puerto Rico during the outbreak. It could also be applied for TTZIKA risk assessment in other parts of the United States, should ZIKA outbreaks occur. It provides a tool to inform FDA risk management on TTZIKA.

P.120 Yang, JZ*; Huang, J; University at Buffalo;
zyang5@buffalo.edu

Seeking for your own sake: Chinese citizens' motivation for information seeking about air pollution

Based on data collected from a panel of Chinese residents maintained by Qualtrics (N = 504), this study examined participants' information seeking behaviors about air pollution through mass media, social media, interpersonal channels, and over the Internet in general in the past six months. Guided by the risk information seeking and processing (RISP) model, results from structural equation modeling indicate that consistent with the propositions of the RISP model, information insufficiency, negative affect, perceived information gathering capacity, and attitudes toward information seeking exerted significant positive influences on information seeking. Perceived hazard characteristics had a significant indirect effect on information seeking through information insufficiency. In contrast to recent research based on the RISP model, however, informational subjective norms (ISN) were not a significant predictor of information seeking. These findings suggest that for a risk topic (e.g. air pollution) that poses a direct threat to the health and wellbeing of the research population, individuals' communication behaviors are driven by their own cognitive evaluations and affective responses, rather than social motivations related to others' expectations of their information level about the issue (ISN). For theory-testing purposes, results from this study attest to the applicability of the RISP model to examining an important environmental issue in a Chinese context. In terms of practical implications, findings from this research suggest that public communications about air pollution in China should aim to foster a sense of urgency and to enhance self-efficacy among the target audience.

W3-A.4 Yang, K*; Davidson, RA; Nozick, LK; Blanton, B; Blanton, C; University of Delaware; kunyang@udel.edu
Presenting the evolution of hurricane uncertainty over time with scenario-based hazard trees

When a hurricane first develops, there is great uncertainty in how it will evolve in the following days until it dissipates. The hurricane development uncertainties include physical changes in direction, forward speed, and intensity of wind, storm surge, and rainfall in both coastal areas and inland. As time progresses, that uncertainty is reduced, but so is the ability to evacuate or undertake other preparations. Understanding how quickly the uncertainty is likely to be resolved can thus offer useful input for emergency managers. If the effects of a hurricane are likely to become more certain soon, an emergency manager may wait for more information. If not, he may proceed with preparations. In this paper, we introduce scenario-based hazard trees, a new tool that depicts the resolution over time of uncertainty in a hurricane's effects. A scenario ensemble commonly developed as part of a hurricane forecast is used as input. A linear integer program transforms the ensemble into a tree. The hazard trees provide a new dynamic way to think about how uncertainty changes during the course of a hurricane, and can provide the required input for a multi-stage stochastic programming evacuation model. A case study is presented for Eastern North Carolina in Hurricane Isabel.

T3-F.3 Yasuda, Mari*; Rui, Nouchi; Tohoku University; yasuda@irides.tohoku.ac.jp

Educational tools for risk recognition and awareness of disaster mitigation as needed to lessen damage from tsunamis

Tsunamis differ from other types of natural hazards because is a secondary effect after a primary disaster. As a result, tsunami preparation and countermeasures are arguably easier than other types of natural hazards due to lead time, especially in evacuation. To lessen the risk of damage in areas with high tsunami risks in the future it will be necessary for children themselves to be able to take appropriate action to evacuate on their own at the moment they feel the tremors of an earthquake or hear a warning, without waiting for instructions from adults. Implanting and nurturing in everyday living a recognition of disaster risks and an awareness of the need for readiness, in order to increase children's awareness of disaster mitigation, can be expected to have a positive impact on their families as well, resulting in higher levels of risk recognition and awareness of the need for readiness among all members of the family. It was thought that Japanese people would have been fully aware of the risks of a tsunami, as risks that affect them directly as residents of a country subject to frequent tsunamis are ever present. After people lost their lives in the 2011 Great East Japan Earthquake it became evident that there was a need for raising awareness of disaster mitigation among the people who play leading roles in society. For this reason, if safety measures are conducted, such as relocating communities to higher elevation and setting up warning equipment, then residents' awareness of the risks of a tsunami would decrease rapidly. To break this vicious cycle in which enhancement of physical countermeasures leads to neglect of mental preparedness, and eventually to sustain the abilities to recognize and respond to risks across generations, it would be desirable to implement education to raise awareness of disaster mitigation among youth, when they have high levels of curiosity, by incorporating methods intended to help them imagine natural disasters in practical terms.

