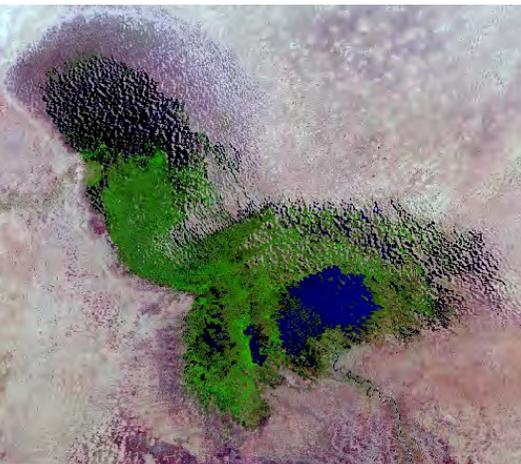


Purdue Climate Change Research Center

# 2015 ANNUAL REPORT



The **Purdue Climate Change Research Center** (PCCRC) is a faculty-led, university-based research center on the campus of Purdue University serving to increase scientific and public understanding of the causes and impacts of climate change through fundamental research and effective learning and engagement.

The PCCRC receives financial support from Purdue's Colleges of Agriculture, Engineering, and Science, and the Office of the Executive Vice President for Research and Partnerships.

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**Cover photographs:** **LEFT:** A composite satellite photo showing the maximal water extent for Lake Chad in 2013 where, blue and black are open water, green is inundated vegetation, and dark grey is former lake bed; **MIDDLE:** Ph.D. student Laura Ploughe, Biological Sciences, measures soil moisture in one of her precipitation manipulation experiments at the Purdue Wildlife Area. Rainout shelters are used to remove varying amounts of precipitation from the experimental plots. **RIGHT:** Kimberly R. Marion Suiseeya, an assistant professor of political science; Sarah Huang, a graduate student in cultural anthropology; Laura Zanotti, an associate professor of anthropology; Scott Benzing, an undergraduate student in natural resources planning and decision making; Elizabeth Wulbrecht, a graduate student in political science; Suraya Williams, an undergraduate student in ecology, evolution, and environmental biology; and Fernando Tormos, a doctoral degree candidate in political science, at the Paris Climate Summit, COP21.

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Jeffrey S. Dukes  
Professor and Director

## Message from the Director

For climate change science and policy, 2015 brought new developments, both exciting and sobering—and PCCRC members were there, helping to shape and record this history. Global temperatures set a new record high, with contributions from the developing El Niño and record-high greenhouse gas emission levels. Diplomats in Paris outlined a new international agreement that is likely to bring wider participation, and potential for greater impact, than any of the previously negotiated pacts. Researchers around the world continued to study and identify ways to mitigate and adapt to the changing climate. The breadth and ambition of these global efforts was mirrored at Purdue, in the academic efforts of our 60+ faculty affiliates and their students and employees.

The number of faculty, staff, and students affiliated with the PCCRC grew markedly in 2015; I encourage you to get acquainted with our newest affiliates (pages 4-5), and read about our newly formed Graduate/Post-Doc group (page 31).

As you will read throughout the pages of this report, members of the PCCRC spent 2015 working to understand and model past and future changes in climate, and to prepare our society for the future. We were proud to see several of our members receive broad recognition for their efforts; some of their honors are detailed on the following page. Among these was the prestigious “Partnership Award for Mission Integration” from the U.S. Department of Agriculture to the U2U project.

(This project was covered in detail in our 2014 annual report, and their latest decision support tool is briefly covered here on page 10).

December’s climate change meeting in Paris attracted diplomats and activists from around the world, as well as researchers eager to inform or study this global negotiation process. Several of those researchers came from Purdue, with support from the PCCRC. Professors Laura Zanotti and Kimberly Marion-Suiseeya brought a group of students, and the team fanned out across the meeting activities to try to understand how and whether the policy positions of indigenous peoples affected negotiations and became implemented in the final agreement. You can read about this “Presence to Influence” project on page 19.

To more directly address the challenges of climate change at home, the PCCRC in 2015 hired Melissa Widhalm (also project manager of the U2U project) to manage a new effort: the Indiana Climate Change Impacts Assessment (IN CCIA). This PCCRC-led activity will bring together stakeholders and researchers from around the state to assess the challenges for Indiana related to climate change, and to highlight potential solutions. The IN CCIA will involve many PCCRC members in its activities during 2016, facilitating contacts among stakeholders and researchers around the state. For more information, and to sign up for email updates, see page 26-27.

Thanks for your interest in the PCCRC, and we hope you enjoy the report.

## AWARDS & HONORS

**Sylvie Brouder**, *Department of Agronomy*, has been appointed to the U.S. Environmental Protection Agency's Science Advisory Board. She will serve on the board through September 2017.

**Indrajeet Chaubey**, *Department of Earth, Atmospheric and Planetary Sciences and Department of Agricultural and Biological Engineering*, was awarded the 2015 ADS/Hancor Soil and Water Engineering Award at the ASABE Annual International Meeting for his accomplishments and contributions in the development of knowledge to improve watershed management and in educating and mentoring young professionals.

PCCRC director **Jeff Dukes**, *Department of Forestry & Natural Resources and Department of Biological Sciences*, was named a 2016-2107 public engagement fellow by the American Association for the Advancement of Science. Jeff will join 14 other climate change researchers as the first cohort of the Alan I. Leshner Leadership Institute for Public Engagement with Science.

The U2U Project Team, led by **Linda Prokopy**, *Department of Forestry & Natural Resources*, enjoyed national recognition with a National Institute of Food and Agriculture Partnership Award for Mission Integration. The award honors work aligned with NIFA strategic goals that support the mission of the U.S. Department of Agriculture. The U2U Team was also awarded the 2015 Purdue College of Agriculture TEAM Award, an acronym for Together Everyone Achieves More, is given annually to a Purdue team of professionals for their interdisciplinary achievements.

**Wally Tyner**, *Department of Agricultural Economics*, was awarded the 2015 Morrill Award for outstanding career achievements in all three land-grant missions: learning, discovery and engagement. Prof. Tyner also received international recognition as an Honorary Life Member of the International Association of Agricultural Economists.

## PCCRC FACULTY & STAFF

**Aeronautics & Astronautics:** James Garrison

**Agronomy:** Laura Bowling, Sylvie Brouder, Melba Crawford<sup>1</sup>, Richard Grant, Cliff Johnston, Dev Niyogi<sup>2</sup>, Ronald Turco, and Jeffrey Volenec

**Agricultural & Biological Engineering:** Indrajeet Chaubey<sup>2</sup>, Keith Cherkauer, Jane Frankenberger, Margaret Gitau, and Sweta Singh

**Agricultural Economics:** Otto Doering, Alla Golub, Benjamin Gramig, Thomas Hertel, Jacob Ricker-Gilbert, Juan Sesmero, Gerald (Jerry) Shively, Wally Tyner, and Dominique van der Mensbrughe

**Anthropology:** Jennifer Johnson and Laura Zanotti

**Building & Construction Management:** Kirk Alter

**Chemistry:** Paul Shepson<sup>2</sup>

**Civil Engineering:** Larry Nies, Suresh Rao<sup>4</sup>, Amisha Shah, Cary Troy, David Yu<sup>8</sup>

**Curriculum and Instruction:** Dan Shepardson<sup>2</sup>

**Earth, Atmospheric and Planetary Sciences:** Ernest Agee, Michael Baldwin, Timothy Filley, Alexander Gluhovsky<sup>3</sup>, Jon Harbor, Harshvardhan, Matthew Huber, Nathaniel (Nat) Lifton, Greg Michalski, Wen-wen Tung, Lisa Welp, Yutian Wu, and Qianlai Zhuang<sup>4</sup>

**Economics:** Timothy Cason

**English:** Robert Marzec

**Forestry and Natural Resources:** Jeffrey Dukes<sup>5</sup>, Songlin Fei, Reuben Goforth, Douglass Jacobs, Rick Meilan, Bryan Pijanowski, Linda Prokopy, Guofan Shao, and Robert Swihart

**Health & Human Sciences:** Jonathan Day, Jennifer Freeman and James McGlothlin

**Industrial Engineering:** Roshi Nateghi

**Mechanical Engineering:** Jay Gore

**Political Science:** Kimberly Marion-Suiseeya, Leigh Raymond, and Mark Tilton

**Statistics:** Frederi Viens<sup>7</sup> and Hao Zhang<sup>6</sup>

**Technology Leadership and Innovation:** Brett Crawford

**Visual and Performing Arts:** Charles Gick

**Executive Committee:** Michael Baldwin, Laura Bowling, Otto Doering, James Garrison, Kimberly Marion-Suiseeya, Linda Prokopy, Laura Zanotti, and Qianlai Zhuang

### Administrative Staff

Jeffrey Dukes, Director

Cindy Fate, Administrative Assistant

Rose Filley, Managing Director

Melissa Widhalm, Operations Manager

<sup>1</sup>joint appointment in Civil Engineering; <sup>2</sup>joint appointment in Earth, Atmospheric and Planetary Sciences; <sup>3</sup>joint appointment in Statistics; <sup>4</sup> joint appointment in Agronomy; <sup>5</sup>joint appointment in Biological Sciences; <sup>6</sup>joint appointment in Forestry & Natural Resources; <sup>7</sup>joint appointment in Mathematics; <sup>8</sup>joint appointment in Political Science.

## Meet Our Newest Faculty Affiliates



Brett Crawford is an assistant professor in the Department of Technology Leadership and Innovation. His research explores the relationship between climate change and organizations, that is how climate change shapes the actorhood of organizations, as well as how organizations shape and reshape meaning linked to climate change. His current research explores what professional work addressing climate change looks like in practice; how images serve as time capsules for organizational identity and a growing rationality of the anthropocene; and how a heightened rationality of environmental issues on the part of organizations has shifted the identity of corporate actors.



Charles Gick is a professor of Fine Arts in the Patti & Rusty Rueff School of Visual and Performing Arts. An interdisciplinary artist, combining video, performance, painting, photography and assemblage. Current work focuses on humankind's use of the poetics of art to confront and examine our often tenuous, physical, intellectual, and emotional relationships with art, nature and time.



Margaret Gitau is an assistant professor in the Department of Agricultural and Biological Engineering. Her research area is water resources and ecohydrologic engineering, including, for example, hydrologic and water quality modeling; fate and transport of critical contaminants; understanding of the associated ecological responses; trends and impacts of land use, land management and climate on water resources; sustainable water resources management; and the development of computer and internet-based applications.



Douglass Jacobs, is a professor in the Department of Forestry and Natural Resources. His research deals with ecophysiological development of forest regeneration in response to environmental stress and management. This knowledge is used to facilitate reforestation and ecological restoration. His interdisciplinary work seeks to answer questions about how alternative management strategies and climate scenarios affect forest productivity, carbon and nutrient cycling, and ecological resilience.



Jennifer Lee Johnson is an assistant professor of Anthropology. Her research focuses on gender, [il]legality, sustainability, and environmental and social change as they relate to local, regional, and global fisheries markets in Africa. She has conducted long-term ethnographic research with policy-makers, fisheries managers, and fishworkers in Uganda, Kenya, and Tanzania since 2007. She has worked professionally on fisheries issues for the Marine Fish Conservation Network, the National Oceanic and Atmospheric Administration, and the Blue Ocean Institute.



Richard "Rick" Meilan is a professor in the Department of Forestry and Natural Resources. In his laboratory, Rick uses molecular tools to investigate the genetic mechanisms by which key aspects of tree growth and development are controlled. He is also attempting to domesticate and add value to various tree species by genetically engineering them to express genes that impart environmentally beneficial and commercially important traits. Active research projects include efforts to insert genes that control flowering, as a means of transgene confinement; insect (Emerald Ash Borer) resistance; herbicide tolerance; and lignin composition.



Roshi Nateghi is an assistant professor with joint appointments in the School of Industrial Engineering and Division of Environmental and Ecological Engineering. Her areas of focus include modeling sustainability and resilience of energy infrastructure systems, and performance analysis of critical infrastructures under climate change. Her research has been published in the journals of Risk Analysis, Climatic Change, Natural Hazards and IEEE Access.



Dominique van der Mensbrugge is a research professor in the Department of Agricultural Economics and Director of the Center for Global Trade Analysis (GTAP). He specializes in analyzing economic policies of a global nature such as multilateral trade agreements and climate change. His work on climate change has focused on the nature and cost of carbon regimes—carbon tax versus cap and trade, size and composition of country coalitions, ambitious versus sub-optimal climate targets and the role of the cost and availability of ‘clean’ technologies. His more recent work has included looking at the ‘damage’ side of climate change, particularly on agriculture, and assessing the economic tradeoffs between carbon taxes and lower climate damage. His analysis relies on the development and use of a so-called integrated assessment model that integrates economics, greenhouse gas emissions, climate and damages in a coherent modeling framework.



