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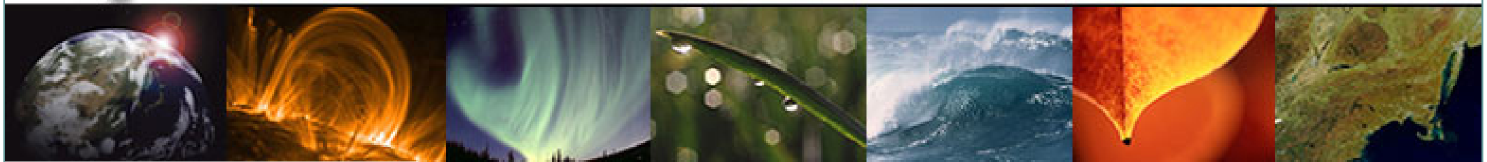
Spheres Online

University of New Hampshire



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Fall 2014
In this Issue of *Spheres*…

Institute for the Study of Earth, Oceans, and Space (EOS)
EOS Director: Harlan Spence
EOS Dir. of Finance & Admin.: Jo Beth Dudley
Editor: David Sims
Designer: Kristi Donahue
Circulation: Laurie Pinciak

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In this issue of Spheres Online, we highlight the work of four graduate students from the Earth Systems Research Center. From master's to postdoc, their work ranges from forest remote sensing, hydrological computer modeling, and Arctic peatland sampling and analysis. An additional thread weaving their work together is that each of them secured funding through an impressive array of fellowships, scholarships, and employment to make it all possible.

In understanding the Earth as an integrated system, the ESRC explores the physical, chemical and biological processes that shape Earth's environment, with an emphasis on the unique role of humans as agents of change. Formerly known as the Complex Systems Research Center, ESRC brings together ecologists, environmental chemists, Earth system modelers, and remote sensing scientists to study natural and human-induced changes in the Earth's water, carbon, and nitrogen metabolism. ESRC graduate education programs encourage interdisciplinary approaches to understanding environmental change.

"Graduate students play a central role in ESRC, far beyond just doing all the heavy lifting on projects dreamed up and planned by their advisors," says tropospheric chemist and ESRC director Jack Dibb. "In most cases, students are pointed toward important and complex questions and encouraged to find an aspect of the problem that intrigues them. As advisors, we mainly need to ensure they tackle manageable projects that allow real progress to be made in a few years, since complete understanding of the systems we are all interested in requires careers of dedication by a large multi-disciplinary community. With each ESRC thesis or dissertation we make small steps forward, but most importantly we create a new member of the community ready to follow up and make the next step, and soon begin mentoring their own future colleagues."

Upcoming issues of Spheres Online will similarly highlight the Space Science Center and the Ocean Process Analysis Laboratory and their graduate students.

Earth Systems Science

A River Runs Through It

PH.D. CANDIDATE Danielle Grogan's scientific career was cemented by her undergraduate research experience at Smith College, where she majored in mathematics and minored in geology. Her research project involved a little campus pond that perpetually filled with silt and had to be dredged every few years. Grogan was tasked with figuring out why, and thereafter was hooked on the hydrologic-human cycle.
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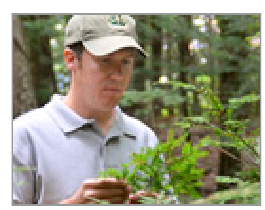

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Around the Hall

News and Notes

• Faculty, Staff, and Student News Read More…
• From the Director: EOS Graduate Research Scholars Read more…

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Earth Systems Science

A River Runs Through It

Water has coursed through Danielle Grogan's postsecondary academic journey since her junior year

Danielle Grogan
Photo by Kristi Donahue, UNH-EOS.

PH.D. CANDIDATE Danielle Grogan's scientific career was cemented by her undergraduate research experience at Smith College, where she majored in mathematics and minored in geology. Her research project involved a little campus pond that perpetually filled with silt and had to be dredged every few years. Grogan was tasked with figuring out why, and thereafter was hooked on the hydrologic-human cycle.

"That was my first experience where the scientific data I collected had a direct impact on people making decisions about the hydrologic system and how to manage water," says Grogan. The research resulted in the college and town of Northampton, Mass. receiving a state grant "to try and improve the whole town's sewage and drainage system because we found most of the sediment was coming through drainage pipes."