T4-E.3 Yemshanov, D*; Koch, FH; Lu, B; Cook, G; Fournier, R; Turgeon, J; Natural Resources Canada; Denys.Yemshanov@canada.ca

A HYPERVOLUME APPROACH FOR ASSESSING RISK UNDER UNCERTAINTY

We present a continuous risk measure that is influenced by both the expected magnitude of risk and its uncertainty. We first represent a set of risk values by their cumulative distribution functions (CDFs) and then, using the first-order stochastic dominance rule, find ordered non-dominant subsets of these CDFs, which we use to identify different classes of risk, from high to low. Because each non-dominant subset is estimated with respect to all elements of the set, the uncertainty in the underlying data is factored into the delineation of the risk classes. We depict each non-dominant subset as a point cloud, where points represent the CDF values of each subset element at defined sampling intervals. For each subset, we then define a hypervolume that is bounded by the outermost convex frontier of that point cloud. This results in a collection of hypervolumes for every non-dominant subset, which together act as a measure of risk. We demonstrate the approach by assessing risks of Asian longhorned beetle epidemic (ALB, *Anoplophora glabripennis*) in Greater Toronto (Ontario, Canada). We calculated the hypervolume metric using estimates of the human-mediated spread of ALB epidemic through the urban environment and compared this metric with traditional risk measures based on the probability of the species' arrival. Overall, the approach offers a rigorous depiction of risk under uncertainty because it factors in the uncertainty that is present in the data and characterizes the risk with a continuous measure that can be used to compare assessments made with different datasets and assumptions.

P.91 Yeh, SS*; Wu, C; Wu, K; National Taiwan University Hospital, National Taiwan University, National Taiwan University; sherryeh@gmail.com

The risk assessment of dietary exposure to acrylamide for adults in Taiwan

Acrylamide (AA) was detected in potatoes and foods cooked at high temperatures. AA could cause neurological damages and reproductive hazards. AA was also hypothesized to act as a genotoxicant via its metabolite glycidamide (GA), and it could cause different kinds of cancers in animal tissues. Many countries had investigated the dietary intake of AA in the general population. However, there was a lack of risk assessment of AA in foods in Taiwan. We gathered information on AA analysis and national food survey in order to calculate theoretical maximum daily intake (TMDI) and lifetime average daily dose (LADD) for adults aged 19 to 65 years. Moreover, Benchmark dose lower confidence limit at 10% risk (BMDL10), margin of exposure (MOE), and cancer slope factor (CSF) were assessed based on two-year drinking water cancer studies conducted by National Toxicology Program. The results showed that TMDI for twelve food categories were 0.605, 0.04585, 0.1598, 0.3356, 0.0329, 0.5455, 0.3731, 0.3797, 0.5716, 0.1328, 0.6058, and 0.04218 mg/kg/day. LADD was estimated to be 5.975 x 10⁻³ mg/kg/day for consumers at the high (95th) percentile, and BMDL10, MOE and CSF were calculated to be 0.21 mg/kg/day, 35, and 3.262 (mg/kg/day)⁻¹, respectively. Using above data, a lifetime cancer risk related to highest daily intake of acrylamide in foods for 70 years was estimated to be 0.01949. Although these results were calculated at a rather highly conservative condition, these estimates did represent a non-negligible magnitude of cancer risk associated with AA intake in Taiwan.

P.13 Yi, Carine; Tohoku University; carineyi@irides.tohoku.ac.jp

Thailand's granary faces risks of drought due to climate change

Global climate change, including increases in extreme weather such as heat waves, flooding, wildfires, and drought is frequently observed. Climate change impacts topography, land use, agriculture behavior, and eventually human population. Unlikely flood, drought is an extreme water, as well as heat, related disaster which the process is slow and gradually expands its affected areas, and leave impacts for long time on soil. However, it seems global drought hazard has been given lesser attention (than floods) throughout the world until California's drought occurred. Global climate requires a balance of precipitation, evaporation between earth surface, atmosphere, and ground water, as well as changes in agricultural practices, with no international boundary. Therefore, the disaster adaptation strategy is needed. In this study, northeast area in Thailand is selected, where reported crop productivity is low due to poor soil condition of the region, which is amplified due to unsustainable agricultural practices. Decreasing of precipitation and lack of water resources is also reported recently. Now, Thai people are facing risks of flood and drought at a more extreme level as the major disaster events. Furthermore, drought, changes not only river ways, but also ground water levels and land use (as a result of farmers reacting to changing seasons). To clarify the impacts of drought in the local area the precipitation and temperature changes, crop productivity changes by climate, changes in the global crop market price, and any change in crop export amount are needed to be interpreted. Increasing water demands by the population and economic growth, as well as water storage capacity in this drought-suffering areas – which rely on rainfall and traditional water management in personal/community level – will be studied for the long-term water and soil risk management.