Lisa Welp is an assistant professor in the Department of Earth, Atmospheric and Planetary Sciences. She studies the exchange of both water and carbon between the land biosphere and the atmosphere. Grand challenge research questions motivating her work include: What is the tradeoff between CO<sub>2</sub> and water in a changing climate? How can we detect and predict decadal-scale ecosystem changes? How do vegetation changes affect CO<sub>2</sub> and water fluxes? What are the consequences for global and regional climate? Overall, her research aims to improve predictions of future vegetation-climate interactions.



David Yu is an assistant professor with a joint appointment in the Departments of Civil Engineering and Political Science. His research centers on the resilience of partly-engineered social-ecological systems or coupled natural and human systems to unexpected, emergent shocks, and how biophysical and institutional factors interact to shape the dynamics of such coupled systems. He examines these interactions to understand the conditions for building resilient communities in the face of global change.



Laura Zanotti is an environmental anthropologist and interdisciplinary social scientist who partners with communities to examine how local, mostly rural, livelihoods and well-being can be sustained and to identify the pathways that shape just futures. An associate professor in the Department of Anthropology, Laura uses a feminist political ecology framework to map out spatial inequalities and injustices experienced by resource-dependent communities and highlight local creativity in the context of acute change. She also works with communities to examine their experience of climate change as well as identify ways in which global environmental governance regimes can address livelihood goals. With Dr. Kimberley Marion Suiseeya, she co-leads the Presence to Influence project, which seeks to identify and examine the ways in which marginalized and underrepresented groups effectively influence governance processes that directly impact their ways of living—for more about the project, see: [www.presence2influence.org](http://www.presence2influence.org).



## AT THE TOP OF THE WORLD

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The area covered by Arctic sea ice is declining rapidly. This downward trend has multiple consequences that include the loss of habitat for species like polar bears and threats to the livelihoods of indigenous communities. Less visible effects include the loss of albedo (a measure of how well the sea ice reflects sunlight) which warms the region even more, increased water vapor and cloud cover (both potent warming agents), changes to the circulation patterns in the atmosphere, and release of methane (another powerful greenhouse gas) from the permafrost. In early 2016, Professor and PCCRC founding director Paul Shepson and graduate student Angela Raso will be in Barrow, Alaska to continue their work documenting and evaluating the region's changing atmospheric chemistry. Follow their progress from Angela's blog: <http://snowkidding.blogspot.com>

## RESEARCH BRIEFS



### Will Global Change Jeopardize the US Forest Carbon Sink?

For the past 50 years forests in the United States have been a net carbon sink—absorbing more carbon than they release. This sequestration of carbon in forests has provided important benefits for the global climate system and for the United States, offsetting an estimated 10-15% of annual gross U.S. greenhouse gas (GHG) emissions.

Recent projections from the U.S. Forest Service, however, suggest that the ability of the nation's forests to sequester carbon may diminish over the coming decades, in part due to the impacts of climate change, including increasing temperatures and changes in the frequency and intensity of disturbances like forest fires, pest infestations, and severe storms. At the same time, climate change impacts on agricultural crop yields may in turn further impact forests through cropland area expansion.

Important drivers of change include technological progress in agriculture, biofuel production, the future state of the climate and its impacts on agriculture and forestry, all of which are uncertain. As the U.S. looks for climate change strategies and policies for reducing GHGs, a better understanding of these drivers and their interactions is essential.

With funding from the USDA/AFRI, Professor Tomas Hertel and Alla Golub, *Agricultural Economics*, along with collaborators Brent Sohngen, *Ohio State University*, and Yongyang Cai and Ken Judd, *Stanford University Hoover Institution*, will advance understanding of the impacts of climate change, technological progress in agriculture, and production of biofuels on U.S. forest carbon sequestration. Their analysis will factor in the stochastic nature of these drivers and their potential impacts, the global scope of changes, the irreversibility of decisions, and the degree of risk aversion in decision making.

# Interactions of Clouds with Smoke Particles from Fires Burning in Southern Africa

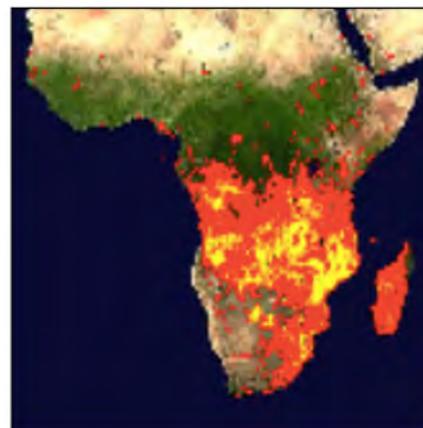
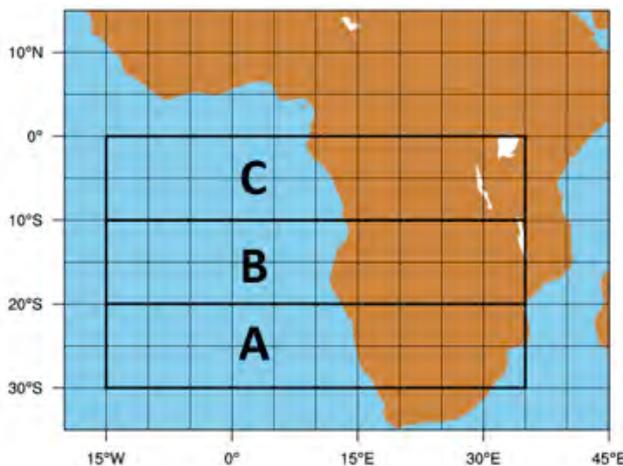
The lack of understanding of aerosol-cloud interactions has been recognized in the scientific community as the largest uncertainty in estimates of the Earth's changing energy budget. In the context of these interactions, the unique situation in the South East (SE) Atlantic arising due to seasonal burning (July-October) of agricultural residue in the southwestern African savannah merits special attention—this region is the world's largest source of biomass-burning aerosols.

A significant portion of the dense, smoky aerosol layer originating from the continent moves westward towards the ocean and initially overlies vast stretches of subtropical stratocumulus cloud decks. However, farther offshore, as the marine boundary layer thickens, it gets mixed into the clouds. Thus, during the course of this transport, aerosol-cloud interactions include changes to aerosol-induced solar heating and microphysical effects.

To improve our predictions of future changes to the Earth's climate system, we must better understand aerosol-cloud interactions in this important region. Professor Harshvardhan and graduate student Sampa Das, *Earth, Atmospheric, and Planetary Sciences*, are analyzing the interactions of smoke particles with clouds

by comparing simulations of the vertical distribution of smoke-aerosol extinction (a fundamental aerosol property) from several chemical transport models including the Goddard Chemistry Aerosol Radiation and Transport (GOCART) and the Community Atmosphere Model (CAM) with observations from the Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP) sensor onboard the CALIPSO satellite. The larger domain of interest—southern Africa—was divided into smaller subsets. Simulated transport features could be further differentiated for sub-regions about 10 degrees of latitude apart (figure, below), starting from the southern end of the domain at 30° S.

The major burning areas for region A (20°S-30°S), for example, are situated along the east coast of the continent (see figure below). Aerosols emitted during this burning get convected to elevated levels prior to reaching the west coast due to strong upward motion over the land. However, only a small fraction of the total emitted aerosols continue the westward transport and a larger fraction escapes towards the southeast direction. CAM and GOCART both simulate the east coast burning at the same place as CALIOP. However, the transport off the west coast and further into the ocean is slightly different for the two models, with GOCART aerosols subsiding to lower levels as they reach the land/ocean boundary. This on-going research is helping to improve our understanding of cloud-aerosol interactions and how those interactions affect the Earth's climate.



LEFT: The domain is divided into three sub-regions. A: 20°S-30°S, B: 10°S-20°S and C: 0°-10°S to study the individual transport features of the smoke particles. RIGHT: the location of fires detected by MODIS satellite instrument (28 Aug- 06Sep '08), representative of the typical burning pattern for the entire season of August-October. The color ranges from red where the fire count number is low to yellow where the number of fires is large.

## Growing Biofuels: Impacts on Key Ecosystem Services

The production of bioenergy is being encouraged as a pathway towards a more sustainable future. Perennial grasses such as Miscanthus and switchgrass are among the most promising long-term biofuel feedstock sources considered for production in the U.S. These renewable energy resources are expected to lessen dependence on fossil-derived fuels, decrease carbon emissions, and they hold the potential to improve water quality in nearby waterways and beyond.

Establishing, managing, and harvesting these crops are similar to those for any traditional perennial crop, however, the impact of growing these crops for biofuel production must be considered within the context of the food-energy-water nexus, and a changing climate. Complexities to consider include how biofuels might compete with food production, lead to deforestation, and strain increasingly limited water resources.

Professor Indrajeet Chaubey, *Earth, Atmospheric, and Planetary Sciences*, is leading an interdisciplinary team,

funded by the Department of Energy, to quantify the potential impacts of various future bioenergy production systems on key ecosystem services under current and projected future climate scenarios in the Midwest U.S. The team uses the Soil and Water Assessment Tool (SWAT) in this project, and has incorporated improvements to the plant model component of the model to better simulate crop growth with the addition of evidence-based growth parameters.

Early results indicate that bioenergy production offers improved ecosystem services compared to the baseline cropping systems of corn-soybeans. A comparison across various different bioenergy production scenarios shows that key ecosystem services related to fresh water availability, food and fuel provision, erosion regulation, and flood control varied as a function of changes in land use and land management. The findings also indicate that these improvements in ecosystem services are generally maintained even as the climate changes.

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## New Decision Support Tool Helps Farmers Manage Nitrogen

The Corn Split N decision support tool, the latest tool from the U2U project, is designed to help farmers and farm advisors understand the risks and benefits of using a post-planting nitrogen (N) application strategy for corn production. Professor Ben Gramig, *Agricultural Economics*, played a major role in developing this tool which combines historical weather and fieldwork data with economic considerations to determine the feasibility and profitability of completing a second (split) N application within a user-specified time period. Farmers in Illinois, Iowa, Indiana, Missouri, Kansas, Wisconsin, Minnesota, South Dakota, North Dakota, Nebraska, Ohio and Michigan can get customized results based on their

planting and fertilization schedule, local costs and available equipment.

The tool also has a summarized fieldwork table and crop calendar so farmers can see how schedule adjustments might affect their ability to fertilize on time. Accumulations of growing degree days, or GDDs, and associated corn growth beyond the current day are estimated based on the historical 30-year average GDD accumulation for a user-selected location. The Corn Split NDST is available online at [SplitN.AgClimate4U.org](http://SplitN.AgClimate4U.org).



## Building a Global Perspective on Drought

Under climate change, precipitation regimes are expected to shift, with the climates of some regions becoming drier and others becoming wetter. At the same time, the precipitation arriving in a given region is expected to come in fewer, larger events. This suggests that, even in areas of the planet that will become wetter, intervals between precipitation events will get longer. This, along with the warmer temperatures, is expected to produce more extreme regional droughts.

To better understand the potential implications of more extreme drought around the world, an international network called Drought-Net was started in 2014. Among this network's activities is the development of the International Drought Experiment (IDE). This "coordinated distributed experiment" will use a simple methodology to impose the equivalent of a local 100-year drought at each of dozens of sites around the world, and study the resilience of ecosystems in different regions. Professor Jeffrey Dukes, *Forestry and*

*Natural Resources and Biological Sciences*, serves on the Drought-Net steering committee and his laboratory has started an IDE site at the Purdue Wildlife Area (PWA), located nine miles west of campus.

In Dukes's laboratory, Ph.D. student Laura Ploughe, *Biological Sciences*, has focused her research on drought responses and led the installation of the IDE site in 2015. At the same time, she has developed additional experiments that manipulate precipitation at the PWA. Her work ultimately seeks to link changes in soil moisture and nutrient cycling with changes in plant growth and species composition in prairie and forest understory. With three experiments underway, and more to come, many new insights about the local effects of drought and their relationship to the sensitivities of other ecosystems and regions are sure to follow.

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BELOW: Ph.D. student Laura Ploughe, *Biological Sciences*, measures soil moisture in one of her precipitation manipulation experiments at the Purdue Wildlife Area. Rainout shelters are used to remove varying amounts of precipitation from the experimental plots.



## What Can Shrinking Ice Caps Tell Us About Climate Change?

Professor Nat Lifton, *Earth, Atmospheric and Planetary Sciences*, graduate student (and 2012 PCCRC Fellow) Casey Beel, and collaborators from the University of Colorado and the University of Buffalo are studying Holocene records of the fluctuations of small ice caps in eastern Baffin Island and western Greenland. The ultimate goal of their research, funded by the National Science Foundation, is to evaluate whether currently observed Arctic warming is outside the range of long-term natural variability.

