2016 ANNUAL REPORT

A NEW CLIMATE
The Purdue Climate Change Research Center (PCCRC) is a faculty-led, university-based research center on the campus of Purdue University. The PCCRC serves to increase scientific and public understanding of the causes and impacts of climate change through fundamental research and effective education and outreach. The center receives financial support from Purdue’s College of Agriculture, Engineering, and Science; Office of the Provost, and the Office of the Executive Vice President for Research and Partnerships.

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Cover photos from left to right, top to bottom: This 3-dimensional image of black carbon (BC) was produced by progressively etching the material’s surface with lasers (laser ablation) and measuring the fluorescence of those particles. Prof. Tim Filley (Earth, Atmospheric and Planetary Sciences) uses this kind of chemical analysis to better understand the reactivity of black carbon. Master’s student Akane Ota (Forestry and Natural Resources) helps harvest plants at the Purdue Wildlife Area in an experiment to assess the drought tolerance of prairie ecosystems. A photo from Prof. Nat Lifton (Earth, Atmospheric and Planetary Sciences) of Johnsonhogna, one of the nunataks visible during his recent field work in Antarctica—it stands tall out of the ice sheet at 2,221 meters above sea level. Stands of poplar trees could soon be used for sustainable production of biofuels. Participants in the INTERCAMBIO meeting in Medellin, Colombia, included lead organizer Alejandro Salazar (on left; Ph.D. student, Biological Sciences), assistant professors Juan-Fernando Salazar and Angela Rendón (Universidad de Antioquia, Medellín, Colombia), Qianlai Zhuang (professor, Earth, Atmospheric, and Planetary Sciences), and Jeff Dukes (professor, Forestry and Natural Resources, Biological Sciences).
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Earth’s climate made the headlines again in 2016, breaking records for global temperature – for the third year in a row – and for lack of polar ice. But as these and other indicators emphasized the urgency of the topic, the results of November’s U.S. election brought new questions about how climate research will now be prioritized and funded, and brought uncertainty about how the U.S. approach to climate policy will change (see Robert Marzec’s report from the U.N. climate meetings in Marrakech; p.38). The “skepticism” professed by some policymakers about fundamentals of climate science is troubling.

The PCCRC was formed “to foster communication, learning, and research related to climate change, and provide quantitative prediction capabilities needed to evaluate and communicate the implications of climate change to both Midwest and global ecologic and managed systems.” In our center’s 13th year of existence, these goals are clearly as relevant as ever, particularly in a state where the public understanding of climate science is relatively weak. We continue to support our members as they explore new avenues for effectively communicating about climate change with stakeholders.

In this report, you will see some of the outstanding progress that our faculty and students made in 2016. There are many highlights. Just a few points of interest: Ernie Agee and colleagues identified an eastward shift in tornado activity within the US over the last 30 years that they believe is linked to climatic changes (p. 4). Shweta Singh’s lab produced new estimates of future energy use by cities to help plan our renewable energy future (p. 10). Tom Hertel and colleagues examined potentially optimal trajectories of global R&D spending for adaptation of agriculture to climate change (p. 3). Finally, Erin Hennes found that people’s willingness to acknowledge the link between human actions and climate change depends in part on their feelings about the strength of the economy (p. 15).

Many of our affiliates, as well as other researchers around the state, were involved in the Indiana Climate Change Impacts Assessment during 2016 (see the update on p. 39). To facilitate this work, the PCCRC hired postdoc Jinwoong Yoo, who has been creating state-of-the-art high-resolution climate projections to better understand how severe weather may change over our state. You can expect to see results of all of this work during 2017.

I have only touched the tip of the iceberg here; please read on to get a better sense of what we’ve been up to. The work of the PCCRC has more urgency than ever. Thanks for your interest in the center, and we hope you enjoy the report.

Jeffrey S. Dukes  
Director and Professor

April 2017
DISCOVERY

The PCCRC seeks to build and apply the scientific knowledge needed to address issues related to the Earth’s changing climate system. Our projects and collaborations span the globe, from the Arctic Circle to Antarctica, to the Northern temperate forests, to the urban centers of developing countries; and cross a full range of scales from the molecular dynamics of carbon storage to shifting patterns of tornado activity to global maps of climate change vulnerability.
The tremendous uncertainty about future developments in the global economy and the associated climate change make it difficult for anyone making decisions with long run consequences. This is particularly problematic when those decisions are irreversible. One such decision is how much to invest in public agricultural research and development (R&D), particularly R&D targeted at climate adaptation. Professor Thomas Hertel, Agricultural Economics, and colleagues have developed robust decision tools for this purpose. Building on the Shared Socio-economic Pathways (SSPs) used by the Intergovernmental Panel on Climate Change (IPCC) to characterize long run economic, social, political and climate uncertainties, the research team calculated the socially optimal path for global R&D over the coming century.

The optimal R&D pathway varies by SSP, as shown in the figure to the right. The team then computed a different R&D pathway, this time factoring in the potential economic losses if policy makers work from one SSP, but the world ends up following a different path. The resulting outcome is designed to minimize the maximum regret (MMR). This ‘regret’ is the loss which arises if, for example, we plan for slow climate change, and it turns out to be much faster. The figure plots the optimal pathways for each of the SSPs, as well as the MMR pathway. The latter suggests that, given the uncertainty associated with future economic, demographic and climate change, we should accelerate R&D spending in the coming decades, allowing this spending to slow after 2035.
Professor Ernest Agee, Earth, Atmospheric and Planetary Sciences, research assistant Jennifer Larson and undergraduate students Alexandra Marmo and Samuel Childs conducted a preliminary study on the possible effects of global warming on the climatological behavior of U.S. tornadoes. Agee’s team studied NOAA Storm Data archives of tornado events from the past 60 years to look for any changes in annual tornado activity. The team divided the 60 years into two successive groups: Period 1 (1954-1983), which was a time of cooler temperatures compared to an increasingly warmer second period, Period 2 (1984-2013). Tornado events for both periods are shown in the graphs below based on annual counts in 2.5⁰ latitude by 2.5⁰ longitude grid boxes (counts shown in side bars). Results show for all counts of tornado intensity (E)F1-(E)F5, as well as for the more violent tornadoes (E)F3-(E)F5, that there is a spatial shift from the traditional tornado alley in the central plains to a new region of maximum annual tornado activity in the Dixie Alley. Agee and his team suspect that climate change is driving this shift, and they plan further study in 2017 of this interesting trend.

The greenhouse-gas mitigation potential of poplar trees

Stands of poplar trees could soon be used for sustainable production of biofuels. Recent work from the laboratory of Professor Rick Meilan, Forestry & Natural Resources, addresses several challenges to growing poplar as an ethanol feedstock.

*Decreasing GHG emissions through better weed control*

To accommodate the growing demand for bioenergy, fast-growing woody crops like poplars are being cultivated in short-rotation intensive culture (SRIC) plantations in countries around the world. High levels of growth and survival are expected from the trees grown under SRIC, which strongly depends on efficient weed management. Meilan’s group investigated the impact of glyphosate (the active ingredient in the herbicide Roundup®) tolerance on weed control and tree growth in field-grown transgenic poplars. Over a six-year rotation, they showed that the growth improvement (as a result of more effective weed control) could provide an ~8% savings in greenhouse-gas emissions per unit of wood produced.

*Engineering more efficient growth*

Commercial use of genetically engineered trees has been limited, in part due to concerns over transgene flow into wild tree populations. In the culmination of nearly 20 years of work, Meilan and collaborators have genetically engineered poplar trees to prevent them from producing reproductive structures. A secondary benefit is that these trees produced more biomass, effectively reducing the acres of land needed to produce a given amount of biomass.

*Improving depolymerization methods*

The lignin found in plants is a desirable renewable feedstock for fuels and other useful compounds. However, breaking down this strong, energy-dense polymer into usable monomers typically requires pretreatment of plant biomass under harsh conditions. These pretreatment steps often cause side reactions within the polymer itself, which lower the overall yields of sugars derived from the cell wall. The Meilan group was part of an international study led by Switzerland’s École Polytechnique Fédérale de Lausanne, with collaborators from the University of Wisconsin and Purdue University, that used formaldehyde during pretreatment to block the reactive groups that lead to carbon-carbon linkages in lignin. The team found that this simple step stabilized lignin during pretreatment, resulting in dramatically improved sugar yields.
Professor Richard Grant, Agronomy, and undergraduate student Evan Flatt, Aviation Technology, spent the summer exploring a new use for unmanned aerial vehicles (known as UAVs or drones) in meteorological research. With collaborators from the Institute of Meteorology and Climate Research (Karlsruhe Institute of Technology, Garmisch-Partenkirchen), and the Max Planck Institute of Biogeochemistry (Jena), Germany, the team is one of the first to use UAVs to measure the concentrations of carbon dioxide and methane through the nocturnal boundary layer, a stable atmospheric layer that forms during nighttime hours when the ground is cooler than the air. While daytime airflow is mostly predictable and measurable, nighttime airflow is poorly understood and difficult to measure. With this information, the team will be among the first to measure emissions directly from soils at night, giving a better understanding of the full impact of agricultural practices, such as fertilizer application, on the environment. The UAV was a customized octocopter purchased with a PCCRC seed grant to Professors Grant and Cherkauer, Agricultural and Biological Engineering.