M2-G.1 Yi, KD; Syngenta Crop Protection, LLC;
sue.yi@syngenta.com

Concepts of 'low dose' and non-monotonic dose response in toxicological research and regulatory science: Harmonization of terminology

There has been debate in the scientific communities around concepts of "low dose" effects and non-monotonic dose responses that may call into question the traditional role of dose-response assessments within the context of regulatory policies. In 2002 the NTP defined "low dose" as doses in the range of typical human exposures or doses below those tested in traditional toxicological assessments. However, in many cases the range of concentrations for those two definitions can vary by orders of magnitude. The potency of a chemical for an effect can also complicate the "low dose" range, especially in the context of estrogenic activities. Similarly, non-monotonic dose response can also be complicated by mechanistic changes in a biological system. Therefore, it is important to standardize and understand these terminologies across the various disciplines. Examples of naturally occurring estrogens will be presented to demonstrate the need for a harmonized understanding of these two terminologies.

P.51 Yin, MC*; Wu, TT; Chou, YJ; Chu, YR; Chan, WC; Tsan, YT; Ho, WC; Chu, CC; Chen, PC; China Medical University;
dream1221@hotmail.com

The effects of air pollution and statin use on the risk of stroke in diabetes mellitus patients after transient ischemic attack: a 5-year population-based cohort follow-up study

Stroke is a major worldwide public health issue. Air pollution related to cardiovascular diseases has been assessed. Statins are the widely used for hyperlipidemia by their cholesterol-lowering effect. Preclinical evidence has shown that statins can reduce the incidence of stroke in diabetes mellitus (DM) patients by their anti-inflammatory, antiproliferative, proapoptotic and anti-invasive effect. However, few studies investigate the effects of air pollution and statins use after transient ischemic attack (TIA) in Diabetics. The aim of this study was to investigate whether air pollution and statin use is associated with stroke incidence among diabetes mellitus patients who had TIA, especially focusing on the both potential critical period effects of before and after TIA. The study design was a retrospective cohort study. The medical records of subjects including stroke events and statins use were collected by Longitudinal Health Insurance Database 2000 (LHID2000). Air pollution was based on Taiwan Environmental Protection Administration high density air monitoring stations and assessed by geographical information system (GIS). Cox proportion hazard regression models were used. The results showed air pollution potentially increasing the risk of stroke for both exposure periods among DM patients who had TIA. Statins use might interact with air pollution on the risk. It is an important to assess stroke risk among DM patients who had TIA, and find out the role of air pollution and statins in the prevention/intervention strategies of stroke. Further study is promised.

P.60 Yin, H*; Xu, LY; Beijing Normal University;
yinhao@mail.bnu.edu.cn

PM2.5 related welfare loss in Beijing, China: health and psychological mood impacts

PM2.5 pollution blanketed most cities in China in recent years, which caused serious health impacts and numerous welfare losses. Some local governments started to implement the emission pricing regulations, including the pollution charges and "cap and trade". The reason for skepticism of such regulations is that there is limited study about how much welfare loss due to the PM2.5 pollution. This paper utilised contingent valuation (CV) method to elicit people's willingness to pay (WTP) to avoid the PM2.5 pollution and whether they support relevant policies. Additionally, people's mood impacts due to the invisibility caused by PM2.5 pollution was also considered in this study. The specific survey was conducted in Beijing, China to estimate the welfare loss due to PM2.5 in 2015. We conducted a face-to-face interview of 727 residents in Beijing applying stratified sampling method. The survey used payment card vehicle to elicit the respondents' WTP for PM2.5 pollution reduction to the second national limit (35 µg/m³). The results showed that 85% of respondents were willing to express their WTP for PM2.5 reduction and mood improvement. The whole WTP for health and mood improvement was US\$ 477 and US\$ 330 million for one year respectively. As expected, WTP increased with the income, education and understanding of PM2.5; and it was larger for men, smaller for aged people. However, there was no significant relationship between WTP and daily PM2.5 concentration, which indicates that the temporary PM2.5 pollution level influence little of people's WTP for pollution reduction. Welfare loss due to the PM2.5 pollution was around 807 million in 2015, which took around 0.22% of the regional GDP. The study results could provide scientific supports for the PM2.5 pollution compensation and tax system establishment in China.