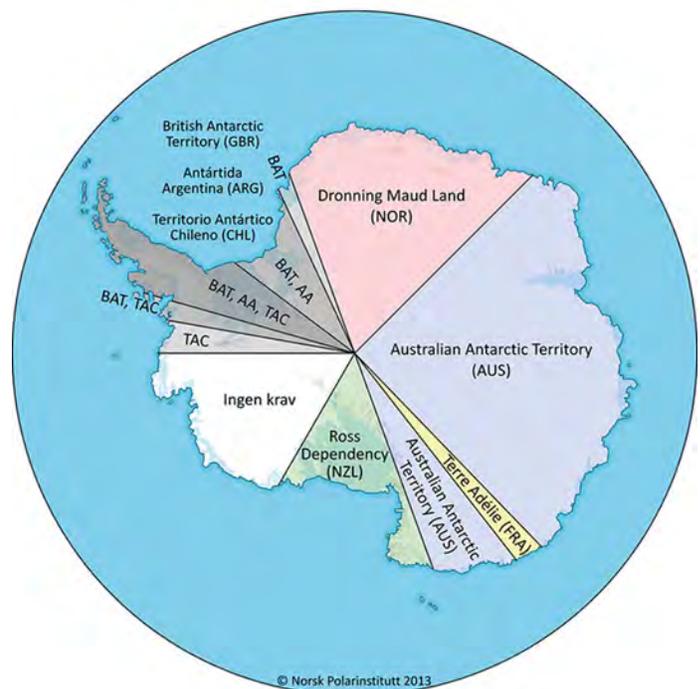
This goal will be addressed with the powerful datasets derived from radiocarbon-dated vegetation preserved beneath cold-based ice caps for centuries to millennia, but now being exposed annually by current ice-margin retreat across northeastern Canada and West Greenland. These chronologies define the pattern and timing of abrupt summer coolings in the recent past and place current warming in a millennial context.  $^{14}\text{C}$  dating of vegetation will be complemented by measuring in situ cosmogenic  $^{14}\text{C}$  inventories in recently exposed rock surfaces, providing essential time constraints on the duration of

ice-covered and ice-free conditions throughout the Holocene.

The team is also using the longer-lived in situ cosmogenic  $^{10}\text{Be}$  and  $^{26}\text{Al}$  pair to assess exposure and cover histories under cold-based ice (ice that is frozen to the bedrock all year round) at longer (i.e., glacial-interglacial) time scales. Early results for  $^{10}\text{Be}/^{26}\text{Al}$  from several deeply weathered high plateau surfaces in western Greenland indicate only minor ice cover over the last 1-2 glacial cycles, while  $^{10}\text{Be}/^{26}\text{Al}$  results from several other ice cap margins in the area indicate long periods of burial by cold-based ice, a more typical Arctic pattern both elsewhere in western Greenland and on Baffin Island. The team suggests that these surprising results are due to differences in the marine- or land-terminating nature of adjacent fjord glaciers and corresponding differences in basal shear stress. A reduction in shear stress at the terrestrial-marine boundary would be expected to cause a lowering of the ice surface profile down-fjord, thus potentially enabling adjacent high-altitude plateaus to remain exposed while surrounded by glacial ice. Results of this latter study comprise the bulk of Beel's M.S. thesis. Work on corresponding in situ  $^{14}\text{C}$  samples is ongoing.

## Mapping/Measuring/Modeling Antarctic Geomorphology and Ice Change

Professors Jon Harbor and Nat Lifton, *Earth, Atmospheric and Planetary Sciences*, have received funding from the National Science Foundation to build an international collaboration focused on reconstructing the long-term pattern and timing of vertical changes in ice-surface elevation across key transects of Dronning Maud Land in the East Antarctic Ice Sheet. These reconstructions will serve as the basis for constraining numerical models of ice sheet behavior. Field sites are nunataks (mountains that extend above current and former ice levels and that can be used as 'dipsticks' to reconstruct changes in ice elevation), and past ice elevation will be determined by field mapping combined with cosmogenic nuclide dating of glacial landforms. Initial field work is planned for Winter 2016/2017.





## Arctic Warming Also Impacts Midlatitude Weather and Climate

The Arctic is warming faster than the rest of the globe; this phenomenon is generally referred to as “Arctic amplification.” There is increasing evidence that Arctic amplification might strongly impact both weather and climate, not only in the Arctic region, but also in regions farther away, such as the Northern Hemisphere midlatitudes. A recent study by Professor Yutian Wu, *Earth, Atmospheric and Planetary Sciences* and Dr. Karen Smith (Lamont-Doherty Earth Observatory, Columbia University) looked at the impacts of Arctic warming on the Northern Hemisphere midlatitude circulation pattern using a simple atmospheric general circulation model.

They found that, as a result of Arctic warming, the midlatitude tropospheric jet stream shifts toward the equator and the stratospheric polar vortex becomes weaker. Wu and Smith also conducted experiments to further explore the role of the stratosphere-troposphere

coupling, or the stratospheric pathway, in linking the Arctic warming to the midlatitude circulation. They found that the Arctic warming could excite more planetary-scale waves to propagate upward into the stratosphere and weaken the stratospheric polar vortex. This signal in the stratosphere could further migrate downward back into the troposphere and the surface and modulate the tropospheric jet stream.

Their study, published in *Journal of Climate*, demonstrates, for the first time, that the stratospheric pathway plays a significant role in linking the Arctic warming to the Northern Hemisphere midlatitude circulation. Many of the currently used climate models, however, utilize a “low-top” atmospheric model with a poorly resolved stratosphere. The findings suggest that use of “high-top” models which have a fully resolved stratosphere with a model top above the stratopause is necessary to fully simulate how atmospheric circulation responds to climate change.

# AFRICA'S GREAT OASIS: the Changing Environments of Lake Chad

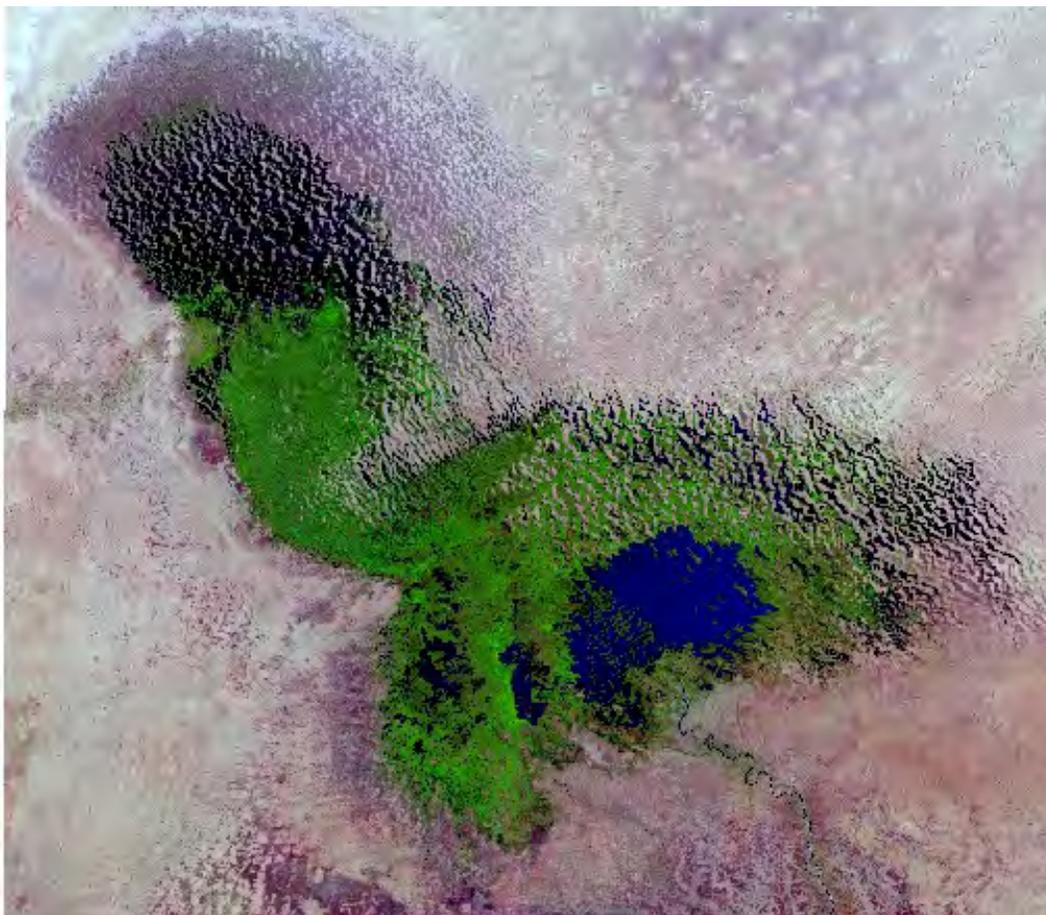
Spanning the borders of Chad, Cameroon, Nigeria, and Niger, Lake Chad and its basin are an important economic and environmental area for all four countries, providing freshwater for irrigation, arable and grazing lands, and fish stocks. Since the late 1960s, however, the size of the lake has seen dramatic variations, including during the great Sahel droughts of the 1970s and 1980s. Many in political circles are pointing to climate change as the cause of the droughts and lake-level fluctuations, which have had dramatic impacts on the millions of people relying on the lake's waters for their livelihood, in this poorest of regions of the globe. Others blame overuse of water for agriculture within the basin, poor enforcement of environmental legislation, and difficulties with water resources management of this trans-national water system.

In an effort to better understand the changes, Professors Frederi Viens, *Statistics*, Otto Doering, *Agricultural Economics*, undergraduate student researchers Kexin Nie, Mikaela Meyer, and Brain Kidd, along with collaborators Jacques Lemoalle (IRD, Montpellier, France), C.J. Johnston (Marian

University), and Molly Brown (University of Maryland) are gathering data and using Bayesian modeling to determine the key factors influencing the hydrology of Lake Chad.

Lake Chad is now understood to have entered a new regime described by hydrologist Lemoalle as "small lake Chad," in which its three sub-pools (North, South, and Archipelago) communicate yearly during the wet season only. The composite satellite photo below shows the maximal water extent for Lake Chad in 2013 and the three sub-pools (blue and black are open water, green is inundated vegetation, dark grey is former lake bed). The team's goal in this next year is to complete the work on what drives the lake's changes and quantify the value of ecosystem services provided by Lake Chad as a function of how much water is in the lake over a hydrological year.

The map on the facing page, reproduced from a 2014 publication by Lemoalle, shows the variety of activities around Lake Chad. One notes in particular that the north pool activities are described as "miscellaneous," because the environment changes so unpredictably. The team will build on Lemoalle's



groundbreaking hydrological study (Lemoalle, J.; Bader, J.-C.; and Leblanc, M. (2011) *Modèle hydrologique du Lac Tchad*, Hydrological Sciences Journal, 56:3, 411-425), providing validation of key parameters and an evaluation of uncertainty in their hydrologic model. The team has also recently partnered with Purdue anthropologist Professor Jennifer Johnson, an Africanist, to better explore the influence of the historical and current practices in the region.

Preliminary Bayesian analyses over a 40-year period show that the major external factor influencing lake volume is regional rainfall. The analysis also shows that most agricultural activities in the larger Lake Chad basin do not seem to have an adverse influence on the lake's volume, but those activities closest to the lake do, particularly those taking water away from the North pool (e.g. from irrigation projects along the Komadugu Yobe river system in Nigeria's Yobe state, and along the shores of the lake itself in Borno state). It has proven difficult to obtain reliable data on the various factors influencing Lake Chad over the entire Lake Chad Basin given its multi-national geography.

In the summer of 2015, Viens and Johnston, assisted by undergraduate Brian Kidd, traveled to colonial archives in Paris and London (the colonial powers before 1960) to find documentation that the lake level saw great variations in amplitude and number since the first Europeans visited the area in 1823, and to document colonial agricultural activity in the region before 1970. While the team has a good handle on historical



documents describing the area's hydrology and agricultural activities qualitatively, they are still looking in France and the UK for production numbers for thirsty crops such as cotton, and for fisheries production, during the colonial period.

Working with geographer Molly Brown to estimate local rainfall values, the team is using the so-called Chirps database, which uses infrared satellite data designed for USAID's Famine Early Warning System, to estimate daily rainfall reliably since 1981. Converting the data into reliable rainfall values for entire states (e.g. Yobe and Borno states in Nigeria) is a non-trivial task, and undergraduate students Kexin Nie and and Mikaela Meyer are working with Purdue GIS specialist Dr. Nicole Kong to generate the data.