Researchers Jost Lavric (left) and Martin Kunz (center) of the Max Planck Institute for Biogeochemistry assist Purdue aeronautical engineering technology student Evan Flatt (right) with preflight preparations on an unmanned aerial vehicle used to measure nighttime air flow. Photo credit: Richard Grant

Protected areas play big role in climate change mitigation

Over the last decade, the NASA Land-Cover and Land-Use Change (LCLUC) Program has sponsored research contributing a significant amount of knowledge and data on climate and environmental change in the Northern Eurasia region. However, very few efforts have taken advantage of these advancements to investigate the feedbacks and effects of regional LCLUC on global climate and human society. Professor Qianlai Zhuang, Agronomy and Earth, Atmospheric, and Planetary Sciences, and colleagues Jerry Melillo and David Kicklighter from Marine Biological Laboratory, and John Reilly from MIT, are conducting a synthesis study using remote sensing data and an Integrated Assessment Model to evaluate how future LCLUC will impact global climate and socioeconomic systems. With this coupled modeling framework, the team examined the role of protected land in carbon sequestration potential. In Northern Eurasia, about 2.1 million km² of land are currently identified as protected areas, which provide society with many ecosystem services including climate-change mitigation. The team estimates that protected areas in Northern Eurasia currently sequester 0.05 Pg of carbon annually, which is about one tenth of the carbon sequestered by all land ecosystems annually in this region and also about one tenth of the carbon sequestered in all protected areas across the globe. Using an integrated earth systems model to generate climate and land-use scenarios for the twenty-first century, They project that rapid climate change, similar to high-end projections in the IPCC’s Fifth Assessment Report, would cause the annual carbon sequestration rate in protected areas to drop to about 0.3 Pg C by 2100. For the scenario with both rapid climate change and extensive land-use change driven by population and economic pressures, 5.6 million km² of protected areas would be converted to other uses, and carbon sequestration in the remaining protected areas would drop to near zero by 2100.
One-sixth of land on Earth is highly vulnerable to invasive species

The spread of invasive alien species (IAS) outside their natural distribution threatens biological diversity, ecosystems and human health and livelihoods. Recent examples of invasive species in the U.S. include West Nile virus, emerald ash borer, and tumbleweed. Economically developed countries like the U.S. currently have the highest numbers of IAS, but they also have the strongest IAS management efforts and the greatest knowledge about the extent of invasions. In the future, however, the geographical patterns of invasions are likely to be substantially different from that of today due to globalization and environmental change – the speed at which trade, transport and the environment are changing is more rapid today than at any time in human history.

An international team of researchers that included PCCRC director Jeff Dukes set out to create the first worldwide analysis of invasive species threats, providing a global-scale outlook on how the introduction and spread of invasive species could shift in coming decades as a result of increasing globalization and climate change. They also assessed individual nations’ abilities to manage existing invasive species and respond to new ones, providing the first country-level evaluation of its kind.

The analysis showed that one-sixth of the Earth’s land is highly vulnerable to invasive species, and most countries have a limited capacity to protect their natural resources from non-native animals, plants or microbes.

The maps below show the global distribution of terrestrial IAS threat, and the estimated capacity of each nation to prevent or control the spread of IAS. They show a continued high risk of invasion in the U.S., Europe, and China – areas that already have relatively strong IAS management strategies. Many countries, however, like Thailand, Nicaragua, and Chad, and Mozambique, have both a high threat of IAS and a low capacity to respond.

Professor Jeff Dukes

‘Coordinating efforts and sharing data with neighboring countries are simple, cost-efficient ways for nations to better prepare themselves to deal with invasive species.'
Assessing long-term food security

Dominique van der Mensbrugghe, a professor in the Department of Agricultural Economics and Director of the Global Trade Analysis Project (GTAP), is a member of the Global Economics Modeling Team of the Agricultural Model Intercomparison and Improvement Project (AgMIP). AgMIP is a global network of researchers divided into three broad categories—climate modelers, crop modelers and economic modelers. The main focus of AgMIP is model intercomparison and improvement, but also to promote deeper interactions across modeling disciplines. van der Mensbrugghe participated in the Global Workshop held in June 2016 where new research directions were outlined and discussed, including challenges to food security in 2030 (and 2050) under different socio-economic conditions. Key issues identified as areas requiring additional collaborations include: GHGs and soil carbon, nutrition and health, and remote sensing and near-term projections.

Meeting biofuels production targets

Perennial grasses such as Miscanthus and switchgrass are considered superior for bioenergy production than annual grasses such as maize and sorghum because of their ability to produce high biomass with relatively low nitrogen (N), phosphorus (P), and potassium (K) fertilizer inputs. However, the relative contribution of these perennial and annual crops to total greenhouse gas (GHG) emissions, particularly on P- and K-deficient soils is not known. A study by post-doctoral research associate (now, assistant professor, Clemson University) Bhupinder S. Farmaha and Professors Sylvie Brouder and Jeff Volenec, Agronomy, set out to compare GHG emissions from replicated side-by-side trials of an annual grass study (continuous maize and continuous sorghum) and three perennial grass studies (Miscanthus, switchgrass, and mixed native prairie). Their results indicate that Miscanthus can produce large amount of biomass with low direct total GHG emissions per unit of biomass produced when grown on low P, medium K and moderate erosivity lands and thus could serve as a potential dedicated energy crop to meet the nation's targets for biofuel production from cellulosic feedstocks.

Does crop insurance inhibit climate change adaptation?

A research team composed of agronomists, engineers, hydrologists, social scientists and economists, led by Professor Michael Wetzstein, Agricultural Economics, has set out to investigate the possible collateral damage of crop insurance on climate adaptive water use (CAWU) adoption. CAWU is an approach to crop production, which employs technologies for mitigating the potential downside risks of production facing environmental changes. The team is considering the impact of adoption of CAWU on the resiliency of drained agricultural land. The outcome of the research is to develop government mechanisms that have the potential to reduce any collateral damage from crop insurance. A unique aspect of this project is that the team will directly consider this interrelation of water issues and policies. This project is the first attempt to measure the impact that government subsidized crop insurance has on technological adoption for mitigating climate change. Further, this measurement integrates the technical, economic, and social criteria for adoption.

Interactions of economies with climate change

Global Trade Analysis Project (GTAP) Director Dominique van der Mensbrugghe continues to work with the Envisage model, an integrated assessment model that focuses on interactions between economies and the global environment as affected by anthropogenic greenhouse gas emissions. The model has been used to support analytical work at some key international agencies in the past year (Organisation for Economic Cooperation and Development (OECD), the World Bank, and the Asian Development Bank). The Envisage model has undergone a thorough update including the incorporation of the new GTAP-based power database and water. The GTAP Center is pursuing an active program in integrating water in climate change assessments.
Using innovative isotope and imaging tools to track black carbon in fire-prone ecosystems

In many landscapes, fire is a key regulator of important ecosystem processes including nutrient cycling, maintenance of ecosystem boundaries, soil carbon storage, and even regulation of the activity and population of soil microbes. Black carbon (BC), the product of incomplete fires, contributes up to 20% of the organic carbon in some soils and is easily distributed to the atmosphere via aerosols. As such, changes to the production rate of BC have important regional impacts as well as implications for the global carbon cycle.

A series of papers published this year from Professor Timothy Filley’s group, Earth, Atmospheric and Planetary Sciences and Agronomy, along with collaborators Professors Jeff Bird, City University of New York, and Knute Nadelhoffer, University of Michigan, addressed critical gaps in our knowledge of how fire temperature, plant taxa, and environmental exposure control the stabilization of BC in soils and the interactions of black carbon with the soil microbial community and existing soil organic matter. The team set out to determine how shifts in tree taxa distribution and increases in forest fire intensity could affect the formation and reactivity of black carbon (BC). A comparison of two important tree taxa, maple and pine, showed that maple-dominated forests produce black carbon that is potentially more degradable and less surface active that those dominated by pine. In a second study, the team found that exposure to the sun (photochemical weathering) imparts important changes to the reactivity of black carbon and soil microbial activity. These changes influence soil systems by ultimately lowering turnover rates for both the original soil carbon and the introduced black carbon.

In an effort to understand how black carbon, which can be stable for millennia in soil, changes its surface chemistry over time, the team used a novel tool developed in the Filley lab, 13C-labeled tetramethylammonium hydroxide thermochemolysis, to extract molecular fragments of decomposed back carbon. They were able to identify a suite of chemicals that indicates slow oxidative alteration of the particles occurs deep in soil profiles and that these chemicals can serve as markers for in-situ oxidation. Although this work was directed at production of BC in forest ecosystems, these findings have application to commercial possibilities directed at the intentional production of BC as a soil amendment to improve the agricultural productivity of degraded lands.

The next stages in the research will use imaging techniques such as laser ablation and X-ray tomography to identify the internal chemical and structural changes that occur during fires that cannot easily be measured by bulk chemical analysis.
Designing future pathways for sustainable cities

Habitat III, the United Nations Conference on Housing and Sustainable Urban Development, was convened in October 2016 to reinvigorate the global commitment to sustainable urbanization and to focus on the implementation of a “New Urban Agenda.” In preparation for this international meeting, the International Renewable Energy Agency (IRENA) prepared a report, Renewable Energy in Cities, to highlight proven and emerging renewable energy technology solutions, examine the growing linkages between the heat, transport and power sectors, and consider the build-out of smart grids and demand-side management. The report details examples of city experiences, challenges, and success stories to highlight viable and carbon-effective options for renewable energy deployment. The energy modeling underpinning the report was completed by Professor Shweta Singh, Agricultural and Biological Engineering, and second-year doctoral student Liz Wachs. Singh and Wachs estimated global energy consumption in 2030 under different climate change scenarios for 3646 cities across the world using a model first developed by Prof Singh and Professor Chris Kennedy, University of Toronto.