P.140 Yong, AG*; Lemyre, L; Pinsent, C; Krewski, D; University of Ottawa; ayong089@uottawa.ca

Disaster preparedness and natural disasters in Canada: A mixed-method inquiry of Canadians' experiences

Urbanization, population growth and varied physical features in Canada have increased the risks of Canadians experiencing a significant loss from natural hazards. This highlights the need to increase disaster preparedness in Canada. In view of better risk communication and management, this study aimed to understand the Canadian public's natural disaster risk perception and preparedness responses, as well as the context and meaning in their decision-making using quantitative and qualitative methodology. We conducted a nationally representative survey on Canadian adults (N = 3,263) who reported their risk perception, preparedness behaviours and risk beliefs using 5-point Likert ratings. Then, semi-structured interviews on natural disaster risks and issues in Canada were conducted. Results showed the Canadian public's risk perception was moderate (M = 2.76, SD = 1.06). As well, their level of pre-disaster preparedness routine (e.g., emergency kit) remained low (M = 2.37, SD = 1.08). However, they were inclined to follow evacuation recommendations (M = 4.31, SD = .88) and were likely to have people to search for them post-disaster (M = 3.68, SD = 1.41). Linear regressions revealed the Canadian public's disaster preparedness was driven by three underlying risk belief systems: External Responsibility for Disaster Preparedness, Self-preparedness Responsibility, and Illusiveness of Preparedness. Interview findings showed the Canadian public's decision-making included: (a) downplaying the risk in Canada, (b) lack of urgency, knowledge and information in disaster preparedness, and (c) over confidence in the Canadian government to provide adequate care. Results suggest risk management and communication should focus on clarifying the responsibility of individuals, communities and government in disaster preparedness, as well as using context-based knowledge in public awareness and education programs. Theoretical and practical implications will be discussed.

P.191 Yu, C; Argonne National Laboratory; cyu@anl.gov
Background Radiation Dose and Cleanup Criteria

Throughout history, mankind has been exposed to radiation from many environmental sources, including cosmic rays, cosmogenic radionuclides, and primordial radionuclide decay products. In its Report No. 160 (2006), the National Council on Radiation Protection and Measurements (NCRP) stated that the U.S. population receives an effective dose of 6.2 mSv per person. Nearly all the dose resulted from ubiquitous background radiation (50%) and medical exposure (48%). The background radiation varies from location to location. For example, in Denver, Colorado, the background dose is about twice as high as in Chicago, Illinois. For radiation protection, both the NCRP and the International Commission on Radiological Protection recommend a dose constraint of 1 mSv/yr above background. This value has been adopted by the U.S. Department (DOE) and the U.S. Nuclear Regulatory Commission (NRC) and other organizations, including the International Atomic Energy Agency, as the dose limit for protection of the general public. For cleanup and release of radiologically contaminated sites, both DOE and NRC implement a dose criterion of 0.25 mSv/yr plus ALARA (As Low As Reasonably Achievable). Note that this criterion is a small fraction (~4%) of the background dose and well within the variation of the dose received by the average U.S. population. In this paper, we use the RESRAD-ONSITE code, which has the capability to calculate both dose and risk for radionuclides and to compare risks associated with background radiation and dose-based cleanup criteria. We also used the RESRAD-BUILD code in another example to illustrate the potential dose incurred while working in a building constructed with granite (such as the U.S. Capitol Building). Using the average radionuclide concentrations found in granite, the dose for an office worker is on the order of 1 mSv/yr, which is four times higher than the DOE or NRC dose constraint for release of property.

P.131 Yuko, A; Tokaigakuin University;
yadachi@tokaigakuin-u.ac.jp

Differences in Risk Perceptions about Medical Practices among General People and Health Professionals

Medical practices have brought many benefits to health and vigor of human beings. However, people often try to avoid medical practices if they can, since these practices also possess risks such as dread for the participant or future impact. This phenomenon can be viewed as a problem of risk perception. Different characteristics of risk perception have been obtained for various other types of hazards (e.g., traffic accidents, biotechnology, nuclear) in previous studies; for example, when nuclear waste started being recognized as a hazard, its risk perception increased, especially since this issue was considered unnatural and even immoral. Therefore, we expect that specific features will be observed for medical practices as well. Furthermore, grasping the differences in risk perception between lay people and medical experts will lead to better risk communication between medical staff and patients and smoother communication among the various medical professionals treating a patient together (i.e., team medical care). Additionally, risk perception is an important factor when accepting risks related to medical practices. Since many countries aim to improve their medical check-up rate, findings related to risk perception will also be helpful in achieving this goal. We examined the differences in the risk perception between medical experts (doctors, nurses, and pharmacists) and lay people who did not work as medical health professionals through a questionnaire. We surveyed 677 Japanese adults recruited via the Internet. We targeted 17 relatively well-known medical practices (e.g., protective vaccination, blood transfusion, X-ray test). After asking whether participants had heard of the medical practices or not (awareness exceeded 70%), we asked them questions about the risk dimensions of practices they were familiar with (e.g., old/new or fatal/not fatal). In this paper, we report the characteristics of risk perception for each group.