Ultimately, the team hopes to be able to understand drivers of changes in the lake and be able to estimate future states of the lake and its resources, based on various climate and agricultural scenarios to better inform policy decisions about Lake Chad.



PHOTO: From left to right, undergraduate student researchers Brian Kidd, Mikaela Meyer, and Kexin Nie.



Mesquite-savanna parkland ecosystem at the Texas AgriLife La Copita Research Area

## Degradation of Global Grasslands: A Soil Organic Matter Perspective

Grasslands cover approximately 35% of the Earth's land surface. These highly dynamic ecosystems provide important services such as provisioning of food, maintaining biodiversity and pollination, providing flood control, and supporting nutrient cycling and soil formation. Globally, however, grasslands are among the most degraded ecosystems, threatened by land use and land cover change, nitrogen deposition, fire suppression, and climate change.

Not all grasslands are equally vulnerable to such stresses. Those facing some of the biggest challenges are often defined by coarse, sandy, nutrient-poor soils, like the grasslands found across wide spans of the North American South and West and in Inner Mongolia, China. Research out of Professor Timothy Filley's group, *Earth, Atmospheric and Planetary Sciences*, studies how these important ecosystems are changing, both above and below ground, and what that means to our understanding of the regional controls on soil organic matter stability and its resilience to environmental stress.

At field sites in Texas and Arizona the group is investigating how woody plant encroachment into grass-dominated ecosystems is altering the above- and belowground storage and cycling of carbon and affecting soil organic matter stability. Work led by

Courtney Creamer (PhD 2012; now at USGS- Menlo Park) studied the encroachment of honey mesquite trees into grasslands impacted by over a century of overgrazing and fire suppression. They found that the grass-to-woody transition changes the source, rate and chemistry of microbial decomposition of organic carbon below ground; and that groupings of trees coincided with a suppressed microbial use of woody-plant carbon in the soil.

Parallel work in the arid grasslands of New Mexico, in collaboration with Heather Throop and Jennie DeMarco (visiting scholar in Filley lab), *New Mexico State University*, found that woodland replacement of degraded grasslands increased the proportion of mineral-stabilized soil carbon, which was shown to have a greater than anticipated resistance to microbial decay even after 50 years post-tree death by intentional woodland removal. These two studies are helping improve representation of plant-soil interactions in global carbon cycle models.

A separate study led by Ruzhen Wang, a U.S.-China Ecopartnership Visiting Scholar, looked at the coupled impacts of nitrogen (N) addition and changing rainfall patterns in a 9-year long manipulation experiment in a semi-arid grassland in Inner Mongolia, China. The team found that microbes housed within different soil particle size classes have distinct responses to N input and greater water availability. As soil carbon accessibility and concentration varied across the particles, the team was able to demonstrate the spatial heterogeneity of microbial-controlled soil response to environmental change.

# Transformation of Organic Sulfur in Natural Waters: Implications to the Global Radiation Budget

Coastal waters such as the Chesapeake Bay estuary are strong sources of a range of volatile sulfur-containing gases like carbon disulfide (CS<sub>2</sub>) and carbonyl sulfide (COS). Once in the atmosphere, these gases are readily oxidized to sulfate aerosols that affect radiative forcing directly (they can scatter and absorb both solar and terrestrial radiation), as well as indirectly (by influencing cloud formation). Professor Amisha Shah, *Civil Engineering and Environmental and*

*Ecological Engineering*, is studying the key reaction pathways through which dissolved organic sulfur compounds such as the amino acid cysteine are converted to COS and CS<sub>2</sub> when exposed to sunlight, with an ultimate goal of improving our understanding of the global sulfur budget.

Shah and collaborator Michael Gonsior, University of Maryland, have built a photochemical reactor that allows them to run experiments over different sunlight exposures at controlled temperatures. Early results from their work indicate that water type (freshwater vs. seawater) is an important factor in the conversion of cysteine to CS<sub>2</sub> and COS, with a predominance of CS<sub>2</sub> formation over COS. Additional work is underway examining samples collected from Chesapeake Bay.

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## Linking Rainfall to Child Growth Outcomes in Uganda

In Uganda, child growth outcomes, measured by stunting, wasting and underweight, have been on the decline over the past two decades, but still remain above the set Millennium development goals (MDG). Over 80 percent of Ugandans live in rural areas and depend on agriculture as their main source of food and income. Agriculture in Uganda mainly relies on precipitation, especially rainfall, which plays an important role in food production. Nearly two-thirds of households in Uganda are net buyers of staple foods. This underscores the importance of precipitation through its direct impacts on food production and its indirect impacts on food prices.

Professor Jerry Shively, *Agricultural Economics*, and graduate student and PCCRC graduate fellow, George Omiat, are studying the links between rainfall and child growth outcomes in Uganda, to specifically answer two questions: (1) how do rainfall anomalies impact food price dynamics in Uganda's staple food markets? and (2) how does rainfall influence child nutritional outcomes?

Precipitation is linked to child growth outcomes through two pathways, agricultural production and household health. The agricultural production pathway links precipitation to child growth through the impact of rainfall on food production. Rainfall

affects crop yields, which directly affects household food consumption, and indirectly affects food prices. The team examined these impacts by analyzing the least-cost, nutritionally-adequate diet based on a "basket" representing 10 major foods and a set of 14 nutrient requirements. An increase in the price of key staple foods raises the cost of the food basket, especially for households that are net buyers of food. When the cost of the food basket rises, these households may turn to cheaper sources of calories or cut back on food consumption with potentially serious implications for the health of pregnant women, infants, and young children.

The household health pathway links precipitation to child growth through the impact of rainfall on the household disease environment. The team is examining the impact of both severe storms and drought on the prevalence of diarrheal disease. Diarrheal disease is associated with poor child growth outcomes because it lowers the intake and absorption of nutrient and calories leading to weight loss.

Through this project, the team will develop an empirically-based and data-driven understanding of the overlap between agricultural issues and health/nutrition issues in Uganda, with the goal of improving the effectiveness of nutrition policy in Uganda and elsewhere, especially in the USAID Feed the Future countries of east Africa.

## Prices a Poor Metric for Food Security Outcomes in Climate Change Analysis

The implications of climate change for food security were recently the focus of an IPCC Expert Meeting convened in May 2015 in Dublin, Ireland to discuss assessment options. Food prices seem an obvious metric—and they have been the historical focus in the literature—but, as Professor Thomas Hertel, *Agricultural Economics*, points out in his recent Commentary in the journal, *Nature Climate Change*, this linkage is misleading at best, and altogether wrong in some cases.

Because climate change will have differential impacts on income, a broader measure of household well-being, such as changes in absolute poverty, is needed to assess the impact of climate change on food security. Agriculture-dependent households can benefit from higher food prices as long as they sell more than they buy; for example, in countries where

poverty is concentrated among agricultural households, such as Bangladesh or Uganda, higher food prices should lead to improved incomes and food security for the poor. Urban households, on the other hand, are likely to feel the full impact of rising food prices.

Hertel and post-doctoral researcher Dr. Uris Baldos have also explored the role of international trade in managing food security risks from climate change. This work, published in the journal *Food Security*, finds that free trade and strongly linked global food markets could help counterbalance projected climate change impacts on agricultural production, both from single events such as a severe drought in the U.S. Midwest, as well as more gradual declines in crop yields, particularly in the tropics.

With current trade policies, the number of people in South Asia suffering from malnutrition would rise 120 percent in 2050 under the worst-case climate change scenario. Economic models indicate that fully integrated world markets would dramatically stem these effects, offering "insurance" against these worst-case outcomes.

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## Frames Describing Local Climate Change Impacts Affect Public Opinion in Distinct Ways for Democrats and Republicans

States and sub-national governments have taken the lead on climate change mitigation policy in many parts of the world, including the United States. In the U.S., however, explaining the variations among states—why some states facing serious threats from climate change have taken little to no action on the issue, while others have moved aggressively to reduce emissions—remains a challenge.

In a study led by graduate student Sara Wiest and Professors Leigh Raymond and Rosalee Clawson, *Political Science*, laboratory experiments were used to test the influence of different frames presenting

projected *local* versus *global* climate impacts on individual perceptions of the severity of climate change, behavioral intentions to address the issue, and attitudes toward different climate change policies. The results indicated that frames stressing local impacts from climate change increased both perceptions of severity of the problem and support for local policy action on the issue among all subjects, as well as behavioral intentions among only Republicans. Interestingly, the study also found that presenting individuals with projected benefits as well as losses from climate change weakens perceptions of problem severity for all subjects, but decreases support for local policy action among Democrats only.

Overall, these results are consistent with policy research suggesting that perceptions of local vulnerability are an important factor in the adoption of sub-national climate change policies. The findings also imply that the effectiveness of particular climate change impact frames will vary from one state to another depending on a state's partisan leanings.



Graduate student Fernando Tormos with Christina Figueres, executive secretary of the UN Framework Convention on Climate Change.



Indigenous representatives from Peru pose for a photo in front of the Peru pillar outside the entrance to the Le Bourget conference site in Paris.

## From Presence to Influence: The Politics of Representation in Global Environmental Governance

The United Nations has identified indigenous peoples and women as two of the groups most affected by climate and global environmental change. Although indigenous peoples make up approximately 5% of the global population, they constitute more than one-third of the world's poorest and govern, occupy, or use nearly 22% of global land area, thus suggesting that effective representation of indigenous peoples, and indigenous women, in particular, in global environmental governance, like the United Nations Framework Convention on Climate Change (UNFCCC), is key for more resilient responses to climate change.

Professors Kimberly Marion Suiseeya and Laura Zanotti, along with a group of graduate and undergraduate students, attended this year's UNFCCC Conference of the Parties (COP21), held in Paris, France. The team seeks to better understand how various networks and governance practices at COP21 engage in the politics of indigenous representation to shape the outcomes of the negotiations.

During the two-week Paris Climate Conference, the team used collaborative event ethnography—a team-based approach to study mega-events—to observe and analyze the process of negotiation and decision-making regarding forest issues by and for indigenous peoples,

examining how their ideas related to forest conservation and local livelihoods are created, promoted, contested, debated, and ultimately incorporated partially or wholly into global agreements. Because influence is increasingly understood as a phenomenon that unfolds over time and is not always measurable through specific decision outcomes, attention to the details of the politics of representation—which often emerge in fleeting moments—is critical to identifying pathways to influence. These pathways include actions that, for example, change the course of debate, undermine another actor's strategy, or insert an idea that is taken up in other rooms or venues. Using the PCCRC observer credentials, the team was able to sit-in on official COP21 negotiations, as well as cover civil society events.

The team also explored the use of digital ethnography to complement their on-site data collection. Thirty-three graduate and undergraduate students from Professor Marion Suiseeya's International Environmental Policy course followed key actors in the COP21 negotiations to examine how these groups use virtual worlds to influence the negotiations. The digital ethnography team used the same project analytics as the field team.

This work is part of a long-term research project to identify and examine the ways in which marginalized and underrepresented groups effectively influence governance processes that directly impact their ways of living. Their next effort will focus on the September 2016 World Conservation Congress. You can follow their work on Twitter at @COP21Research or visit the project website: [presence2influence.org](http://presence2influence.org).

# THE YEAR'S PEER-REVIEWED PUBLICATIONS

Atkin, O. K., K. J. Bloomfield, P. B. Reich, M. G. Tjoelker, G. P. Asner, D. Bonal, G. Bönisch, M. G. Bradford, L. A. Cernusak, E. G. Cosio, D. Creek, K. Y. Crous, T. F. Domingues, J. S. Dukes, N. G. Smith... (2015). Global variability in leaf respiration in relation to climate, plant functional types and leaf traits. *New Phytologist* 206 (2), 614-636.

Auyeung, D. S. N., J. B. H. Martiny, J. S. Dukes (2015). Nitrification kinetics and ammonia-oxidizing community respond to warming and altered precipitation. *Ecosphere* 6 (5), 1-17.

Baldos, U. L. C. and T. W. Hertel (2015). The role of international trade in managing food security risks from climate change. *Food Security* 7:2, 275-290.

Burnham, M. and Z. Ma (2015). Linking smallholder farmer climate change adaptation decisions to development. Taylor & Francis Group Online.

Buzan, J. R., K. Oleson, and M. Huber (2015). Implementation and comparison of a suite of heat stress metrics within the Community Land Model version 4.5. *Geosci. Model Dev.* 8, 151-170.