How to Synthesize 100 Articles in Under 10 Minutes

The amount of scientific literature being produced and made readily available has grown exponentially in the past few decades. For example, a basic search on Web of Science for articles classified under the topic category of ‘ecology’ from 1950 to 2014 found 125,000 research articles, among which 70,000 occurred in the last 7 years. Because this growth in available literature is not paralleled by an increase in available time or cognition, literature synthesis becomes progressively more difficult, hindering the advancement of science. To overcome this growing challenge, a recent paper out of Professor Songlin Fei’s (Forestry and Natural Resources) group, led by graduate student Gabriela Nunez-Mir, introduced the utility of automated content analysis, a method for qualitative and quantitative literature synthesis not yet adopted in the ecology and evolutionary biology field. A summary of the paper appears in methodsblog, the blog of the journal, Methods in Ecology and Evolution: http://bit.ly/2IJ5UI6
Climate Change Field Experiments

Researchers can study how future climate conditions will impact ecosystems by using climate manipulation experiments. Warming, elevated CO₂, precipitation, and nitrogen deposition can all be simulated in controlled microclimates within natural settings. These experiments provide a measure of how climate changes affect the growth of plants as well as microbes in the soils.

The Boston-Area Climate Experiment

In 2016, research at the PCCRC-led Boston-Area Climate Experiment (BACE) focused on measurements to improve Earth system models. Specifically, BACE researchers are working with researchers at the National Center for Atmospheric Research, Cornell, Virginia Tech, and the University of New Hampshire to improve the widely used Community Earth System Model (CESM). At the BACE, Nick Smith (postdoc and former PCCRC graduate fellow) studied how the temperature sensitivity of photosynthesis and leaf respiration adjust over time to longer-term changes in temperature. Additional fieldwork at the site carried out by graduate students Alejandro Salazar and Akane Ota examined responses of the soil microbial community to changes in temperature and precipitation.

Precipitation change in Indiana ecosystems

As climate changes, precipitation patterns are expected to change. These changes will vary by location, but around the world precipitation is expected to come in fewer, larger events - meaning longer dry stretches between heavier rains. To better understand the dependence of Indiana's vegetation on precipitation patterns, graduate student Laura Ploughe has been conducting a variety of rainfall removal experiments. The largest of these got underway in 2016 at the Purdue Wildlife Area (PWA), and examines how a restored prairie responds to timing and duration of drought. Another project simulates a 100-year drought at the site, and is part of a network conducting similar rain removal experiments at ~100 sites worldwide. Laura's fieldwork at PWA will continue for another year.

The INTERFACE Research Coordination Network

To produce realistic projections of future climate, Earth system models include subunits that represent the atmosphere, oceans, ice sheets, and ecosystems on land. Developers of the land models draw on a variety of sources of knowledge to ensure the models perform well. Historically, though, they have not taken full advantage of information from the many experiments simulating climate change in the field. The PCCRC-led INTERFACE Research Coordination Network exists to help bridge this gap. The network brings researchers in these communities together to spark new collaborative activities. Students and postdocs are critical participants in these activities; one of INTERFACE's major goals is to help develop a new generation of researchers who are familiar with both experimentation and modeling. The network sponsored a variety of meetings in 2016. These included two that were organized by PCCRC Director Jeff Dukes: a meeting on "Frontiers in terrestrial climate feedbacks: Integrating models and experiments to explore climate feedbacks in an increasingly managed and warming world" in St. Pete Beach, Florida, and a joint meeting with a European network titled "After the extreme: Measuring and modeling impacts on terrestrial ecosystems when thresholds are exceeded" in Florence, Italy. Researchers continue to work on projects that were started at each of these meetings.
What are soundscapes telling us about climate and related environmental change?

Over the last two years, the Center for Global Soundscapes (CGS) has embarked on several research missions that focus on climate change and its impact on animal biodiversity and behavior. These projects, led by Professor Bryan Pijanowski, Forestry and Natural Resources, have taken soundscape ecologists to locations spanning the globe, from the forested steppes of central Mongolia to the Patagonian ice fields. In Mongolia, the CGS team placed six long-term acoustic sensors in locations where reduced precipitation has lowered groundwater levels, with significant impact to the landscape—including die-off of the Siberian birch trees at these locations (photo, below, right). Six additional sensors were placed along slopes with the same aspect and elevation, but where the groundwater system still allows the forest to survive (photo, below, left). The team’s analysis will lead to better understanding of the impact of climate and related environmental change on these ecosystems, including the wildlife that live in these habitats.

In a second study, the CGS team traveled to South America where rapidly changing glacier systems are another indicator of a changing climate. Here, the team is developing new techniques using hydrophone recordings of retreating glaciers in Patagonia to capture a variety of dynamics, including calving, melting, sublimation, and movement. Melting glaciers not only contribute to sea level rise, but they are a major concern to populations downstream who depend on the ice fields as a water supply for drinking and agriculture. The CGS recordings extend 6 weeks from the end of the Southern Hemisphere’s summer into the fall. Analysis of these recordings are underway.

The team has been busy locally, too. The Tippecanoe Soundscape Study, now in its 10th year of continuous recording, represents a mission that will allow CGS to examine how long-term climate change trends and unusual seasonal events affect the timing and intensity of biological sounds like the chorusing of frogs, the emergence of insects, and the migration patterns of birds.

This year, the CGS, with funding from NSF’s Advancing Informal STEM Learning program, released its IMAX/Giant Screen/Dome Theater show to science theaters around the world. This show is designed to turn the typically passive learning environment of a large screen theater into an active learning environment for youth and families. Part documentary and part instructional film, it showcases the work of CGS team members in exotic places like eastern steppes of Mongolia where wild horses roam and pastoralists tune their songs to nature, and Costa Rica, where tropical frogs are being threatened by disease, habitat alteration and climate change. A trailer of the film can be viewed at www.soundscapeshow.com.
Improving hurricane prediction

On December 15, 2016, NASA launched the Cyclone Global Navigation Satellite System (CYGNSS) with the goal of better predicting hurricane track and intensity forecasts. Previous space-borne instruments have been unable to accurately measure ocean surface winds in the inner core of hurricanes because their signals are degraded in regions of heavy precipitation. Using a constellation of eight small satellites carried to orbit on a single launch vehicle, CYGNSS aims to overcome this obstacle. In orbit, these eight micro-satellite observatories will receive both direct and reflected signals from four Global Positioning System satellites. In this exciting, first application of Garrison’s technology, CYGNSS has the potential to make real breakthroughs in hurricane prediction by calculating wind speeds inside hurricanes.

Garrison, in collaboration with NOAA, will also develop the algorithms to assimilate CYGNSS data into hurricane forecast models.

Measuring root-zone soil moisture

Garrison is leading another NASA-funded project that will extend the ideas first demonstrated in GNSS-reflectometry to lower frequencies using reflections of P-band (230-270 MHz) communication satellite transmissions to penetrate the soil and sense “root-zone” soil moisture (RZSM)—an important variable for hydrological and weather forecast models. RZSM is not presently measured by any remote sensing satellite as it is not feasible to use active radar (spectrum allocation problem) or passive radiometry (too much interference) at such low frequencies. The first airborne experiments of this new instrument were conducted this year at the Little Washita watershed in Oklahoma.

Managing water for increased resiliency of drained agricultural landscapes

A new project led by Professor Jane Frankenberger, Agricultural and Biological Engineering, and funded by the USDA, is an 8-state coordinated effort to make drained agriculture more resilient to climate change. The project addresses the need to provide more secure water for crops throughout the growing season while maintaining adequate drainage during wet periods and limiting nutrient losses from drained agricultural landscapes. The team has created a common database that now contains 101 site-years of data on management practices that may improve water management under climate change, established new research sites, and shared their efforts with many stakeholders.
Reconstructing the past to better predict the future

In collaboration with several international research teams, Purdue researchers are mapping and measuring how big the glaciers in Central Asia were during the last ice age. In Antarctica, the team will reconstruct how ice sheet thickness varied through time. This important work will help researchers better understand how and why climate changed in the past, which will, in turn, help predict how climate will change in the future.

The glaciers across Central Asia

A group of Purdue researchers including Professors Jon Harbor and Nat Lifton, Earth, Atmospheric and Planetary Sciences, and Marc Caffee, Physics, are part of an international scientific team focused on reconstructing changes in glacier extent across central Asia. The goals of the project are to significantly increase our understanding of temporal and spatial changes in glacier extent in the region, and the climate drivers for these changes. The project includes collaborators from universities and research institutes in Sweden, China, Russia, Kyrgyzstan, Mongolia, and Germany. As described in recently completed PhD dissertations and associated publications, the project has made contributions both methodologically, in terms of techniques used to establish the ages of material deposited in the past by glaciers and approaches to interpreting patterns of ages, as well as providing extensive new insight into timing and patterns of past glacier changes across central Asia, including the Tibetan Plateau, Tian Shan, and Altai mountains in China, Kyrgyzstan, Mongolia, and Russia. Part of the fieldwork was also featured in a documentary produced in Sweden (poster above).

The ice sheets of Donning Maud Land, Antarctica

Purdue co-leads an international scientific team focused on ice sheet modeling and reconstructing spatial and temporal changes in vertical ice sheet extent across the Dronning Maud Land sector of the East Antarctic Ice sheet. The goals are to significantly increase our understanding of temporal and spatial changes in ice sheet vertical extent in the region, as a way to iteratively improve and test ice sheet models. The project includes collaborators from universities and research institutes in Sweden, Germany, Norway, and the UK. Initial ice sheet modeling is driving the prioritization of field locations for geological sampling to determine past changes in ice sheet extent. The field sites are nunataks, which are mountains that stick out above the ice sheet, and thus act as "dipsticks" that include evidence for past ice levels.