W4-J.5 Yuan, S*; Besley, JC; Michigan State University;
yuanshup@msu.edu

The Effects of Audience Knowledge and Risk Perception as Moderators for Risk Communication about Vaccine Safety

We have long passed the era when communication researchers believed that simply educating audiences with knowledge about risks will result in substantial behavioral change on most issues. Instead, communication style is an important element of communication strategy but little research has explored this topic in the context of risk communication. The current study aimed to examine the effect of one specific type of communication style - aggressive message - on individual's evaluation on the message quality and writer likability, with individual's expectancy violation of communicator's style (aggressive or not) as the mediator, based on expectancy violation theory. Moreover, we also included factors that influence audience differences - knowledge and risk perceptions as moderators, which were not considered by the existing theory. An online experiment was conducted with 689 parents. The results showed that individuals' expectancy violation was a significant mediator: aggressive message led to a higher level of expectancy violation, which resulted in a negative effect on perceived message quality and writer likability. Moreover, individual's level of knowledge had an interaction effect with aggressive condition on expectancy violation: The level of violation decreased significantly with the increase of knowledge on vaccination in aggressive condition. In other words, participants found the aggressive message more acceptable when they obtain a high level of knowledge on vaccines. Risk perception appeared to influence how they perceive expectancy violation, message quality, and writer likability, but did not have an interaction effect with aggressive condition. The findings yielded a novel way to understand the effect of aggressive communication in risk contexts, and provided an important complement to the theory by considering knowledge level as a moderator. Practically, the implications provide risk communicators more insights when talking with different audiences.

W3-G.4 Zabinski, J; MacDonald Gibson, J*; University of North Carolina at Chapel Hill; jackie.macdonald@unc.edu
Advancing dose-response models to incorporate genetic and epigenetic data: use of Bayesian belief networks

Dose-response functions currently used in assessing the health risks of human exposure to chemical pollutants in the environment in order to inform environmental regulatory decisions are based on methods that do not allow the incorporation of modern genetic and epigenetic data. Most existing dose-response functions are based on fitting regression models to studies of the responses of laboratory animals, typically mice or rats, to progressively increasing contaminant doses. Such models do not account for the increasingly large volume of data on the responses of the human genome to contaminant exposures. Bayesian belief networks (BBNs) could provide a powerful framework for incorporating such data, but little prior research has examined this possibility. To address this gap, we developed BBN-based models predicting two potential health responses from exposure to arsenic in drinking water: low birthweight at gestational age in newborn infants and diabetes status in adults. For both health outcomes, BBNs were fitted to exposure and health outcome data from the arsenic-endemic Zimapan and Lagunera regions of Mexico. The BBNs' performances in correctly classifying infant birthweight status (relatively small for gestational age or not) or adult diabetes status (diabetes present or not) were compared to those of models based on traditional regression approaches. The results show that BBNs offer a promising opportunity to advance regulatory risk assessment by incorporating modern genetic and epigenetic data.

M2-I.2 Zafonte, R.; Football Players Health Study at Harvard University; cdeubert@law.harvard.edu

What we do we know about the risks of playing in the NFL?

This presentation will discuss the current state of scientific knowledge concerning the risks of playing in the NFL. Considerable research has been performed and is underway concerning the incidence of certain medical conditions believed to be associated with or caused by playing in the NFL. This presentation will discuss the data and findings that have advanced our understanding of the risks of playing in the NFL, while also discussing those areas in need of additional research. In addition, the presentation will draw on and discuss the work of the Population Studies component of the Football Players Health Study, which entails research using questionnaires and testing to better understand player health status, wellness, and quality of life, including the largest ever cohort study of living former NFL players.

M3-I.1 Zahry, NR*; Besley, JC; Michigan State University; zahrynag@msu.edu

Genetic Engineering, Genetic Modification, or Agricultural Biotechnology: Does the Term Matter

The risk perception and communication literature appears to use terms such as genetic engineering (GE), genetic modification (GM), and agricultural biotechnology (agbiotech) almost interchangeably. The current research therefore aimed to compare the effect of these three terms. Key variables under investigation were consumers' perceptions of risk, benefits, control over technology, trust in information sources, affect, demand for labeling, support, and stated willingness to purchase. The study drew on the equivalency framing literature in conducting two question wording experiments that largely replicated the designs of two well-cited previous studies. The primary difference in the replication was that participants were randomly assigned to receive a version that uses one of the three different terms. Findings showed that the framing effect of food technology as either GE, GM or agbiotech did not influence respondents' perceived risk nor demand for labelling. That is, respondents perceived the three technologies as imposing similar risks and reported that food should be labeled irrespective of the technology framing. Nevertheless, framing food technology as 'agbiotech' and 'GE' were similarly associated with higher perceived benefits compared to GM. Yet, agbiotech was the only food technology that consumers supported its development relative to GE and GM. In light of these findings, while we saw few differences, it seems possible that framing food technology as "GM" may have the most negative effects and 'agbiotech' have the most positive effects. Further research is needed to examine the framing effect of food technologies across product categories (e.g., fresh produce vs. processed foods).