Cambaliza, M. O. L., P. B. Shepson, J. Bogner, D. R. Caulton, B. Stirm, C. Sweeney, S. A. Montzka, K. R. Gurney, K. Spokas, O. E. Salmon, T. N. Lavoie, A. Hendricks, K. Mays, J. Turnbull, B. R. Miller, T. Lauvaux, K. Davis, A. Karion, B. Moser, C. Miller, C. Obermeyer, J. Whetstone, K. Prasad, N. Miles, and S. Richardson (2015). Quantification and source apportionment of the methane emission flux from the city of Indianapolis. *Elementa: Science of the Anthropocene*, 3, 000037.

Carlton, J. S., R. Perry-Hill, M. Huber, and L. S. Prokopy (2015). The climate change consensus extends beyond climate scientists. *Environmental Research Letters* 10, 9.

Chang, C.H., K. Szlavecz, T.R. Filley, J.S. Buyer, M.J. Bernard, and S.L. Pitz (2015). Belowground competition among invading detritivores. *Ecology*, published online Dec 2015.

Church, S., T. Haigh, M. Widhalm, L.S. Prokopy, J. Arbuckle, J. Hobbs, T. Knoot, C. Knutson, A. Loy, A. Mase, J. Mcguire, L. Morton, J. Tyndall (2015). Farmer Perspectives on Agricultural Practices, Information, and Weather Variability in the

Corn Belt: A Statistical Atlas, Volume 2. Purdue University Research Repository 04 Aug 2015.

Davidson, E.A., E.C. Suddick, C.W. Rice, and L.S. Prokopy (2015). More Food, Low Pollution (Mo Fo Lo Po) A Grand Challenge for the 21st Century. *Journal of Environmental Quality* 44(2) 305-311.

Fu, Z., S. Niu, J. S. Dukes (2015). What have we learned from global change manipulative experiments in China? A meta-analysis. *Scientific Reports* 5, 12344.

Gladich, I., J. S. Francisco, R. J. Buszek, M. Vazdar, M. A. Cagnano, and P. B. Shepson (2015). Ab Initio Study of the Reaction of Ozone with Bromide Ion. *Journal of Physical Chemistry A* 119, 4482-4488.

Grant, R. H. and M. T. Boehm (2015). Inhomogeneity of methane emissions from a dairy waste lagoon. *Journal of the Air & Waste Management Association* 65, 11.

Grant, R. H., M. T. Boehm, B. W. Bogan (2015). Methane and carbon dioxide emissions from manure storage facilities at two free-stall dairies. *Agricultural and Forest Meteorology* 213, 102-113.

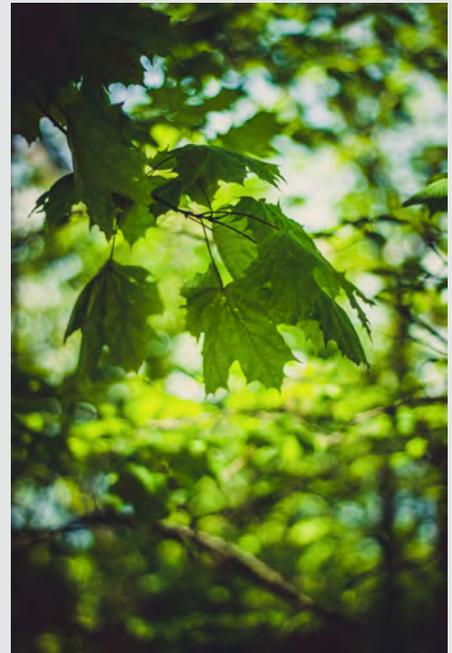
**HIGHLIGHT:** The existence of anthropogenic climate change remains a public controversy despite the consensus among climate scientists. The controversy may be fed by the existence of scientists from other disciplines publicly casting doubt on the validity of climate science. The extent to which non-climate scientists are skeptical of climate science has not been studied via direct survey. In this paper, led by postdoctoral researcher Stuart Carlton, the authors report on a survey of biophysical scientists across disciplines at universities in the Big 10 Conference. Most respondents (93.6%) believe that mean temperatures have risen and most (91.9%) believe in an anthropogenic contribution to rising temperatures. Respondents strongly believe that climate science is credible (mean credibility score 6.67/7). Those who disagree about climate change disagree over basic facts (e.g., the effects of CO<sub>2</sub> on climate) and have different cultural and political values. These results suggest that scientists who are climate change skeptics are outliers and that the great majority of scientists surveyed believe in anthropogenic climate change and that climate science is credible and mature.

- Stuart J. Carlton, R. Perry-Hill, M. Huber, and L. S. Prokopy (2015). [The climate change consensus extends beyond climate scientists](#). *Environmental Research Letters* 10, 9.



**HIGHLIGHT:** Plant photosynthesis and respiration are the largest carbon fluxes between the terrestrial biosphere and the atmosphere, and their parameterizations represent large sources of uncertainty in projections of land carbon uptake in Earth system models (ESMs). The incorporation of temperature acclimation of photosynthesis and foliar respiration into ESMs has been proposed as a way to reduce this uncertainty. In this paper, led by doctoral student Nicholas Smith, the authors show that across 15 flux tower sites spanning multiple biomes at various locations worldwide (10° S–67° N), acclimation parameterizations improve a model's ability to reproduce observed net ecosystem exchange of CO<sub>2</sub>. This improvement is most notable in tropical biomes, where photosynthetic acclimation increased model performance by 36%. The consequences of acclimation for simulated terrestrial carbon uptake depend on the process, region and time period evaluated. Globally, including acclimation has a net effect of increasing carbon assimilation and storage, an effect that diminishes with time, but persists well into the future. The results suggest that land models omitting foliar temperature acclimation are likely to overestimate the temperature sensitivity of terrestrial carbon exchange, thus biasing projections of future carbon storage and estimates of policy indicators such as the transient climate response to cumulative carbon emissions.

- Nicholas G. Smith, S. L. Malyshev, E. Shevliakova, J. Kattge and J. S. Dukes (2015). [Foliar temperature acclimation reduces simulated carbon sensitivity to climate](#). *Nature Climate Change*, published online 07 Dec 2015.



Guo, Q., S. Fei, J. S. Dukes, C. M. Oswalt, B. V. Iannone III, K. M. Potter (2015). A unified approach for quantifying invasibility and degree of invasion. *Ecology* 96: 2613-2621.

Haigh, T., E. Takle, J. Andresen, M. Widhalm, J.S. Carlton, and J. Angel (2015). Mapping the Decision Points and Climate Information use of Agricultural Producers across the U.S. Corn Belt. *Climate Risk Management* 7, 20-30.

Haigh, T., L. W. Morton, M. C. Lemos, C. Knutson, L. S. Prokopy, J. J. Lo, J. Angel (2015). Agricultural Advisors as Climate Information Intermediaries: Exploring Differences in Capacity to Communicate Climate. *Weather, Climate and Society*, 7(1) 87-93.

Hao, G., Q. Zhuang, Q. Zhu, Y. He, Z. Jin, and W. Shen (2015). Quantifying microbial ecophysiological effects on the carbon fluxes of forest ecosystems over the conterminous United States. *Climatic Change* 133, 4,695-708.

Jiang, Y., A. V. Rocha, E. B. Rastetter, G. R. Shaver, U. Mishra, Q. Zhuang, B. L. Kwiatkowski (2015). C–N–P interactions control climate driven changes in regional patterns of C storage on the North Slope of Alaska. *Landscape Ecol.* 31, 195-213.

Jiang, Y., A. V. Rocha, J. A. O'Donnell, J. A. Drysdale, E. B. Rastetter, G. R. Shaver, and Q. Zhuang (2015). Contrasting soil thermal responses to fire in Alaskan tundra and boreal forest. *Journal of Geophysical Research Earth Surface* 120, 2, 363-378.

Jin, Z., Q. Zhuang, J.S. He, X. Zhu, and W. Song (2015). Net exchanges of methane and carbon dioxide on the Qinghai-Tibetan Plateau from 1979 to 2100. *Environmental Research Letters* 10(8), 085007.

Kayler, Z. E., H. J. De Boeck, S. Fatichi, J. M. Grünzweig, L. Merbold, C. Beier, J. S. Dukes... (2015). Experiments to confront the environmental extremes of climate change. *Frontiers in Ecology and the Environment* 13, 4, 219-225.

Kellner, O. and D. Niyogi (2015). Climate Variability and the U.S. Corn Belt: ENSO and AO Episode-dependent Hydroclimatic Feedbacks to Corn Production at Regional and Local Scales. *Earth Interactions* 19, 1-32.

KrÖel-Dulay, G., J. Ransijn, I. K. Schmidt, C. Beier, P. De Angelis, Giovanbattista de Dato, J. S. Dukes, B. Emmett, M. Estiarte, J. Garadnai, J. Kongstad, E. Kova'cs-La'ng, K. Steenberg Larsen, D. Liberati, R. Ogaya, T. Riis-Nielsen, A. R. Smith, A. Sowerby, A. Tietema and J. Penuelas (2015). Increased sensitivity to climate change in disturbed

ecosystems. *Nature Communications* 6, 6682.

Lavoie, T. N., P. B. Shepson, M. O. L. Cambaliza, B. H. Stirm, A. Karion, C. Sweeney, T. I. Yacovitch, S. C. Herndon, X. Lan, D. Lyon (2015). Aircraft-Based Measurements of Point Source Methane Emissions in the Barnett Shale Basin. *Environmental Science & Technology* 49 (13), 7904-7913.

Liao, C. and Q. Zhuang (2015) Reduction of Global Plant Production due to Droughts from 2001 to 2010: An Analysis with a Process-Based Global Terrestrial Ecosystem Model. *Earth Interactions* 19, 1–21.

Liu, J., T. W. Hertel, N. S. Diffenbaugh, M. S. Delgado, and M. Ashfaq (2015). Future property damage from flooding: sensitivities to economy and climate change. *Climatic Change* 132(4) 741-749.

Liu, Y., Z. Pan, Q. Zhuang, D. Miralles, A. Teuling, T. Zhang, P. An, Z. Dong, J. Zhang, D. He, L. Wang, X. Pan, W. Bai, and D. Niyogi (2015). Agriculture intensifies soil moisture decline in Northern China. *Scientific Reports* 5, 11261.

Liu, Y., Q. Zhuang, D. Miralles, Z. Pan, D. Kicklighter, Q. Zhu, Y. He, J. Chen, N. Tchebakova, A. Sirin, D. Niyogi, and J. Melillo (2015). Evapotranspiration in Northern Eurasia: Impact of forcing uncertainties on terrestrial ecosystem model estimates. *Journal of Geophysical Research Atmospheres* 120, 7, 2647-2660.

Lombardozi, D. L., G. B. Bonan, N. G. Smith, J. S. Dukes, R. A. Fisher (2015). Temperature acclimation of photosynthesis and respiration: A key uncertainty in the carbon cycle-climate feedback. *Geophysical Research Letters* 42 (20), 8624-8631.

Mase, A.S., Cho, H., and L.S. Prokopy (2015). Enhancing the Social Amplification of Risk Framework (SARF) by exploring trust, the availability heuristic, and agricultural advisors' belief in climate change. *Journal of Environmental Psychology* 41, 166-176.

Niyogi, D, X. Liu, J. Andresen, Y. Song, A.K. Jain, O. Kellner, E. Takle, and O. Doering (2015). Crop Models Can Capture the Impacts of Climate Variability on Corn Yield. *Geophysical Research Letters* 42(9)3356-3363.

Papanicolaou, A. N. (T.), K.M. Wacha, B.K. Abban, C.G. Wilson, J. Hatfield, C. Stanier, and T.R. Filley (2015). From soils to landscapes: A landscape oriented approach to simulate soil organic carbon dynamics in intensively managed landscapes. *Journal of Geophysical Research Biogeosciences*, 120, 11, 2375-2401.

O'Rear, E. G., K. Sarica, and W. E. Tyner (2015). Analysis of impacts of alternative policies aimed at increasing US energy independence and reducing GHG emissions. *Transport Policy* 37 pp. 121-133.

Parmentier, F. J. W., W. Zhang, Y. Mi, X. Zhu, J. van Huissteden, D. J. Hayes, Q. Zhuang, T.R. Christensen, and A. D. McGuire (2015). Rising methane emissions from northern wetlands associated with sea ice decline. *Geophys. Res. Lett.*, 42, 7214-7222.

Peterson, P. K., W. R. Simpson, K. A. Pratt, P. B. Shepson, U. Frieß, J. Zielcke, U. Platt, S. J. Walsh, and S. V. Nghiem (2015). Meteorological controls on the vertical distribution of bromine monoxide in the lower troposphere *Atmos. Chem. Phys.* 15, 2119-2137.