The role of the Asian summer monsoon in troposphere-stratosphere exchange

Previous studies have suggested that the Asian summer monsoon has an important role in the upper troposphere-lower stratosphere (UTLS) exchange of water vapor, carbon monoxide, ozone and many other important chemical species. This troposphere-stratosphere transport has important implications for the climate system including radiation, dynamics, and atmospheric chemistry. However, the underlying dynamical mechanism is not fully understood. Professor Yutian Wu, Earth, Atmospheric, and Planetary Sciences, and collaborator Tiffany Shaw, University of Chicago, used a set of idealized numerical model experiments get at this understanding. The study found that the surface monsoon heating is critical in linking the surface with the UTLS effectively. The surface monsoon heating generates a low-level cyclonic circulation and low-level convergence, which is coupled to an ascent and an upper-level anticyclone circulation. The work suggests that via the strong coupling of low-level cyclone and upper-level anticyclone, the Asian summer monsoon circulation provides an effective transport pathway. Having established a mechanistic understanding of the influence of the Asian summer monsoon on troposphere-stratosphere transport, the team’s future work will use comprehensive chemistry climate models to determine the influence of anthropogenic climate change on the system.
Scientific evidence may not be enough

Skepticism about climate change may be linked to concerns about the economy. Purdue Prof Erin Hennes, Psychological Sciences, and colleagues from Cornell University, University of Massachusetts, New York University, and Climate Central report that, to the extent that sustainability initiatives are seen as threatening to the socioeconomic system, individuals may downplay environmental problems in order to defend and protect the status quo. In their study, published in the Journal of Experimental Psychology, those who were concerned about the economy, as well as free-market advocates, expressed more doubt about the existence of anthropogenic climate change. Those who believe the economy is strong and stable were more likely to accept the scientific evidence of human-caused climate change and its impacts. These findings help explain why many Americans haven’t been swayed by public education efforts, and why belief in climate change dropped by 11% during the 2007-2009 recession. The work suggests that linking environmental information to statements about the strength of the economic system may satiate system justification needs and break the psychological link between pro-environmental initiatives and economic risk.

Useful to Usable (U2U): Transforming Climate Variability and Change Information for Cereal Crop Producers

Improving communication to the agricultural community

A team of social scientists from the Useful to Usable (U2U) project, led by Linda Prokopy, Forestry and Natural Resources, have been working to help land grant university extension services across the Midwest address stakeholder needs related to adaptive management and the agricultural impacts of climate change. They studied strategies for improving climate science communication with farmers, including the importance of message framing and the need for localized context. They also developed recommendations for enhancing institutional capacity for delivering credible climate science to the agricultural community. Suggested institutional actions include building relationships with agricultural advisors, incorporating adaptation and mitigation strategies into existing programming, and strengthening connections between Extension administration and field staff.

New tool helps farmers with irrigation investment decisions

The Irrigation Investment DST – the latest tool from the U2U project – lets farmers explore the potential profitability of installing irrigation equipment at user-selected locations across the U.S. Corn Belt. This tool combines historical weather data and crop simulation model data with customizable yield, cost, tax and loan information to help Midwestern farmers make profitable data-driven decisions. With this tool you can calculate the net present value of your investment, compare dryland and irrigated corn and soybean yields under different rainfall conditions, and explore whether past years would have been profitable with irrigation.

The future of irrigation demand and profitability

The majority of corn and soybeans grown in the Midwestern U.S., including Indiana, rely on natural rainfall to provide moisture for crops. Under current climate conditions and crop production costs, irrigation investments generally have limited profit potential. However, after the severe 2012 Midwestern drought, associate professor Benjamin Gramig, Agricultural Economics, and his former master’s student Molly van Dop (now, PhD student, University of California at Berkeley) wanted to understand how future climate conditions might affect irrigation demand and potential profitability. They found a drastic expansion in irrigation profitability across the U.S. Corn Belt largely driven by increased yields and profitability associated with soybeans.
The chemistry of an Arctic sunrise

Just after the sun rises in the Arctic spring, the atmosphere becomes a photochemistry reaction chamber. Among the dramatic chemistry that occurs during this time is rapid and complete loss of ozone in the near-surface atmosphere in a process known as an “ozone depletion event” (ODE). Ozone depletion events are important because they change the atmosphere’s oxidation capacity (nature’s way of ‘cleaning’ the atmosphere). We know these ODEs are initiated by an increase in reactive halogen (chlorine, bromine, and iodine) concentrations in the polar atmosphere; however, the processes that cause both the rise of reactive halogen concentrations and the depletion of ozone are not fully understood.

Previous work from the Shepson group has shown that reactive halogens can be produced by photochemistry on snow surfaces, but fluxes of these halogens have previously only been estimated. Modifications of a chemical ionization mass spectrometer allowed the Shepson research team to collect, for the first time, high frequency measurements of multiple halogen species, and the first eddy covariance flux measurements of halogens above the snowpack.

Many challenges were faced during this field campaign, including power outages, rapid winds, snowdrifts, and rabid foxes. In spite of these challenges, an unprecedented data set has been collected which will allow many insights into this complex system. You can read about the Shepson group’s three-month long field campaign in Utqiagvik on Angela Raso’s blog, Snowkidding.
New Books

**Reclaiming the Atmospheric Commons**
In 2008, a group of states in the northeast United States launched an emissions trading program, the Regional Greenhouse Gas Initiative (RGGI). With RGGI, these states—Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont—achieved what had been considered politically impossible: they forced polluters to pay the public for their emissions. The states accomplished this by conducting auctions of emissions “allowances”; by 2014, they had raised more than $2.2 billion in revenues. In this first in-depth examination of RGGI, Leigh Raymond, *Political Science*, describes this revolutionary and influential policy model and explains the practical and theoretical implications for climate policy.


**Radical Territories in the Brazilian Amazon: The Kayapó Fight for Just Livelihoods**
Indigenous groups are facing unprecedented global challenges in this time of unparalleled environmental and geopolitical change, a time that has intensified human-rights concerns and calls for political and economic restructuring. Within this landscape of struggle, the Kayapó, an indigenous nation in the central Brazilian Amazon, emerge as leaders in the fight. Radical Territories in the Brazilian Amazon sheds light on the creative and groundbreaking efforts Kayapó peoples deploy to protect their lands and livelihoods. Now at the front lines of cultivating diversified strategies for resistance, the Kayapó are creating a powerful activist base, experimenting with nontimber forest projects, and forging strong community conservation partnerships. Tracing the complex politics of the Kayapó’s homeland, Laura Zanotti, *Anthropology*, advances approaches to understanding how indigenous peoples cultivate self-determination strategies in conflict-ridden landscapes.

The year’s peer-reviewed papers


The GreenMatter program helps train people to work in agriculture-related fields while simultaneously teaching relevant and quality biodiversity skills. Manjana Milkoreit and colleagues explored how programs like GreenMatter can also help understand the different components of a better future (Bennett et al., 2016).


Faculty affiliates by department

**Aeronautics & Astronautics:** James Garrison

**Agronomy:** Laura Bowling, Sylvie Broutier, Melba Crawford, Richard Grant, Cliff Johnston, Dev Niyogi, Ronald Turco, and Jeffrey Volenc

**Agricultural & Biological Engineering:** Indrajeet Chaubey, Keith Cherkauser, Jane Frankenberger, Margaret Gitau, Sara McMillan, and Shweta Singh

**Agricultural Economics:** Otto Doering, Alla Golub, Benjamin Gramig, Thomas Hertel, Paul Preckel, Jacob Ricker-Gilbert, Juan Sesmero, Gerald (Jerry) Shively, Nathaniel Thompson, Wally Tyner, Dominique van der Mensbrugghe, and Michael Wetzstein

**Anthropology:** Jennifer Johnson and Laura Zanotti

**Building & Construction Management:** Kirk Alter

**Chemistry:** Paul Shepson

**Civil Engineering:** Samuel Labi, Larry Nies, Suresh Rao, Amisha Shah, Cary Troy, and David Yu

**Curriculum and Instruction:** Dan Shepardson

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

**Economics:** Timothy Cason

**English:** Robert Marzec

**Forestry and Natural Resources:** Jeffrey Dukes, Songlin Fei, Reuben Goforth, Brady Hardiman, Tomas Höök, Douglass Jacobs, Rick Meilan, Bryan Pijanowski, Linda Prokopy, Guofan Shao, Robert Swihart, and Pat Zollner

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

**Industrial Engineering:** Hua Cai and Roshi Nateghi

**Mechanical Engineering:** Jay Gore

**Political Science:** Manjana Milkoreit, Leigh Raymond, and Mark Tilton

**Psychological Sciences:** Erin Hennes

**Statistics:** Hao Zhang

**Technology Leadership and Innovation:** Brett Crawford

**Visual and Performing Arts:** Charles Gick

**Youth Development and Agricultural Education:** Linda Pfieffer

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**Executive Committee:** Michael Baldwin, Laura Bowling, Otto Doering, James Garrison, Linda Prokopy, Shweta Singh, and Qianlai Zhuang

**Staff**

Jeffrey Dukes, Director

Cindy Fate, Administrative Assistant

Rose Filley, Managing Director

Melissa Widhalm, Operations Manager

Jinwoong Yoo, Postdoctoral Researcher

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**Rose Filley**

‘Few climate change research centers are as comprehensive as the PCCRC. Our faculty, students and staff are advancing discoveries that cut across many important and difficult issues—from rising seas to biodiversity to persistent problems like poverty and environmental justice. It’s inspiring to see the results of this research helping people in the real world.