T2-G.3 Zelikoff, J; NYU Langone Medical Center; judith.zelikoff@nyumc.org

Central nerve system effects from exposure to e-cigarettes in rodents during pregnancy and early life

Electronic cigarettes, battery powered devices containing nicotine, glycerin, propylene glycol, flavoring and other substances, are increasing in popularity particularly among adolescents and young adults. Nicotine is a known neurotoxicant for the developing brain; hence the hypothesis that e-cigarette exposure during early life stages could induce changes in central nervous system (CNS) gene expression associated with adverse neurobiological outcomes. Pregnant C57BL/6 mice were exposed daily throughout gestation to whole-body aerosols without nicotine and to various doses of nicotine; after birth, pups and dams were exposed together to these aerosols throughout lactation (postnatal days 4-6). Frontal cortex recovered from one-month old male and female offspring were excised and analyzed for gene expression by RNA sequencing. Comparisons between the treatment groups revealed that e-cigarette constituents other than nicotine might be partly responsible for the observed biological effects. Transcriptome alterations in both sexes of offspring and treatment groups were all significantly associated with downstream adverse neurobiological outcomes. Behavioral studies performed on subsets of offspring of both sexes, allowed to mature into adulthood, demonstrated significant increases in activity. Moreover, exposure to nicotine-containing e-cigarette aerosols during pregnancy demonstrated a dramatic drop in adult murine sperm concentration and mobility. Overall, results from this research demonstrate that e-cigarette exposure during early life alters CNS development, potentially leading to chronic neuropathology and produces hyperactive behavior later in life. Ongoing studies are seeking to understand the observed effects, but this work suggests that a conservative approach to e-cigarette use during pregnancy in humans should be considered.

M4-C.4 Zhang, MX; MacKenzie, C*; Iowa State University; zmx428@gmail.com

Analyzing Different Decision-Making Methods for Situations with Deep Uncertainty

Making good risk-based decisions is especially difficult for situations with deep uncertainty that extend over time. Security and defense problems are especially prone to difficult uncertainties, and yet decision makers need to plan for several years or decades into the future. Traditional decision-making theories may be limited if probability distributions are difficult to ascertain. This presentation will compare different decision-making methods for a complex problem under the presence of long-term uncertainty. The decision-making methods are expected utility, robust decision making, information gap, and flexible strategies. The purpose of comparison is to find the differences in the results from each method and what the results mean for making good risk-based decisions.

P.61 Zhang, W; Zhen, G; Chen, L; Wang, H; Li, Y*; Ye, X; Tong, Y; Zhu, Y; Wang, X; East Tennessee State University; liy005@etsu.edu

Benefits of mercury controls for China and the neighboring countries in East Asia

Exposure to mercury poses significant risks to the health of humans and wildlife. Globally, coal-fired power plant (CFPP) is a major source of mercury emissions, with China being the largest contributor to global atmospheric mercury. As a signatory country of the Minamata Convention on Mercury, China is developing its National Implementation Plan on Mercury Control, which gives priority to control of mercury emissions from CFPPs. While social benefits play an important role in designing environmental policies in China, the potential public health and economic benefits of mercury control in the nation are not yet understood, mainly due to the scientific challenges to trace mercury's emissions-to-impacts path. Moreover, little is known about the potential benefits for the neighboring countries in East Asia resulted from China's mercury control. This study evaluates the health and economic benefits for China and neighboring countries in East Asia from mercury reductions from China's CFPPs. Four representative mercury control policy scenarios are analyzed, and the evaluation is explicitly conducted following the policies-to-impacts path under each policy scenario. We link a global atmospheric model to health impact assessment and economic valuation models to estimate economic gains for China and its three neighboring countries (Japan, South Korea and North Korea) from avoided mercury-related adverse health outcomes under the four emission control scenarios, and also take into account the key uncertainties in the policies-to-impacts path. Under the most stringent control scenario, the cumulative benefit of the mercury reduction by 2030 is projected to be \$430 billion for the four countries together (the 95% confidence interval is \$102-903 billion, in 2010 USD). Our findings suggest that although China is the biggest beneficiary of the mercury reduction in CFPPs, neighboring countries including Japan, South Korea and North Korea can also benefit (~7% of the total benefits) from China's mercury reduction.