Prokopy, L. S., J. Staurt Carlton, J. Gordon Arbuckle Jr., T. Haigh, M. C. Lemos, A. S. Mase, N. B., M. Dunn, J. Andresen, J. Angel, C. Hart, R. Power (2015). Extension's Role in Disseminating Information about Climate Change to Agricultural Stakeholders in the United States. *Climatic Change* 130, 261-272.

Prokopy, L.S., C.E. Hart, R. Massey, M. Widhalm, J. Andresen, J. Angel, T. Blewett, O.C. Doering, R. Elmore, B.M. Gramig, P. Guinan, B.L. Hall, A. Jain, C.L. Knutson, M.C. Lemos, L.W. Morton, D. Niyogi, R. Power, M.D. Shulski, C. X. Song, E.S. Takle, and D. Todey (2015). Improving team communication for enhanced delivery of agro-climate decision support tools. *Agricultural Systems* 138, 31-37.

Prokopy, L.S., J.G. Arbuckle, A.P. Barnes, V.R. Haden, A. Hogan, M.T. Niles, and J. Tyndall (2015). Farmers and Climate Change: A Cross-National Comparison of Beliefs and Risk Perceptions in High-Income Countries. *Environmental Management* 26(2) 492-504.

**HIGHLIGHT:** Recent trends in the frequency and intensity of extreme weather events have raised the concern that climate change could increase flooding risks and property damage. However, a major challenge in attributing and projecting changes in disaster risk is that damage is influenced not only by the physical climate hazard, but also by non-climatic factors that shape exposure and vulnerability. Recent assessments of integrated disaster risk have been hampered by the paucity of literature analyzing local-scale interactions between hazard, exposure and vulnerability in the historical record. In this paper, led by doctoral student Jing Liu, the authors develop an integrated empirical analysis of historical flood damage that emphasizes spatial and temporal heterogeneity in flood hazard, economic exposure and social vulnerability. Using the Midwestern United States as a testbed, they show that annual property damage from flooding is projected to increase by 13 to 17.4 % over the next two decades. At the state level, over half of the increase is driven by projected growth in housing units. However, at the county level, the dominant factor causing future damage varies, emphasizing the value of a fully integrated, spatially and temporally resolved approach to assessing flooding risk and control strategies.

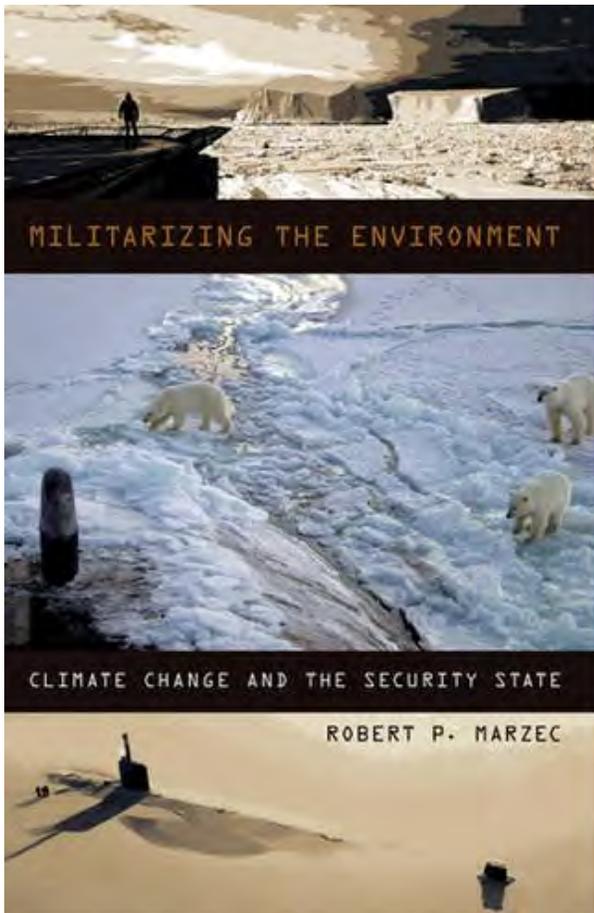
- Jing Liu, T. W. Hertel, N. S. Diffenbaugh, M. S. Delgado, and M. Ashfaq (2015). [Future property damage from flooding: sensitivities to economy and climate change.](#) *Climatic Change* 132(4) 741-749.



- Prokopy, L.S., L. W. Morton, J. G. Arbuckle Jr., A. S. Mase, A. Wilke (2015). Agricultural Stakeholder Views on Climate Change: Implications for Conducting Research and Outreach. *Bulletin of the American Meteorological Society* February 2015, 181-190.
- Samples, A. C. Riseng, and J. Day (2015). Engaging Marina and Harbor Operators in Climate Adaptation. *Michigan Journal of Sustainability* 3.
- Sarkar, A., T. R. Filley, and S. Bera (2015). Carbon isotopic composition of lignin biomarkers: Evidence of grassland over the Gangetic plain during LGM. *Quaternary International* 355, 194-201.
- Shakun, J.D., P.U. Clark, F. He, N.A. Lifton, Z. Liu, B.L. Otto-Bliessner (2015). Regional and global forcing of glacier retreat during the last deglaciation. *Nature Communications* 6, 1-7.
- Shi, L.Y., W.C. Ma, G.F. Shao, L.N. Tang, Y.Y. Wang, and H.W. Wang (2015). The US and China need to turn ongoing bilateral dialogue into immediate joint mitigation. *International Journal of Sustainable Development & World Ecology* 22(1) 25-29.
- Sesmero, J., M. Pratt, and W. E. Tyner (2015). Supply Response, Marginal Cost and Soil Erosion Implications of Stover-Based Energy. *Applied Economic Perspectives and Policy* 37(3) pp. 502-523.
- Smith, N. G., S. L. Malyshev, E. Shevliakova, J. Kattge, and J. S. Dukes (2015). Foliar temperature acclimation reduces simulated carbon sensitivity to climate. *Nature Climate Change*, published online 07 Dec 2015.
- Suseela, V., N. Tharayil, B. Xing and J. S. Dukes (2015). Warming and drought differentially influence the production and resorption of elemental and metabolic nitrogen pools in *Quercus rubra*. *Global Change Biology* 21, 4177-4195.
- Tan, Z., Q. Zhuang, K. Walter Anthony (2015). Modeling methane emissions from arctic lakes: Model development and site-level study. *Journal of Advances in Modeling Earth Systems* 7, 2, 459-483.
- Thompson, C. R., P. B. Shepson, J. Liao, L. G. Huey, E. C. Apel, C. A. Cantrell, F. Flocke, J. Orlando, A. Fried, S. R. Hall, R. S. Hornbrook, D. J. Knapp, R. L. Mauldin III, D. D. Montzka, B. C. Sive, K. Ullmann, P. Weibring, and A. Weinheimer (2015). Interactions of bromine, chlorine, and iodine photochemistry during ozone depletions in Barrow, Alaska. *Atmospheric Chemistry and Physics* 15, 9651-9679.
- Törnqvist R., J. Jarsjö, J. Thorslund, P.S.C. Rao, N.B. Basu, G. Destouni (2015). Mechanisms of Basin-Scale Nitrogen Load Reductions under Intensified Irrigated Agriculture. *PLoS ONE* 10(3) e0120015.
- Turnbull, J., C. Sweeney, A. Karion, T. Newberger, S. Lehman, P. Tans, K. J. Davis, T. Lauvaux, N. L. Miles, S. J. Richardson, M. O. Cambaliza, P. B. Shepson, K. Gurney, R. Patarasuk, I. Razlivanov (2015). Towards quantification and source sector identification of fossil fuel CO<sub>2</sub> emissions from an urban area: Results from the INFLUX experiment *Journal of Geophysical Research* 120, 292-312.
- Walters, W. W., S. R. Goodwin, and G. Michalski (2015). Nitrogen Stable Isotope Composition ( $\delta^{15}\text{N}$ ) of Vehicle-Emitted NO<sub>x</sub>. *Environmental Science and Technology* 49(4) 2278-2285.
- Walters, W., D. Simonini, G. Michalski (2015). Nitrogen isotope exchange between NO and NO<sub>2</sub> and its implications for  $\delta^{15}\text{N}$  variations in tropospheric NO<sub>x</sub> and atmospheric nitrate. *Geophysical Research Letters* 43, 440-448.
- Wang, F., G. Michalski, J. Seo, D. Granger, N. Lifton, M. Caffee (2015). Beryllium-10 concentrations in the hyper-arid soils in the Atacama Desert, Chile: Implications for arid soil formation rates and El Nino driven changes in Pliocene precipitation. *Geochimica et Cosmochimica Acta* 160, 227-242.
- Wang, G., L. Zhang, Q. Zhuang, D. Yu, X. Shi, S. Xing, D. Xiong, Y. Liu (2015). Quantification of the soil organic carbon balance in the Tai-Lake paddy soils of China. *Soil and Tillage Research* 155, 95-106.
- Wang, R., L. C. Bowling, K. A. Cherkauer (2015). Estimation of the effects of climate variability on crop yield in the Midwest USA. *Agricultural and Forest Meteorology* 216, 141-156.
- Wang, R., M. Dorodnikov, S. Yang, Y. Zhang, T.R. Filley, R.F. Turco, Y. Zhang, Z. Xu, H. Li, Y. Jiang (2015). Responses of enzymatic activities within soil aggregates to 9-year nitrogen and water addition in a semi-arid grassland. *Soil Biology & Biochemistry* 81. 159e167.
- Whisler, K. M., H. I. Rowe, J. S. Dukes (2015). Relationships among land use, soil texture, species richness, and soil carbon in Midwestern tallgrass prairie, CRP and crop lands. *Agriculture, Ecosystems & Environment* 216, 237-246.
- Wu, N., T. R. Filley, E. Bai, S. Han, P. Jiang (2015). Incipient changes of lignin and substituted fatty acids under N addition in a Chinese forest soil. *Organic Geochemistry* 79, 14-20.
- Yaling L., Q. Zhuang, D. Miralles, Z. Pan, D. Kicklighter, Q. Zhu, Y. He, J. Chen, N. Tchebakova, A. Sirin, D. Niyogi, and J. Melillo (2015). Evapotranspiration in Northern Eurasia: Impact of forcing uncertainties on terrestrial ecosystem model estimates. *Journal of Geophysical Research Atmospheres* 120, 2647-2660.
- Yoder, J., C. Alexander, R. Ivanic, S. Rosch, W. Tyner, and S. Wu (2015). Risk versus Reward, a Financial Analysis of Alternative Contract Specifications for the Miscanthus Lignocellulosic Supply Chain. *Bioenergy Research* 8, 644-656.
- Zhuang, Q., X. Zhu, Y. He, C. Prigent, J.M. Melillo, A.D. McGuire, R.G. Prinn, and D.W. Kicklighter (2015). Influence of changes in wetland inundation extent on net fluxes of carbon dioxide and methane in northern high latitudes from 1993 to 2004. *Environmental Research Letters* 10, 095009.

## NEW BOOK

# Militarizing the Environment: Climate Change and the Security State



As the seriousness of climate change becomes more and more obvious, military institutions are responding by taking a prominent role in the governing of environmental concerns, engaging in “climate change war games,” and preparing for the effects of climate change—from conflicts due to loss of food, water, and energy to the mass migration of millions of people displaced by rising sea levels. This combat-oriented stance stems from a self-destructive pattern of thought that Robert P. Marzec, *English*, names “environmentality,” an attitude that has been affecting human–environmental relations since the seventeenth century.

*Militarizing the Environment* traces the rise of this influential mindset in America and other nations that threatens to supplant ideas of sustainability with demands for adaptation. In this extensive historical study of scientific, military, political, and economic formations across five centuries, Marzec reveals how environmentality has been instrumental in the development of today’s security society—informing the creation of the military-industrial complex during World War II and the National Security Act that established the CIA during the Cold War.

Now embedded in contemporary Western thought, environmentality has even infiltrated scientific thinking—transforming Darwinian insights into a quasi-theology that makes security the biological basis of existence. Marzec exposes the self-destructive nature of this increasingly accepted worldview and offers alternatives that counter the blind alleys of national and global security.

## STUDENT TRAVEL GRANTS

**Robin Blomdin**, masters student in Earth, Atmospheric, and Planetary Sciences, for travel to the Association of American Geographers Annual Meeting.

**Heather Caan**, doctoral student in Political Science for travel to the Western Political Science Association Meeting.

**Johanna Desprez**, doctoral student in Forestry and Natural Resources for travel to Association of American Geographers Annual Meeting.

**Christy Gibson**, doctoral student in Earth, Atmospheric, and Planetary Sciences, for travel to the European Geophysical Union General Assembly.

**Ben Gottesman**, doctoral student, Forestry and Natural Resources for field work to study the impacts of bleaching on coral reefs.