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1 joint appointment in Civil Engineering; 2 joint appointment in Earth, Atmospheric and Planetary Sciences; 3 joint appointment in Statistics; 4 joint appointment in Agronomy; 5 joint appointment in Biological Sciences; 6 joint appointment in Political Science.
Meet our newest faculty affiliates

Hua Cai, *Industrial Engineering*, studies the environmental implications of emerging transportation systems (e.g., electric vehicle, ride sharing, autonomous vehicles). Three focus areas include emissions reductions, policy incentives and infrastructure development and unintended effects of biofuels production.

Brady Hardiman, *Forestry and Natural Resources*, studies the interaction between human activity, forest structure, and carbon cycling to improve understanding of biosphere-atmosphere exchanges of carbon and the role of forests in regulating climate.

Tomas Höök, *Forestry and Natural Resources*, is an aquatic ecologist with a focus on the ecology of fish in large lakes. His research group is interested in how anthropogenic stressors, including changing climate, may interactively structure future fish populations and communities.

Erin Hennes, *Psychological Sciences*, examines the consequences of the motivation to resist changes to existing socio-structural arrangements on basic psychological processes such as perceptual judgment, recall, and evaluation of scientific and media information.

Manjana Milkoreit, *Political Science*, integrates cognitive theory and international relations to study motivations and policy design in global climate change politics and diplomacy. She is currently examining the challenges of future thinking in climate change policy and decision-making, and the design of effective review mechanisms under the 2015 Paris Agreement.

Paul Preckel, *Agricultural Economics*, is Faculty Director of Indiana’s State Utility Forecasting Group. His research interests include energy modeling, assessment of the effects of policy across an economy’s income spectrum, supply chain management, and modeling imperfectly competitive markets.

Linda J. Pfeiffer, *Youth Development and Agricultural Education*, studies how to meaningfully communicate complex science, like climate change and climate change impacts, to a non-science audience. Her particular focus area is the construction of science news stories.

Pat Zollner, *Forestry and Natural Resources*, works on understanding the interactions between animal behavior (specifically movement patterns) and landscape patterns of habitat resulting from human activity (e.g., forest management or fragmentation; climate change). Typically his work focuses on mammalian models systems although he has some experience working with birds as well.

Michael Wetzstein, *Agricultural Economics*, has broad research interests that center on applied microeconomic theory, with emphasis on natural resource and environmental impacts upon production systems.

Samuel Labi, *Civil Engineering*, focuses on understanding how climate change will impact transportation infrastructure and engineering systems, more broadly. His interests also include design codes for planned structures and the adoption of adaptation and mitigation measures for existing systems.

Sara McMillan, *Agricultural and Biological Engineering*, studies the hydrology and biogeochemistry of coupled human and natural systems, particularly utilizing ecological engineering solutions to improve water quality. She integrates field-based research with quantitative modeling approaches to develop solutions to advance the science of ecosystem restoration.

Nathaniel Thompson, *Agricultural Economics*, studies production economics and farm management, with a specific emphasis on risk management as it pertains to farm-level decision making.
Better estimates of pan-Arctic methane emissions by assimilating satellite data and using different biogeochemical models

Global concentrations of methane (CH₄) in the atmosphere are now more than 2.5 times greater than pre-industrial values, and they are growing rapidly. Because methane is a powerful greenhouse gas (it has a higher global warming potential than carbon dioxide), measuring methane emissions from the Arctic, a fast-warming carbon reservoir is important for projecting future climate changes.

A study led by graduate student Zeli Tan and his advisor, Prof. Qianlai Zhuang, with collaborators from UCBoulder, Cal Tech, NOAA, Harvard, and the National Institute for Environmental Studies in Tsukuba, Japan, integrated methane emissions from surface and satellite measurements with different mathematical models to estimate the amount of methane coming from wetlands and lakes—the largest, and most difficult to track sources of methane from the region.

The graphs below show pan-Arctic CH4 fluxes in 2005 at 1/2° by 2/3° resolution using both SCIAMACHY and NOAA/ESRL observations for the following six different biogeochemical models: a) BERN; (b) CLM4Me; (c) DLEM; (d) ORCHIDEE; (e) SDGVM; and (f) WSL.
TOMORROW’S LEADERS

As we work to ready our students for the challenges of the 21st century, the PCCRC strives to create a learning environment that introduces students to interdisciplinary thinking and fosters the development of cross-disciplinary interactions and collaborations.
New Courses

PCCRC affiliates offer a wide range of climate-change related learning experiences for our graduate and undergraduate students. Here, we share the newest course offerings from our faculty.

POLICY ANALYSIS FOR CLIMATE CHANGE ADAPTATION
Public policy in support of climate change adaptation faces many obstacles. Future conditions are deeply uncertain; the various impacts of climate change are felt on different geographic and time scales, affecting different stakeholder groups in very different ways. The effectiveness of adaptation strategies is difficult to predict. An appropriate response may require interdisciplinary analysis, long-term planning and investment to a degree atypical of many government agencies. This course focuses on interdisciplinary approaches to climate change adaptation at the local, state, and regional level. Course objectives are to introduce students to the topical areas of climate change adaptation and long-range planning, to provide a multidisciplinary toolkit for analyzing uncertainty and tradeoffs between multiple competing objectives, and to facilitate effective presentation and communication of policy analysis results. Taught by Prof. David Johnson.

GLOBAL GREEN POLITICS
Modern societies both depend on and heavily influence the functioning of the biosphere - planet Earth's metabolism. Recognizing the increasing set of challenges created by human-environment interactions from the individual to the global scale, this course explores the political dynamics of global environmental affairs. Starting with an assessment of the state of the planet and the multiple human drivers of global change, we discuss how different kinds of political actors - governments, economies, civil society and individuals - seek to address and deal with environmental problems that cross national boundaries. Taught by Prof. Manjana Milkoreit.

CURRENT TOPICS IN GLOBAL CHANGE ECOLOGY SEMINAR
In this weekly seminar, students discuss current topics in global change ecology. Readings are taken from the latest scientific literature, and will cover topics such as climate change, invasive species, nitrogen deposition, biodiversity loss, and other anthropogenic changes, typically as they relate to their effects on ecosystems. Taught by Prof. Jeffrey Dukes.

WATER AND FOOD SECURITY
This is an introduction to global and regional water resources issues, in particular relation to food production. We address the role of water in agriculture throughout the world and agriculture's impact on water resources. We focus first on developing the scientific underpinnings of water supply and crop water use. With this background, we then discuss key issues relating to water scarcity and balancing agricultural and urban demands for water, water quality and soil salinization, water footprints of food and the use of virtual water embedded in food to offset national water deficits, regulation and the roles of science and policy in solving water problems. Taught by Prof. Laura Bowling.

ANTHROPOLOGY OF WATER
Using an anthropological and social science perspective on water issues, this course explores the myriad ways in which water resources are part of the lives of millions of people in the world. Focusing on issues of access, use, and resource management, students examine the politics and rules surrounding water in freshwater and marine environments. Students in this course conducted digital ethnographies with the Presence to Influence team during the 2016 IUCN World Conservation Congress. Taught by Prof. Laura Zanotti.

INTEGRATED GLOBAL SYSTEM MODELING
Projecting the complex future changes in our land, air and water requires integrated global system analytical tools that couple the dynamics of the atmosphere, land, ocean and human dimension. The objective of this course is to provide students the state-of-the art knowledge and skills to develop and apply such integrated global system models. The course will also showcase a series of model applications to provide sound scientific knowledge that will aid decision-makers in confronting the coupled challenges of future food, energy, water, climate and air pollution, among others. Taught by Prof. Qianlai Zhuang.
Science & Society: Natural Hazards

According to the National Oceanic and Atmospheric Administration, the year 2016 saw 15 weather and climate events with losses exceeding $1 billion each across the United States. These events included drought, wildfire, 4 inland flood events, 8 severe storm events, and a tropical cyclone. Cumulatively, these 15 events led to 138 fatalities and caused $46.0 billion in damages.

The Science & Society: Natural Hazards course aims to help students develop the skills needed to critically evaluate the complex issue of disasters caused by natural hazards such as tornadoes, earthquakes, wildfires, and hurricanes. Taught by professors Timothy Filley, Earth, Atmospheric, and Planetary Sciences and Agronomy, and Megan Sapp Nelson, Libraries, the course explores the interacting scientific, economic, political, and ethical viewpoints that inform personal and societal preparedness, response, and mitigation efforts. Students learn the fundamental science of natural hazard phenomena, and consider how and why the magnitude of the physical and emotional impacts of a natural hazard are linked to personal, community, and societal vulnerability and resilience.

Guest speakers include local and state government officials who provide personal accounts of their role in specific natural disasters (e.g., Hurricane Isabel, the Greensburg Tornado, and the ‘93 Midwest Floods), and in framing the policies and decisions made in the aftermath of these events. Many of these individuals are on the “front-line” and offer a unique opportunity to engage in a two-way discussion of the short and long term consequences of policy and technological choices these communities have made.

The course also incorporates an active collaboration with the National Weather Service (NWS) in Indianapolis that explores how social media affects the public’s response to severe weather. Using software developed by Purdue’s center for Visual Analytics for Command, Control, and Interoperability Environments (VACCINE) and the Department of Homeland Security, students analyze a sample of the tweets from a storm’s immediate vicinity. In this analysis, students gain a better understanding of the societal impacts of natural hazards while also considering the accuracy and bias of social media platforms – and their results provide the NWS with valuable information that could improve warning systems. The course has been featured on National Public Radio’s All Things Considered program.

LEFT: Storm damage assessment (colored triangles) from tornadoes that ripped through north central Indiana on August 24, 2016, co-visualized with tweets (red circles) from the same day that included the word, “tornado.” These tweets represent 471 of nearly 27,000 tweets from that area; many of these were retweets from the National Weather Service’s warning to take cover.