P.67 Zhao, Y; Peking University; zhaoyan_pku@qq.com
Accidents risk assessment on China petroleum and chemical enterprises

With the development of social economy, China has become a large producer and consumer of petrochemical products in recent years. By the end of 2010, there were about 35,000 enterprises above state designated size in China's petroleum and chemical industrial. However, due to the weak capacity of safety management and the lack of prevention and control measures, environmental incidents and safety accidents took place frequently, which caused a significant threat to public health and environment. Faced with the possible losses of accidents, quantitative risk assessment and loss evaluation are needed for the sake of reasonable insurance expenses and security budgets. At the same time, risk analysis can show a basic framework on accident prediction and loss distribution simulation of petrochemical enterprises, and provide reference on related risk assessment model parameters. In view of these, this study assessed Chinese petrochemical enterprises' accident risk, measure and predict related accidents risk level and loss distribution in a nationwide scale by using probability risk model and geographical information system. As at present there is no relevant accidents database in China, this study framed a petrochemical accident information database, by means of retrieving China's petrochemical accident news during 2006-2015 through web crawlers, and combining with accident information that China State Administration of Work Safety and Ministry of Environmental Protection and their affiliates disclosed on website. In addition, according to China's administrative divisions and corresponding risk level, a risk map of Chinese petrochemical enterprises accidents were drawn. Based on the preliminary description of the spatial and temporal distribution of the accidents, over the past decade the number of overall petroleum and chemical-related incidents has declined, and both in the national and provincial scale, the regional distributions of accidents were quite uneven.

P.151 zhang, xiao; The University of Tokyo; blue2624@gmail.com
How GM issue has been told at Chinese newspapers? Comparative Analysis of National and Local Newspaper Coverage of GM issue in China, 2000--2014

Proper newspaper coverage of GM food issue is important in terms of the current GM industry dilemma in China. This study examined news coverage of GM issue published at 718 newspapers, one wire services and one news website from 2000 to 2014 in China. News articles at newspapers that public could access daily and easily could highlight the salience of GM issue in China and influence public perception. We examined GM articles in local and national newspapers in mainland China by applying content analyses methods, both quantitatively and qualitatively, including language aspects. Our data verified events-orientation trend again and we identified as many as 70 GM events since 2009. Furthermore, qualitative content analyses on unilateral (national or local coverage on the first day only) coverage of events indeed showed differences in terms of subjects, attitudes, and information sources. By comparing the number of GM articles in national and local newspapers, we found that in terms of volume, growth rate, frequency and improvement of frequency, local newspapers performed much better. The results of this study lead to the conclusion that GM issue has been a growing salient issue in Chinese newspaper coverage especially at local level. Although national newspapers still play an important leading and agenda-setting role in GM coverage, diverse information source and narrative forms and great potential indeed exist at local level. We were also able to observe interaction cycle consist of different national and local coverage which promoted development of coverage of event.

P.187 Zhao, Y; Peking University; zhaoyan2014@pku.edu.cn
Accidents risk assessment on China petroleum and chemical enterprises

With development of society and economy, China has become a large producer and consumer of petrochemical products in recent years. By the year of 2015, there were about 30000 enterprises above state designated size in China's petroleum and chemical industry. However, due to the weak capacity of safety management and the lack of prevention and control measures, environmental incidents and safety accidents took place frequently, which immediately threatened to public health and environment. For the sake of reasonable insurance expenses and security budgets, quantitative risk assessment and loss evaluation are needed confronting the possible losses of accidents. Further, risk analysis could provide a basic framework on accident prediction and loss distribution simulation of petrochemical enterprises, and provide reference on related risk assessment model parameters. In view of these, this study assesses accident risk in Chinese petrochemical enterprises using probability risk model. By retrieving China's petrochemical accident news during 2006-2015 through web crawlers, and combining with accident information that China State Administration of Work Safety and Ministry of Environmental Protection and their affiliates disclosed on website, this study framed a petrochemical accident information database, which contains 1509 accident records. The accident risk is analyzed by employing Bayesian theory for both frequency (Poisson) and severity distributions (Generalized Pareto). The result shows that there are significant differences in severity and frequency among provinces, where the highest petrochemical accident risk was found in provinces along China's eastern coastal where more extreme accidents is found. In addition, the accident time trends at province level is independent of accident risk level of that province.