**Zhenong Jin**, doctoral student, Earth, Atmospheric, and Planetary Sciences for travel to the American Geophysical Union Annual Meeting.

**Luis Pena Levano**, doctoral student in Agricultural Economics for travel to 18th annual GTAP conference.

**Cheng Hsien Lin**, doctoral student in Agronomy for travel to the Air and Waste Management Association 108th Annual Conference.

**Michael Schuster**, doctoral student in Forestry and Natural Resources, for travel to the Ecological Society of America Annual Meeting.

**Nick Smith**, doctoral student in Biological Sciences for travel to the American Geophysical Union Annual Meeting.

**Zeli Tan**, doctoral student, Earth, Atmospheric, and Planetary Sciences for travel to the Ecological Society of America Annual Meeting.

**Molly Van Dop**, masters student in Agricultural Economics for travel to the Agricultural and Applied Economics Association Annual Meeting.

**Wendell Walters**, doctoral student, Earth, Atmospheric, and Planetary Sciences for travel to the American Geophysical Union Annual Meeting.

**Lili Wang**, doctoral student in Agricultural and Biological Engineering for travel to the IAGLR's 58th Annual Conference.

## SEED FUNDING

### **Comparison of three common stochastic weather generators: implications for water resources modeling**

Margaret Gitau (PI), Agricultural and Biological Engineering; Dennis Flanagan, National Soil Erosion Research Laboratory; Michael Baldwin, Earth, Atmospheric and Planetary Sciences

### **Influence of agricultural media framing and the role of uncertainty in influencing agricultural advisors' willingness to promote climate change adaptation**

Linda Prokopy (PI), Forestry and Natural Resources; Erin Hennes, Psychological Sciences; Sarah Church, Forestry and Natural Resources, Ajay Singh, Forestry and Natural Resources

### **How has the declining number of oak trees in Indiana affected forest water use efficiency?**

Lisa Welp (PI) Earth, Atmospheric and Planetary Sciences; Rick Meilan, Forestry and Natural Resources; and Kim Novick, Indiana University

### **Assessing the impacts of Asian monsoon on troposphere-stratosphere exchange of water vapor and pollutants**

Yutian Wu (PI) Earth, Atmospheric and Planetary Sciences

# The Indiana Climate Change Impacts Assessment

The PCCRC is leading the Indiana Climate Change Impacts Assessment (IN CCIA), a new statewide effort to bring together the best available climate change research into a series of reports that show how a changing climate will affect state and local interests. This assessment brings together PCCRC researchers with other climate change researchers around the state to help answer stakeholder questions about the potential consequences of climate change for natural natural and human-built environments.

Increased awareness of climate change impacts can help Hoosiers prepare for future challenges and capitalize on the opportunities. This new effort builds on the 2008 PCCRC assessment conducted at the requests of then-Senator Richard Lugar. The INCCIA will provide accessible, credible climate science to citizens and decision makers, helping them better understand climate change-related risks in support of a more resilient future.



ASSESSMENT TOPICS INCLUDE: \* Agriculture \* Energy Use \* Ecosystems \* Infrastructure \* Natural Hazards \* Public Health \* Water supply & quality

## STEERING COMMITTEE

Michael Baldwin, Associate Professor of Earth, Atmospheric and Planetary Science, Purdue University

Keith Cherkauer, Associate Professor of Agricultural and Biological Engineering, Purdue University

Otto Doering, Professor of Agricultural Economics, Purdue University

Erin Hennes, Assistant Professor of Social Psychology, Purdue University

Daniel Johnson, Associate Professor of Geography, Indiana University-Purdue University Indianapolis

Kathy Luther, Director of Environmental Programs, Northwestern Indiana Regional Planning Commission

Jamie Palmer, Senior Policy Analyst, IU Public Policy Institute

Linda Prokopy, Professor of Natural Resources Social Science, Purdue University

Daniel Vimont, Associate Professor of Atmospheric and Oceanic Sciences, University of Wisconsin-Madison

## PARTICIPATING ORGANIZATIONS

Ball State University

Central Hardwoods Climate Change Response Framework

City of Bloomington

Earth Charter Indiana

Hoosier Environmental Council

Illinois-Indiana Sea Grant

Indiana Association of Cities and Towns

Indiana Dept. of Natural Resources

Indiana Environmental Health Association

Indiana Farm Bureau

Indiana Geological Survey

Indiana Silver Jackets

Indiana State Dept. of Health

Indiana State University

Indiana University

IU Public Policy Institute

Indiana University-Purdue University Indianapolis

Indiana Utility Regulatory Commission

Indiana Water Resources Research Center

Northwest Indiana Regional Planning Commission

Purdue Calumet

Purdue Climate Change Research Center

Purdue University

State Utility Forecasting Group

University of Notre Dame

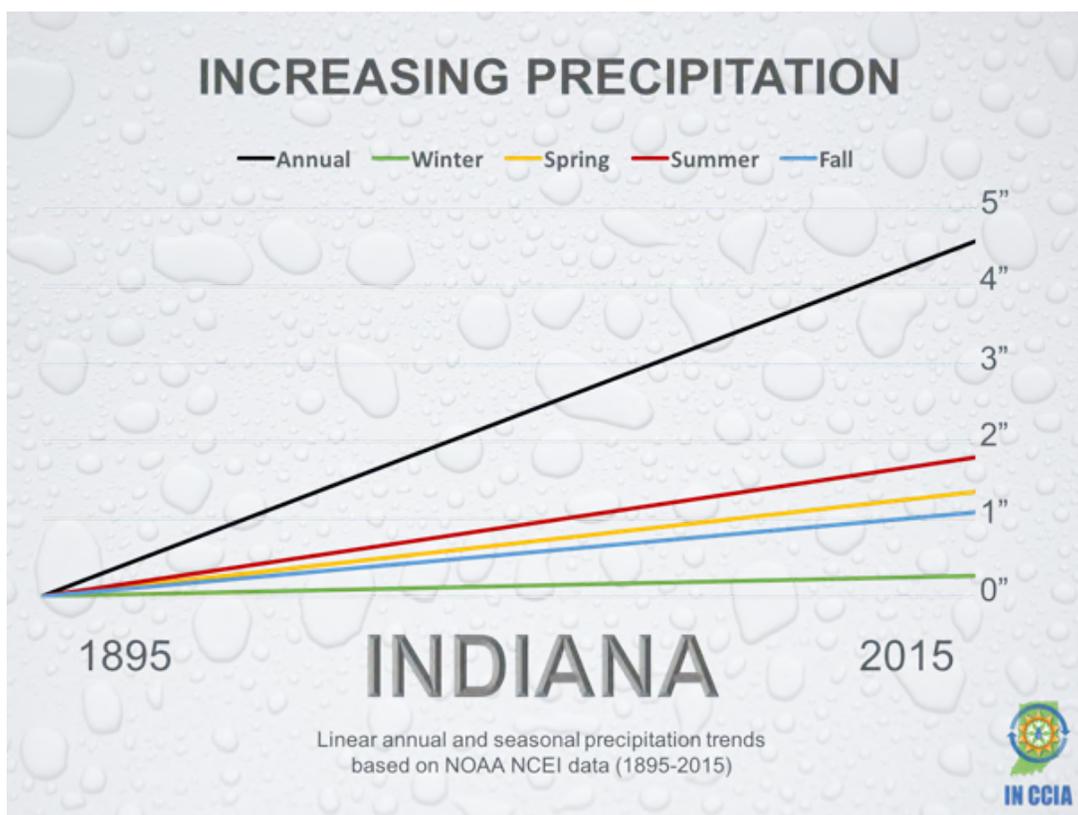
# WE'RE LISTENING...

The INCCIA effort is focused on creating information that matters. We're taking a collaborative approach to engage experts and decision makers in a meaningful dialogue about climate change concerns, impacts, and information needs. By connecting with stakeholders early and often in the assessment process we will gather diverse perspectives and ensure the IN CCIA includes relevant information that is actually usable by state and local decision makers.

The PCCRC is partnering with organizations from around the state to host feedback sessions and seminars beginning in 2016. These sessions will give decision makers and the public an opportunity to learn about the IN CCIA and share their perspectives with us. Some questions we're asking during these sessions include:

- What is your most memorable Indiana weather / climate event? What were the impacts? Have these events been changing?
- How can climate change information be used to support your planning and decision making? What decisions might you change from this info? What prevents you from using this info?
- What specific questions or topics should we address in the IN CCIA reports? What climate conditions and impacts are of most interest to you?
- Who do you trust for information about climate change?

Feedback from these events will directly influence the topics addressed within the IN CCIA reports. If you are unable to attend one of our events you can send comments any time to IN CCIA coordinator Melissa Widhalm at [mwidhalm@purdue.edu](mailto:mwidhalm@purdue.edu).



ABOVE: The graphic displays the linear trends in annual and seasonal precipitation for Indiana from 1895-2015 based on the NOAA NCEI Climate at a Glance database. The baseline average is calculated from the 1901-2000 recorded observations. For simplicity, the inter-annual and inter-seasonal variability in our precipitation record are not shown. While overall our precipitation is increasing, individual seasons or years may be above or below average.

## PCCRC DOCTORAL FELLOWS

**Nick Smith** is a 2014 PCCRC Fellow and a sixth-year doctoral student in Jeff Dukes' lab in the Department of Biological Sciences. Nick spent this last year finishing up research projects and writing in preparation for his defense in March of 2016. He had two first-author papers published. The first study, published in *Nature Climate Change*, examined the influence of foliar temperature acclimation on Earth System Model simulations (ESMs). Nick found that acclimation improved model performance and resulted in an increase in future carbon uptake on land. These results suggest that models that do not include temperature acclimation (and most of them do not) are overestimating the sensitivity of the land surface to climate change.

Nick has also been working on using greenhouse experiments to help constrain acclimation functions to provide further model improvement. He has found that acclimation ability differs among plant species. This work is currently in review for publication and was presented at last summer's Ecological Society of America (ESA) annual meeting. Another paper, published in *Journal of Applied Ecology*, examined the influence of increased rainfall variability and nitrogen addition on plant community diversity in a tallgrass prairie; a study that was initiated with a PCCRC seed grant. The experiment found that the two expected global changes synergistically reduced plant diversity by promoting the dominance of a few species. This research suggests that managers of restored prairies will likely need to proactively combat future global changes to maintain a diverse plant community. In addition to conducting research, Nick also organized an oral session at last summer's ESA meeting on reducing ecological uncertainty in ESMs.



ABOVE: Nick Smith shoots an arborist's slingshot to sample upper canopy tree leaves. Leaf samples are used to help understand how carbon uptake by trees responds to changes in climate.

Nick is still currently working on a number of projects revolving around using experiments to improve models. Following graduation, he will continue as a postdoc in the Dukes lab, working on a multi-university, USDA-funded project to improve the management applicability of ESMs.



**Ruoyu Wang** is a 2011 PCCRC Fellow in the Department of Agricultural and Biological Engineering. He works with Professor Keith Cherkauer, with Professor Laura Bowling, *Agronomy*, serving as co-adviser. In the past year, Ruoyu continued his research on evaluating climate variability and climate change impacts on crop growth via an integration of eco-hydrological modeling and remote sensing technology. Ruoyu summarized his main findings in his Ph.D dissertation, and will defend in February of 2016. He has recently published work in the journal *Agricultural and Forest Meteorology* estimating the effects of climate variability on crop yield in the Midwest U.S. (see page 25 for citation). His dissertation work is expected to generate three additional journal papers.

**Olivia Salmon** joined Paul Shepson's Atmospheric Chemistry research group as a PCCRC fellow in 2013. She conducts airborne measurements from the Shepson Group's Airborne Laboratory for Atmospheric Research (ALAR). Her projects include measuring surface-atmosphere exchange of greenhouse gases over forests and urban areas.

Highlights of her past year include passing her PhD candidacy exam, and taking part in the Washington, D.C.-based airborne campaign WINTER, or the Wintertime Investigation of Transport, Emissions, and Reactivity. Her current research focus has been on quantifying emissions of water vapor from urban areas, and understanding the meteorological conditions and sources that contribute to instances of excess urban water vapor relative to surrounding rural areas. She has shared these observations at the 2015 AGU Fall meeting and the 2015 NOAA Global Monitoring Annual Conference. Her next project will seek to better understand emissions of urban water vapor using Professor Lisa Welp's, *Earth, Atmosphere, and Planetary Sciences*, water vapor isotope analyzer on experimental flights in Washington, D.C. and Indianapolis during 2016.