Impacted cities included Kokomo and Fort Wayne. Coincidently, Kokomo Mayor Greg Goodnight and Fort Wayne Mayor Thomas Henry were at the Climate Leadership Summit in Indianapolis earlier that day, before the tornado outbreak.
In 2015, the PCCRC launched a new program to augment assistantship and fellowship offers to incoming graduate students with exemplary records and demonstrated potential for graduate study. Graduate Student Incentive awards are provided for the specific purpose of recruiting to Purdue outstanding master’s or doctoral-degree seeking students interested in interdisciplinary climate change research. An award of $4000 is provided to student recipients to facilitate their intellectual and professional development.

**Elisabeth Krueger**

Elisabeth Krueger, a doctoral student in the Ecological Sciences and Engineering program, is a 2015 Graduate Incentive Grant recipient. Krueger studies how critical infrastructure, governance institutions, decision-making processes, and social networks all combine to determine the resilience of urban communities around the world. The Amman, Jordan water utility is a key study site. This summer, she presented results from an analysis of the city’s water infrastructure networks. The study, conducted with Jordanian collaborators, also included a household survey to understand how local citizens adapt to the (unreliable) water supply. The team interviewed 350 households in Amman and analysis of the transcripts is underway.

Krueger then traveled to Mongolia, a second field site where she collected water infrastructure network data for two major cities, Ulaanbaatar and Darkhan). These will be analyzed in the spring of 2017. While in Mongolia, Krueger was invited to present a seminar on urban water resources management to a class of civil engineering students at the Mongolian University of Science and Technology (MUST) in Darkhan. She also presented parts of her work at the Urban Transitions Global Summit in Shanghai, China, in September 2016.

**William McClain**

William McClain is in his second year as a Ph.D. student in the Department of Agricultural Economics working under Professor Paul Preckel in conjunction with Purdue’s State Utility Forecasting Group (SUFG). He is working with the energy system model, IN-MARKAL to develop an assessment of the impacts of climate change on the energy supply system in Indiana. This is collaborative, interdisciplinary work involving the Departments of Industrial Engineering, Political Science, and Agricultural and Biological Engineering at Purdue, as well as the Lugar Center for Renewable Energy at IUPUI. McClain is a 2015 Graduate Incentive Grant recipient.

**Yuomi Oh**

Yuomi Oh is a doctoral student in the Department of Earth, Atmospheric and Planetary Sciences and a 2016 Graduate Incentive Grant recipient. In her first semester at Purdue, Oh examined how seasonal changes in the carbon isotope signals of leaves compare with the carbon isotope signals from tree rings. Carbon stable isotope ratios of tree rings have been used to infer how trees have responded to environmental variations like drought in the past. Oh’s work is focused on better understanding how tree physiology is “recorded” in tree rings. The study evaluated samples from 4 different tree species, over 3 consecutive years. Oh presented her work in a poster session at the American Geophysical Union Fall meeting in San Francisco, CA in December 2016.
Sarah Huang, doctoral student in the Department of Anthropology, is a 2016 Graduate Incentive Grant recipient. Her research explores how dominant narratives of food security and climate change may inhibit imaginative possibilities for livelihood construction. The research proposes that a farmer’s alternative perceptions and practices of food security may reveal nuances to understanding adaptation strategies to climate change and thus uncertain futures of food security. Huang uses a suite of ethnographic methods including participant observation, semi-structured interviews, and cultural mapping to better understand environmental changes, how generations of farmers utilize agricultural land and technologies, and how temporal and spatial conceptualizations can portray relationships between climate change and farmer food security.

In summer 2016, Huang traveled to Vietnam for an exploratory field visit to the Mekong River Delta. Huang was awarded a U.S. Borlaug Global Food Security Research Fellowship that will take her to Vietnam where she will begin a year-long fieldwork dissertation research assignment between August 2017-August 2018. In August 2016, she also had the opportunity to join the Presence to Influence research team led by Professor Kim Marion Suiseeya (Northwestern University) and Professor Laura Zanotti, Anthropology, to examine forms of indigenous representation at the 2016 World Conservation Congress (WCC) in Honolulu, Hawai’i. She was able to meet with other scholars who work in Southeast Asia and better understand how representation and influence can take different forms as they are legitimized in global environmental governance events, like the WCC.

Our recent graduates

Dr. Wendell Walters

Dr. Wendell Walters (2012 PCCRC Fellow) joined Professor Greg Michalski’s group in 2012 to study reactive nitrogen inputs to the atmosphere. Dr. Walters successfully defended his Ph.D. dissertation entitled, “Unraveling the “fingerprints” of nitrogen oxides using stable isotopes: implications for source partitioning and oxidation chemistry,” in the fall of 2016. He received an NSF post-doctoral research fellowship to conduct research on urban ammonia sources at Brown University, which he started in December 2016.

Dr. Nicholas G. Smith

Dr. Nicholas Smith (2013 PCCRC Fellow) is a plant physiologist, ecologist, and modeler. He received his Ph.D. from Purdue in May 2016; Professor Jeffrey Dukes, advisor. Dr. Smith currently holds affiliations with Purdue and Lawrence Berkeley National Lab. His current research is focused on understanding the plant physiological processes that govern biosphere-atmosphere feedbacks and how these processes vary over space and time. A major motivation for this work is improving the representation of these processes within the Earth system models that are used to project climate change.
Student Travel Grant Program

The PCCRC Student Travel Grant Program aims to support the professional development of our students by helping to defray the cost of presenting their scholarly work (papers or posters) at professional conferences and meetings. The program also supports student travel to workshops or to field sites related to their research program. This year, the center provided 19 travel grants to students representing 9 different departments in 4 colleges.

Spring 2016 Recipients

Colin Bell, Agricultural & Biological Engineering: Presented “Export of nutrients and carbon in urban watersheds with stormwater control measures” at the American Society of Agricultural and Biological Engineers Annual Meeting in Orlando, FL in July 2016.

Kate Haapala, Political Science: Conducted field research in Alaska, May 27-June 12, 2016.

Sarah Huang, Ecological Sciences and Engineering (Anthropology): Conducted field research in Vietnam.

Jonathan Knott, Forestry and Natural Resources: Presented “Assessing the Impacts of Climate Change on Phenology Using a Common Garden Study” at the Ecological Society of America Annual Meeting in Fort Lauderdale, FL in August 2016.

Luis Pena Levano, Agricultural Economics: Presented “Climate change interactions with agriculture, forestry sequestration, and food security,” at the 2016 International Food and Agribusiness Management Association in Aarhus, Denmark in June 2016.

Laura Ploughe, Biological Sciences: Presented “Plant community composition resistant to rain and snow manipulations in Midwestern deciduous forest understory and tallgrass prairie” at the Ecological Society of America Annual Meeting in Ft Lauderdale, FL in August 2016.

Rachel Scarlett, Agricultural & Biological Engineering: Attended the Bode Field Course at the Helmholtz Centre for Environmental Research, in Leipzig, Germany, July 4-18, 2016.

Tariq Usman Saeed, Civil Engineering: Presented two talks on his work modeling the effects of maintenance, climate change, and observation-specific correlations to bridge component deterioration at the 8th International Conference on Bridge Maintenance, Safety and Management in Foz do Iguaçu, Brazil in June 2016.

Fall 2016 Recipients


Bithi De, Earth, Atmospheric, and Planetary Sciences: Presented “Role of the stratospheric pathway in linking the arctic sea ice loss to the midlatitude circulation in CMIP5” at the Fall Meeting of the American Geophysical Union in San Francisco, CA, December 2016.

Maria del Rosario Uribe Diosa, Ecological Sciences and Engineering: Presented “Modeling carbon uptake seasonality in tropical evergreen forests of the Amazon with the TEM” at INTERCambiO in Medellin, Colombia in October 2016.


Sayanthi Mukhopadhyay, Civil Engineering: Will present “Big data approach to understand sensitivity of electricity to climate and weather” at the IEEE Power and Energy Society General Meeting Conference, to be held in Chicago, IL, July 2017.

Alejandro Salazar, Biological Sciences: Presented “Microbial control on soil-atmosphere carbon cycling” at INTERCAMBIO in Medellin, Colombia in October 2016.


A PCCRC Travel Grant supported my travel to Anchorage, Palmer, and Homer, Alaska where I was able to interview key individuals working on water quality, conservation, and environmental change in urban and rural areas throughout the state. I conducted interviews with individuals representing the Bureau of Land Management, Conservation Fund, Alaska Center for the Environment, the Environmental Protection Agency, the National Oceanic and Atmospheric Administration among many others. The interviews, and their corresponding transcripts, will allow me to complete a policy gap analysis and a stakeholder analysis. These analyses will allow me to identify potential ecological, political and, social variables with which to build social-ecological models that depict the dynamic interrelationship between institutions, people, and their local ecosystem.

This exploratory field site visit to Alaska also allowed me to investigate various watersheds, wetlands, and river systems, which provided additional insights related to water quality, aquatic resources, and water habitat issues. Across all organizations, individuals focus on salmon as a trust resource in some way. Salmon transcend real and perceived demographic, generational, political, and geographic boundaries in the state of Alaska. Nevertheless, climate change will continue to exacerbate already undesirable circumstances for Native communities in Alaska. For instance, the average temperature across the state of Alaska has increased by roughly 3 degrees Fahrenheit, which is approximately twice as much as the rest of the United States. While temperature increases may seem like a small matter, these seemingly small changes in Alaska’s climate have far ranging impacts on local and global ecosystems. Multiple indigenous cultures in Alaska that depend upon robust salmon populations and corresponding water quality are vulnerable to changes in these resources. Negative impacts to salmon populations brought on by development, climate change, and off-road vehicle usages that destroy riparian buffers along waterways (see photos to the left) make these communities vulnerable to destabilization and affect their ability to live in a traditional way. Moreover, these communities' diets, social networks, economies, and value systems would all be susceptible to dissolution.