W1-A.1 Zimmerman, R; New York University;
rae.zimmerman@nyu.edu

Reducing risk magnification in infrastructure failures

Technological failures affecting infrastructure services often originate from a chain of events, however, intervening at any one of numerous singular vulnerable points along the chain separately can dramatically reduce risks of widespread failure and their socioeconomic consequences. This paper focuses on isolating single points that could disrupt the chain. In some systems, e.g., non-redundant ones, only a single point may exist, whereas in other systems multiple points may exist and intercepting any one can stop the propagation. Case methods and statistical associations are used to identify and portray such points and their role in combination with others for representative critical infrastructure system accidents. These are illustrated for public transit, bridges, waterworks, and energy pipelines, including snowballing effects across socioeconomic systems, using extensive U.S. case archives from the late 20th and early 21st centuries. Single point examples are: dislodged or defective non-redundant bolts or connectors; usage practices exceeding bridge weight capacity limits; and inspection or detection technologies that miss vulnerable points because they are not designed to detect weak points or are defective. This approach expands possibilities for commonly used failure modeling by identifying difficult to detect singular phenomena from actual events. The single-point failure approach is also applied to interdependencies among infrastructures and the role of socioeconomic behavior. Once identified, vulnerable points are used to develop single intervention strategies to reduce failure risks without having to approach all vulnerable points at once. This approach can guide investment priorities, modeling, decision making, risk communication and develop lessons for infrastructure risks from other kinds of hazards, e.g., weather, climate, or geophysical whose effects on infrastructure often originate from vulnerable points similar to those related to accidents.

M3-A.4 Zorn, C*; Pant, R; Thacker, S; Shamseldin, AY; University of Auckland, University of Oxford, University of Oxford, University of Auckland; *czor847@aucklanduni.ac.nz*

Vulnerability of New Zealand transportation networks to disruptions in electricity supply.

Infrastructure networks are becoming increasingly interconnected where disruptions can rapidly propagate causing social and economic complications across national networks. With application to New Zealand, two such critical infrastructures with the potential to contribute to cascading failures are electricity and transportation networks. Applying a system-of-systems based methodology, this presentation examines the interactions between different levels of the electricity transmission and distribution networks with a range of transportation sector networks comprising: airports, ferry terminals, rail, and the major road network embedded within the petroleum distribution network. Nationally significant hotspots of highly co-located transportation infrastructures are compared to the actual dependence placed on each transportation network component. Mapping transportation dependencies on electricity transmission or distribution substation nodes allows disruptions to be traced throughout the networks and provide a criticality weighting to each of these nodes. Through separate transmission and distribution randomly ordered substation removals, different sectorial level vulnerabilities are exposed. Applying this model to the probable Alpine Fault (South Island) earthquake scenario initial damage is simulated based on known component fragilities, likely landslide locations. With expert elicited recovery strategies and empirically based recovery rates, the temporal change in disruptions is studied. Disruptions and re-routing of routine freight movements via sea, land, and rail are considered. To form a common metric between passenger transportation and freight disruptions, economic losses during the recovery phase are estimated through economic input output modelling. Overall, this presentation highlights wider network vulnerabilities which may not otherwise be apparent when assessing disaster risk and recovery based on discrete systems within regional or operational boundaries.

P.125 Zwickle, A*; Hamm, J; Farber, HB; Michigan State University and University of Massachusetts School of Law; *Zwicklea@msu.edu*
The Perceived Risks and Benefits of Drones and Their Various Uses

There are many different kinds of drones (Unmanned Aerial Vehicles) performing a wide variety of functions in our society today. Drones are a rapidly emerging technology whose growth has quickly outpaced the rules and regulation in place to govern their use. They are currently being used for recreational, research, civic, commercial, and military purposes and present benefits and risks at the individual, community, and national level. In this presentation we present findings from a recent survey measuring the public's perception of those risks and benefits, their trust in drone operators and regulators, and support for possible policies regulating the use of different types of drones. This research expands upon a recent survey conducted in Australia (Clothier et al., 2015) enabling us to make some cross-cultural comparisons. Our findings reveal that while the public is concerned about the threats that drones pose to both our privacy and safety, they are split on what their mental image of what a "drone" actually is. In fact, the term used to refer to drones has an impact on the American public's attitudes towards them (as found in Australia). Furthermore, the level of concern regarding privacy and safety differ depending on what type of drone is under consideration, and for what purpose it is to be used for. Respondents were generally undecided whether they would support a total ban on drones, but that level of support differed based on the type and use of specific drones. Their affective response towards drones was generally positive, but also varied significantly across drone type and use. As is common with emerging technologies respondents demonstrated the affect heuristic thru a negative correlation between perceived risks and benefits regardless of the kind of drone or its intended use. Overall, our survey showed a public that feels positive about drone technology while at the same time is wary of certain ways in which they can be employed.