ABOVE: Olivia on field work in Massachusetts, June 2014, with Purdue's Airborne Laboratory for Atmospheric Research



**Wendell Walters** joined the Department of Earth, Atmospheric, and Planetary Sciences in the fall of 2012 as a PCCRC Fellow working with Professor Greg Michalski. Wendell's research is focused on using the nitrogen and oxygen stable isotopes of nitrogen oxides (NO<sub>x</sub>) to help partition NO<sub>x</sub> sources and evaluate atmospheric oxidation pathways. He has focused on

characterizing the nitrogen stable isotope composition ("fingerprints") of various NO<sub>x</sub> emission sources that include gasoline vehicles, diesel vehicles, diesel trucks and buses, airplanes, lawn equipment, power plants, and domestic furnaces. This work has resulted in two recent publications in the journal *Environmental Science & Technology*. Wendell presented this work at the AGU Fall 2015 Meeting with the support from a PCCRC Travel Grant.

Additionally, Wendell has worked on understanding possible nitrogen and oxygen isotope effects associated with NO<sub>x</sub> once emitted into the atmosphere. He has used computational quantum chemistry methods to calculate

theoretical equilibrium isotope effects involving NO<sub>x</sub> and its oxidation products. His work on the nitrogen equilibrium isotope effects has been published in *Geochimica et Cosmochimica Acta* and the oxygen equilibrium isotope effect is currently under review. In order to test some of the calculated equilibrium isotope effects, Wendell worked with undergraduate student Damian Simonini, who received a Purdue Center for Environment undergraduate research internship award for this work. Wendell and Damian experimentally investigated the nitrogen equilibrium isotope effect between nitric oxide (NO) and nitrogen dioxide (NO<sub>2</sub>). This work has important implications for the understanding of the nitrogen isotope composition of NO<sub>x</sub> in the troposphere and was published in *Geophysical Research Letters*. Wendell is currently working on theoretically calculating nitrogen and oxygen kinetic isotope effects associated with NO<sub>x</sub> oxidation and isotopic kinetic modeling. He received the Henry Silver Environmental Science Graduate Student of the Year award (2015) and plans on graduating within the upcoming year.

## INCENTIVE AWARD

In 2015 the PCCRC began offering Graduate Student Incentive Awards to recruit to Purdue outstanding master's or doctoral-seeking students interested in interdisciplinary climate change-related research. Here, Elisabeth Krueger, first recipient of the award, describes her research project and progress to-date.

For my dissertation project, tentatively titled "Interdependent infrastructure and institutions for water security and equity in transforming urban societies," I am seeking to understand how structure and function of infrastructure, organization in governance and decision-making, and social networks following formal and informal relations and norms, determine the resilience of urban communities around the world, and their response to a variety of shocks.

Collaborations with partners in Jordan have helped me access detailed data of urban water infrastructure of the country's capital city, Amman, and I was able to conduct a range of interviews with local stakeholders in order to understand formal decision-making structures.

Amman's water supply infrastructure serves close to 100 % of the city's inhabitants. However, the country located in the heart of the Middle East has one of the lowest per capita water availabilities in the world with a mere 145 liters per capita and day (lpcd; US average: 9,000 lpcd). Due to Jordan's water scarcity, as well as rapidly increasing demand due to population growth, Amman's population receives water through its piped supply system only during 2-3 days per week, causing the need for adaptation measures, such as roof-top storage tanks and alternative supplies, such as private water tanker trucks. The intermittent supply causes strongly fluctuating high and low pressures and triggers rapid degradation of the infrastructure with accordingly high losses of water in the supply system, and impairment of water quality.

Initial findings resulting from the analysis of Amman's water infrastructure data and existing literature shows that, just like rivers and landscapes, urban spaces and infrastructure networks unavoidably evolve to be scale-free through self-organization. Earlier studies have provided strong evidence that the geometry of urban spaces and infrastructure networks



above ground (e.g., roads), as well as the relationships among various indicators of urban metabolism and population, are scale-free. While engineered urban infrastructures tend to have regular geometric patterns (e.g., roads as grids), recent work has shown that it is the functional uses of these infrastructure networks that transform them to have scale-free organization.

We examined high-resolution urban infrastructure data of water distribution and sewer networks using dual mapping techniques, which emphasize the functional attributes of the networks. We observe that water infrastructure networks evolve in space and time to be scale-free, characterized by power-law node-degree distributions and other network topological metrics. We find this as a general principle for water distribution and sewer networks based on the analysis of every water & sewer pipe in the Greater Amman area (Jordan). We found this to be true in the evolution of the networks over a 47-year period, from 1968 through 2015, and for subnets ranging from 1 to 100 km<sup>2</sup> in area. Implications of our findings allow for evaluating the vulnerabilities of networks to external threats, and for the (re)design of urban infrastructure to enhance its resilience (Krueger et al. 2016, in prep.).

I would like to express my appreciation of PCCRC's support for this research.

--Elisabeth Krueger

## A NEW GROUP FOR GRADUATE STUDENTS & POSTDOCTORAL RESEARCHERS

The Graduate/Post-Doc Group is a newly formed committee within the PCCRC working to bring together graduate students and post-docs interested in climate change research at Purdue. The group promotes and organizes activities that contribute to professional development, network building, cross-disciplinary collaboration and communication of current climate change research for its members across campus.

This past year, the Graduate/Post-Doc Group hosted an ArcGIS training seminar instructed by Professor Nicole Kong, *Libraries*, organized several social events at The Pint, and sponsored a Science on Tap talk by Professor Jeffrey Dukes, *Forestry and Natural Resources and Biological Sciences*.

Additionally, the group recently started monthly coffee break sessions to provide members with the opportunity to meet each other, share their research and other current event items of interest, and work on their writing.

In the upcoming year, the group hopes to continue hosting professional development seminars, social events, and guest speakers. The group currently has over 100 members and encourages all graduate students and post-docs associated with the PCCRC to attend Graduate/Post-Doc Group events.

To find out more, visit the PCCRC Graduate/Post-Doc Group Facebook page or send an email to: [pccrcgpgroup@gmail.com](mailto:pccrcgpgroup@gmail.com).



## MEET A CLIMATE CHANGE SCIENTIST

What inspires a scientist to study climate change? For some, it's a fascination with the beauty and complexity of our natural world. For others it's the opportunity to collaborate with researchers from many different fields. The center's new video series, "Meet Our Scientists," provides a short introduction to our faculty, highlighting the questions they are trying to answer and why it matters. They also share with us their thoughts on what is the one thing that everyone should know about climate change. You can find the video series on our website's home page: [www.purdue.edu/climate](http://www.purdue.edu/climate).



# THE FORECASTING CLUB

Rain or shine, the Purdue Forecasting Club is dedicated to delivering weather updates to the campus and community 365 days a year.

The Forecasting Club, an offshoot of the Purdue University Meteorological Association, is advised by Mike Baldwin, Earth, Atmospheric and Planetary Sciences.

Baldwin has been at Purdue since 2006 and teaches EAPS 434, Weather Analysis and Forecasting. His students, primarily seniors in atmospheric science, were the creators of the Forecasting Club.

"This is real-life experience for these students, which is certainly valuable for them," Baldwin says. "Not only are they gaining experience making weather forecasts, they are also learning how to effectively communicate their science to a diverse group of customers."

The club meets on the fourth floor of Hampton Hall, where members have access to a Linux computer lab, a forecasting room and a green screen room. They use those tools, as well as satellite imagery, radars and Purdue's own weather model to organize the day-to-day schedule of forecasts, mentor less-experienced students and hold weekly meetings to discuss weather forecasting tools and techniques.

"This is a great opportunity for atmospheric science students," says Steven Chun, a senior in atmospheric science and member of the forecasting club. "This club has helped many students decide if their career path should include forecasting or if they should pursue a different aspect of the atmospheric science field."

Club forecasts are used by a large and diverse group of customers, including the Purdue Emergency Preparedness and Planning Office, Recreational Sports, and Intercollegiate Athletics. The club's road weather forecasts are used by Purdue Grounds, local street departments, county and school corporations, and several Indiana Department of Transportation customers. It has over 1,000 followers on Facebook and Twitter.

"These students provide around-the-clock weather support, which helps us know how to optimize our staffing to clear the streets, sidewalks, and parking lots during snowstorms," says Gary Evans, director of Grounds. "This is a great example of students applying their knowledge and skills in the real world to benefit not only Purdue, but the local communities as well."

—Emily Sigg

BELOW: Stephanie Buehler (center) and Tyler Heckstall (right), co-presidents of the Purdue forecasting club, review weather data during a club meeting in Hampton Hall. Mike Baldwin, associate professor of earth and atmospheric sciences and the club's advisor, looks on. (Purdue University photo/Mark Simons)

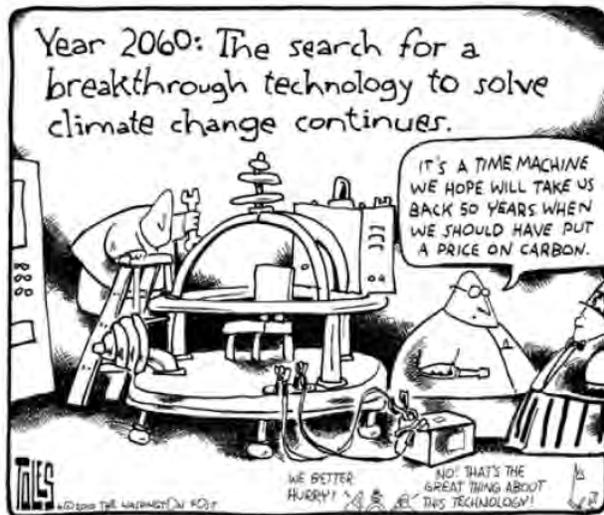


# 2015 PCCRC DISTINGUISHED LECTURE

The PCCRC Distinguished Lecture Series is designed to bring outstanding scholars and other thought leaders to the Purdue campus to catalyze lively, university-wide discussion of climate change issues and to encourage Purdue's creative potential in this area. This year, the center was honored to host Professor Chris Field as the 2015 Distinguished Speaker, in partnership with the Department of Forestry and Natural Resources.

Field delivered his talk titled, "Climate Change: Mapping the Problem Space and the Opportunity Space," on March 27, 2015 to a capacity crowd. Field reflected on the impact of the IPCC Fifth Assessment Report, released in 2013-2014, noting that the world has the opportunity to avoid the worst consequences of climate change and stabilize warming in the range of 2°C above pre-industrial levels—if we act now. Furthermore, action to address climate change through both adaptation and mitigation offers the potential for a wide range of co-benefits that can enhance sustainable development, contributing to robust economies and vibrant communities.

Field urged the audience to consider that reaching this ambitious goal becomes increasingly difficult with delay, incomplete participation, or limitations on the range of non-emitting energy technologies. He closed his lecture with a cartoon (below) by The Washington Post's Tom Toles.



Field is the founding Director of the Carnegie Institution's Department of Global Ecology and Faculty Director of Stanford's Jasper Ridge Biological Preserve. He was co-chair of Working Group II of the Intergovernmental Panel on Climate Change, which led the effort on the IPCC Special Report on "Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation" (2012) and Working Group II contribution to the IPCC Fifth Assessment Report (2014). He was recently named Director of Stanford's Woods Institute for the Environment.

Field's research emphasizes impacts of climate change, from the molecular to the global scale. He is a recipient of a Heinz Award and a member of the National Academy of Sciences; and a fellow of the American Academy of Arts and Sciences, the American Association for the Advancement of Science, and the Ecological Society of America.

# EARTH DAY 2015

In celebration of Earth Day, on April 22, 2015, the PCCRC hosted an afternoon gathering of faculty and students for an informal poster session and networking. Over 50 PCCRCers joined us in the Purdue Memorial Union to share their latest research findings over refreshments.

Immediately following the poster session, the center was excited to welcome Mayor James Brainard (Carmel, Indiana) to campus for the Earth Day Keynote Lecture, an event co-sponsored by the Office of University Sustainability. Brainard is Carmel's first four-term mayor, and has been responsible for many environmental initiatives, including the construction of roundabouts in place of traditional signaled intersections, mandating the use of hybrid or flex-fuel vehicles for city operations, and enacting a "no idling" policy for city employees.

Brainard has recently served on President Obama's U.S. Task Force on Climate Preparedness and Resilience, a committee charged with advising the Administration on how the Federal Government can respond to the needs of communities nationwide that are dealing with the impacts of climate change. He has also served as trustee and co-chair of the Energy Independence and Climate Protection Task Force for the U.S. Conference of Mayors.



ABOVE: Doctoral student Kim Hoogewind, *Earth Atmospheric and Planetary Sciences*, describes her work using high-resolution downscaling of CMIP5 simulations to study the impacts of climate change on severe weather.

BELOW: Carmel, Indiana Mayor, Jim Brainard presenting the 2015 Earth Day Keynote Lecture.