The visit to Alaska reshaped my interests from being solely focused on water quality and access issues to broader questions of ecosystem services, the cultural significance of these resources, as well as the efforts to sustainably manage these resources. I have begun to ask how environmental change and its effect on terrestrial and marine salmon habitat are perceived by individuals, communities, organizations, and the state of Alaska? What are the consequences of significant changes in salmon for individuals, communities, organizations, and the state of Alaska? What are the different definitions for sustainable, robust, or resilient salmon fisheries in Alaska? What are some of the constraints to achieving sustainable, robust or resilient salmon fisheries in Alaska? I ask these questions because salmon and humans have been enmeshed together for millennia and these coupled systems provide spiritual, cultural, economic, social network, and ecological benefits to all biological populations.

—Kate Haapala
I have just returned from a two-week exploratory field visit in Lào Cai and Long Xuyên Provinces in Vietnam. My research focuses on the food–climate change intersection through women’s autonomy and self-determination within rice farming households and communities. I chose these two provinces to conduct research because of the different effects of climate change, as well as the different means of rice production. Anthropologists have long written about adaptive capacity, resilience, sustainable local livelihoods, and resource utilization, by emphasizing how people are building resilience and adaptive capacities within changing climates. Within this context, I believe that anthropology provides a unique lens into the study of climate change through an understanding of the everyday practices of individuals.

While in Long Xuyên, I visited An Giang University (AGU) and my future host, Dr. Kien Van Nguyen at the Research Centre for Rural Development (RCRD), with whom I will be working during a year-long research stay that will start this fall. We visited many local rice fields where the most pressing issue was the impact of drought, which has eliminated one of the three usual growing seasons. Farmers were stressed with reduced crop production as well as a lack of water for animals. Aside from the general concerns of climate change and El Niño causing drought and increased salinity of rice paddies, farmers are not sure what these changes will bring. This region is of particular importance because it lies on the Mekong River Delta, which is Vietnam’s most fertile land resource for rice production. Rice produced in this region is for in-country consumption, making this region vital to the nation’s food security.

In Tp. Lào Cai, I was able to work with Black H’mong farmers in Sapa in the rice terraces of one family. The Black H’mong are an ethnic minority community that lives in the mountains of Sapa. This region has only one growing season that begins during the rainy season. The farmers must grow rice to feed their families for the whole year. The climate change effects that were described to me were felt through changing rainy seasons and drought. Standing at the top of the mountain in the city of Sapa, you can look down and see that most of the rice terraces are filled with water and are successfully growing rice, but as you begin to enter the valley, it
becomes more obvious that many terraces are completely dry. The drought and inability to grow rice reduce the food security of families living in these villages, but these effects are further compounded by the developing tourism industry. As cultural tourism begins to expand into the valley and into the villages, the construction of new road systems and new homestays is a threat to the ability of families to create larger rice terraces to account for growing families and decreased arable land for rice production from drought. The women are at a higher risk of feeling these effects of climate change and increasing development as they are the providers of the household. They are in charge of food production and cooking, as well as participating in cultural tourism. The women’s roles within these contexts have changed as they are now taking on the role of trekkers for cultural tours, but they are put at a high risk when trekking because these new road systems have changed the landscape, so much so, that elderly women do not recognize the land and younger female trekkers are often getting lost in the mountains. The safety of these women in their jobs as trekkers as well as in providing rice for their families is dependent on their ability to adapt to climate change, tourism, and development.

These two weeks in Vietnam helped me see what climate change in these communities actually looks like and also that climate change does not occur within an enclosed system, but is a part of the larger context of ‘changing environments’ that include social, ecological, political, and economic shifts. I’ve learned that when trying to understand or study the effects of climate change on food security we must first understand what climate change and food security looks like within these larger constructs of livelihoods. I knew I wanted to focus on gender and climate change in Vietnam, but what became more relevant to me while in Vietnam was what this actually meant. Gender requires an analysis of both men and women, specifically I am interested in the agricultural practices and adaptive capacities of men and women as both roles are instrumental in contributing to the food security of the household. I learned that while women often face the double burden of cash economy work as well as household work, their adaptions to climate change are felt within the rice fields as much as within the household. Women and men are both changing their roles within the household as they begin to adapt to changing economies, labor, and environments.

—Sarah Huang
Graduate students Alejandro Salazar and Maria del Rosario Uribe Diosa organized and participated in a 3-day conference on climate change in Medellín, Colombia, from October 31st to November 2nd, 2016. INTERCAMBIO—INTERnational Conference on Atmosphere-Biosphere Interactions—brought together researchers from the U.S., UK, Germany, and Colombia with the goal of promoting scientific discussion and collaborative networking with climate change researchers in Colombia. Through academic talks, a poster session, open sessions, and a panel presentation, participants discussed the challenges and opportunities for doing global change research in Colombia, and how this may change in a post-conflict scenario. A summary of these discussions has been submitted for publication.

Maria del Rosario Uribe Diosa

‘This event was a great motivation for my doctoral studies and I am sure these new connections will be of great help during the upcoming years.

Laura Ploughe

‘I had never attended a scientific conference before and found that this conference [the Ecological Society of America Fall Meeting] offered many activities that were relevant to my research, as well as interesting. I also was able to network, speaking with several scientists with similar research interests.

Tariq Usman Saeed

‘This gave me an idea how my research could make an impact in the industry. I feel more encouraged and confident about my research ventures since I’ve had a chance to hear from leading professionals.
MEANINGFUL ENGAGEMENT

What we do in our classrooms and labs makes a difference in the world and what happens in the world influences what goes on in the university. Through a variety of activities and events, the PCCRC aims to develop stronger external partnerships, contribute to civic engagement, and advance the needs of our communities—from the local to the global.
‘Personally speaking, the greatest benefit from participating in these meetings came from the one-on-one discussions with the other participants.

Professor Tomas Hertel

Between the 7th and 18th of November 2016, Marrakech, Morocco hosted the 22nd Conference of Parties (COP22) to the UN Framework Convention on Climate Change (UNFCCC). COP22 started just days after the Paris Agreement had officially become international law. Purdue professors, Thomas Hertel, Agricultural Economics, and Robert Marzec, English, were in Marrakech for COP22, and offer some thoughts about the meeting here.

Upon arrival in the Marrakech airport, it was immediately clear that the Moroccan government had made a huge effort to ensure a smooth COP22 meeting. We were guided through customs with special ‘COP22’ arrows on the floor and walls. Outside, they had a fleet of buses and electric cars (Peugeots, made in Morocco), ready to whisk us off to our hotels – free of charge. I was a host of the Moroccan government – or more specifically, OCP - the state-owned company which manages their Phosphate reserves. Phosphate is an important crop fertilizer and Morocco is the ‘Saudi Arabia of Phosphates.’ They are seeking to expand their involvement in agriculture beyond the provision of fertilizer into the entire agricultural input supply chain and they are opening offices in a dozen countries in Africa in order to promote this wider role. They had one of the largest exhibits at COP-22 and sponsored side-events every day of the conference. I participated in the event on water scarcity and climate change.

I was the only academic in my session. Others included a former Director of the US Army Corps of Engineers who now works with international NGOs, the Vice-President of the IPCC, the head of water for UNESCO, the head of an NGO working on water issues, AGWA, and two Research Directors from the Ministries of Planning and Agriculture, in the government of Morocco. Personally speaking, the greatest benefit from participating in these meetings came from the one-on-one discussions with the other participants. For example, I spent three hours on the final day (en route to our flights home) with one of the founders of SMAG (stands for smart agriculture) – an organization founded 16 years ago to collect, process, and provide information from farms in Europe, and use these data to make location-specific agronomic and economic recommendations to farmers across the continent. They work with farms covering 40 million hectares - about 100 million acres! He had some amazing insights into the prospects for future advances in precision agriculture, environmental conservation and adaptation to climate change. – Thomas Hertel
LOOKING FOR PROMISE at COP22

COP22 may have added little to the decisions made at COP21, but the many Side Event panels revealed strengthened efforts to combat global warming. On the political side the conference was mostly about ratifying and implementing the plans of the Paris Agreement. At least 55 nations producing 55% of global emissions need to ratify the Agreement in order for it to become law. This goal was actually met a week before the start of the conference. By the end of the conference 111 nations had come on board.

This is good news, but at COP21 nations had already agreed that voluntary emissions cuts put forward were not enough to combat climate change. In this sense COP22 can be said to be a deep disappointment, for despite the need to commit to stronger cuts, the conference focused mostly on reinforcing Paris agreements—which are not enough to keep below the desired 2-degree Celsius increase in global temperatures.

Many of the side event panels in the Civil Society space of the conference focused on gaining access to the Green Climate Funds (GCF) promised by wealthy nations to help developing countries generate adaptation and mitigation strategies. Indigenous People (IP) representatives expressed continued frustration that GCFs are practically impossible to access since the funds need to be distributed through large banking mechanisms that are simply not available to IPs. Members of the Funds committee claimed that they would make money available to IPs if their organizations could show adequate armatures for disbursing the funds. But such armatures are based on nation-state models—larger scale systems that are very different from IP communities.

The cloud looming over the conference was of course the election of a climate change denialist to the White House. The potential effects of the US pulling out of the Paris Agreement were expressed in almost every panel I attended after November 8. Even so, the U.S. presence at COP22 did generate some hope. In addition to pledging, along with Canada, to reduce emissions by 80 percent from 2005 levels by 2050, the U.S. released its “United States Mid-Century Strategy for Deep Decarbonization.”

Jonathan Pershing (the U.S. Special Envoy for Climate Change), describes the document as an “analytics exercise”—an exploration of how the US “might decarbonize major sectors of the economy through 2050 and beyond.” Much more is certainly needed, but such documents will be instrumental if there is to be any future in the struggle to combat climate change. —Robert Marzec

“There are increasingly expansive sustainable city projects in the works, and cities were highlighted throughout the COP22 sessions.

ABOVE: Marzec with Ajita Tiwari and Myron Mendes—members of the Indian Network on Ethics and Climate Change, based on Mumbia and New Delhi. They work to include the perspectives of marginalized communities in cities, how the marginalized are addressing the crisis of climate change, and issues of sustainable development and social justice.
Led by the PCCRC, the Indiana Climate Change Impacts Assessment (IN CCIA) is a statewide effort that brings together over 90 experts to synthesize available climate change research into a series of sector-focused reports detailing how a changing climate will affect state and local interests. The IN CCIA will provide accessible, credible climate science to Hoosiers, allowing them to better understand climate change-related risks so they can build effective plans for a more productive future. Over 30 organizations are contributing to the assessment in various ways including co-hosting and/or attending feedback sessions, co-authoring reports, reviewing assessment materials, and/or disseminating results.

2016 Highlights

- Co-sponsored the Indiana Climate Leadership Summit – a first-ever gathering of mayors and city officials to discuss innovations and actions to address climate change
- Held nearly a dozen feedback sessions to better understand Hoosiers opinions and concerns about climate change. We heard from city and regional planners, agricultural commodity representatives and farmers, environmental health workers, land use specialists, transportation specialists, and others.
- Convened nine working groups, with expert contributors from across Indiana tasked with developing sector-focused technical reports for the IN CCIA
- Expanded awareness of the IN CCIA effort through a monthly newsletter, website, social media, and various speaking events
- Partnered with ITaP Research Computing (RCAC) to develop high-resolution simulations of Indiana’s climate and extreme weather events over the next century
- Joined NCAnet – a network of organizations across the U.S. that interface with the National Climate Assessment to communicate local needs, knowledge, and experiences

Meet Melissa Widhalm

Melissa Widhalm is project coordinator for the Indiana Climate Change Impacts Assessment (IN CCIA), and an operations manager in the center. She oversees all aspects of the IN CCIA including public engagement, network building, report development, information dissemination, and strategic planning. She works closely with stakeholders and subject matter experts to ensure the IN CCIA is useful and accessible to decision makers and the public.

Melissa has a passion for applied climate science and public engagement, and she brings over 10 years of experience managing interdisciplinary research and outreach projects. She is a certified Project Management Professional (PMP)® who holds a M.S. in Natural Resources with an emphasis in climate assessments and impacts from the University of Nebraska-Lincoln and a B.S. in Meteorology from Northern Illinois University.

In her spare time, Melissa participates in citizen science projects observing the weather and the natural environment. She also enjoys photography, volunteering in the community, and spending time with family and friends.

‘By engaging Hoosiers throughout this process and incorporating their feedback into our reports, the IN CCIA will have more relevance to peoples’ concerns and be more useful for their decision making.'
INCCIA’s groundbreaking climate change simulations

Researchers from the PCCRC are using ITaP’s new Halstead research supercomputer to develop high-resolution models to better predict climate and extreme weather events in Indiana over the next century. Existing global climate models don’t show an area as small as the state of Indiana in much detail. The global models also don’t explicitly represent the physical effects of atmospheric convection (the mixing of warm, humid air with cooler air, which creates thunderstorms). Using a computationally intensive process called dynamical downscaling, the PCCRC team’s models will overcome these limitations.

These groundbreaking simulations will provide detailed information about Indiana’s future climate, including insights about severe weather, wind, and humidity which will be shared through the Indiana Climate Change Impacts Assessment. The research team, led by Dr. Jinwoong Yoo, PCCRC postdoctoral researcher, includes professors Michael Baldwin and Matthew Huber, Earth, Atmospheric and Planetary Sciences, along with PCCRC director Jeff Dukes, a professor of forestry and natural resources and biological sciences.

Telling the story of climate change

Through the IN CCIA process we strive to inspire and encourage communities to talk about climate change. To increase awareness about climate change risks and impacts, we have developed a series of infographics (left). These short, non-technical infographics offer a few key facts about climate change, and provide examples of projected climate change impacts in Indiana.
Indiana Climate Leadership Summit

The Climate Leadership Summit, held on August 24, 2016, gathered local leaders, environmental organizations, student groups, and other stakeholders to talk about how their cities can prepare for and help mitigate the effects of climate change. The non-partisan event was co-convened by Carmel Mayor James Brainard (R) and Whiting Mayor Joe Stahura (D). The event included plenary talks by Indianapolis Mayor Joe Hogsett, Carmel Mayor Jim Brainard, plus a panel discussion that included Mayor Joe Stahura (Whiting), Greg Goodnight (Kokomo), Mayor Brainard, and Kumar Menon, director of Fort Wayne Utilities. Professors Gabe Filippelli (IUPUI) and PCCRC director Jeff Dukes presented talks on the basics of climate change and work underway with the Indiana Climate Change Impacts Assessment.

Climate Science Day on Capitol Hill

In February, 2016, climate scientists gathered in Washington, D.C. to meet with congressional staff and to emphasize the importance of climate science and its role in many important issues affecting the public. This two-day, non-partisan event organized by 13 professional societies provides an opportunity for scientists to build relationships with congressional members and their staff, and provide them access to the best possible climate science information. Professor and PCCRC director Jeff Dukes participated in the event, meeting with Senator Joe Donnelly, and with staff from Senator Coats’s and Congressman Bucshon’s offices.

In the Courtyard of the Gentiles

This fall, Dominique van der Mensbrugghe, Agricultural Economics and GTAP, was a keynote speaker at a conference hosted by the Vatican. The conference was organized by the Italian embassy to the Holy See and the president of the Pontifical Council for Culture as part of of the initiatives promoted by the Courtyard of the Gentiles—an ongoing effort of the Roman Catholic Church meant to encourage dialogue between believers of all faiths and nonbelievers, often in the form of discussions with secular professors. The conference, “Towards a more humane and just world: a new inclusive economic paradigm in the context of growing inequalities,” facilitated an in-depth debate on the need to define a new economic model, one that is more capable of guaranteeing greater social justice, political stability, and environmental sustainability. Purdue’s van der Mensbrugghe shared the panel with Angus Deaton, Princeton professor and the 2015 winner of the Nobel Prize in Economics, and Jean-Paul Fitoussi, a Professor of Economics at the Institut d’Etudes Politiques de Paris. His remarks focused on climate change as the single biggest threat to the planet, and one that requires urgent and drastic correction. He also discussed the challenge of mitigating climate change while also raising people out of poverty.

Indiana Mayor Joe Hogsett

‘I am confident that if we commit our minds and bodies to the task, together we can face this great challenge of climate change.

ABOVE: Senator Joe Donnelly with Prof Jeff Dukes.
Welcome Back reception

The PCCRC Welcome Back to Campus Reception was held on Wednesday, August 24, 2016. This year, the event brought together over 75 faculty, students and staff for an afternoon of conversation and great food and drinks in the Mann Hall atrium. The center was pleased to welcome and introduce 20 new faculty and student affiliates, share our plans for the upcoming academic year, and learn about our affiliates’ summer activities.

PCCRC Lectures

February 23, 2016: Dr. Stephen M. Gardiner, University of Washington, presented, “Why Geoengineering is Not ‘Plan B.’” The lecture was co-sponsored with the Purdue Lectures in Ethics, Policy, and Science.

August 30, 2016: Dr. Osvaldo Sala, Julie A. Wrigley and Foundation Professor at Arizona State University, presented, “The Effects of Climate Change on Ecosystems Through Directional Changes in Amount and Variability of Precipitation.” The lecture was co-sponsored by the Department of Forestry and Natural Resources.

November 14, 2016: Dr. Danica Lombardozzi, Project Scientist, Climate and Global Dynamics Laboratory, The National Center for Atmospheric Research, presented, “Crop Management & Climate Feedbacks: Insights from the Community Land Model.”

December 5, 2016: Dr. Josh Schimel, Chair of Environmental Studies and Professor in the Ecology, Evolution and Marine Biology Departments, University of California Santa Barbara, presented, “The Biogeochemistry of Drought.”

PCCRC Graduate Student & Postdoctoral Researcher Group

Now in its second year, the Graduate/Post-Doc Group has continued to focus on bringing together graduate students and postdocs interested in climate change research from across Purdue’s campus. The group promotes and organizes activities that contribute to its members’ professional development, network building, cross-disciplinary collaboration, and communication of current climate change research.

This past year, the group’s activities included a LaTeX training seminar, coffee break discussions of current topics in climate change research, and a few social events. The group is now ramping up for a busy coming year, in which it hopes to organize a variety of events and activities, including a panel discussion focused on the future of current climate change research.

The Graduate/Post-Doc Group now has close to 150 members and encourages all graduate students and postdocs associated with the PCCRC to attend its events. To find out more, visit the PCCRC Graduate/Post-Doc Group Facebook page or send an email to: pccrcgpgroup@gmail.com.
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@PurdueCCRC

Spread the word. Share what you are learning, reading, and watching...

Did you know...

58,181 Impressions
100 New Followers
144 Retweets

Reach 17,441

698 Followers
65 Posts