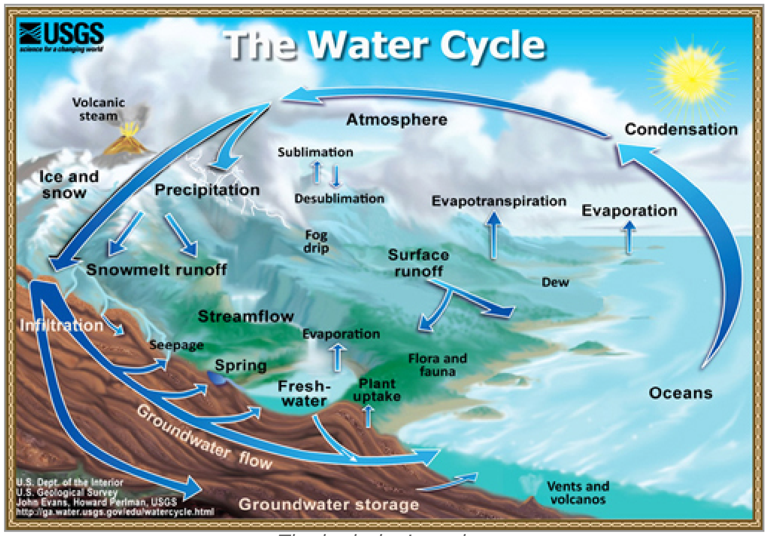
Ever since then, water has been the constant running theme through Grogan's academic career, which included a master's in paleoclimatology from Brown University that focused on hydrological processes of the past. With the hydrologic-human connection having been forged by her undergraduate experience, three years into her doctoral work she is now blending her expertise in hydrologic modeling with social science and economics on a number of projects.

"I'm interested in the interactions between hydrology and people in terms of agriculture, urban development, and climate change," says Grogan. "Water is such a basic fundamental thing in our lives—from how we grow our food to how we run our cities. We interact with it all the time and don't always realize it, and studying hydrology is a great way to get into the connections between science and people."

In late August this year, Grogan returned from ten weeks studying in Japan on a summer research fellowship from the National Science Foundation's East Asia and Pacific Summer Institutes for U.S. Graduate Students program. She worked with researchers at the University of Tokyo's Global Hydrology and Water Resources Engineering Lab directed by world-renowned hydrologist Taikan Oki. The Japan Society for the Promotion of Science jointly sponsored the fellowship.

For this project, Grogan is using two existing hydrologic models—UNH's Water Balance Model developed by the Water Systems Analysis Group (WSAG) over a period of decades—and the University of Tokyo's Catchment-based

Macro-scale Floodplain model. The combined modeling will address a specific set of research questions: How does changing land use from forest to agriculture alter flood risks; how does this compare to flood risks due to urbanization; and, how will climate change increase or alleviate these risks?



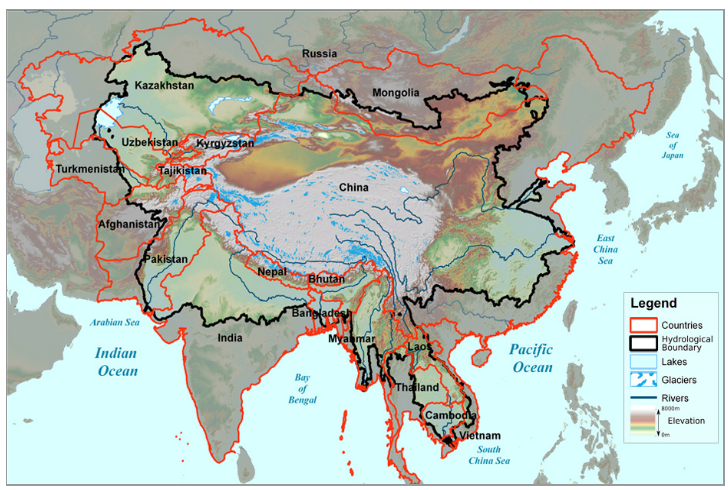
The hydrologic cycle.
Image courtesy of the US Geological Survey.
Illustration by John Evans and Howard Perlman, USGS.

"In the UNH model, the water is always going in one direction, downstream, but once you start flooding you create eddies and it's a more complex representation of water flow."

Crops, climate, canals, and the cryosphere

The fellowship grew out of Grogan's involvement in an NSF-funded project led by Earth Systems Research Center biogeochemical modeler Steve Frolking. The project, titled "Crops, Climate, Canals, and the Cryosphere in Asia; Changing Water Resources Around the Earth's Third Pole," is part of NSF's Water Sustainability and Climate program. ESRC's Changsheng Li, Richard Lammers, and Dominik Wisser are also on the project.

The Third Pole is the 2.5 million square kilometer Tibetan Plateau, and the $1.5 million multidisciplinary, multi-institution study is an assessment of current and projected water resources in the watersheds of the region's major rivers, principally the Indus, Ganges, Brahmaputra, Salween, Mekong, Yangtze, Yellow, Amu Darya, Syr Darya, and Irtysh. Grogan has used the Water Balance Model to estimate how much food is produced in China as a direct result of irrigation systems that use mined groundwater.



The Earth's Third Pole represents the largest and highest collection of mountain ranges in the world. Rivers originating here, fed by glacier and snowmelt, extend in all directions and connect these cold mountain regions with many countries around the Pacific Rim, the Indian Ocean, and Central Asia and supply irrigation water critical for extensive crop production and provide regional food security.
Map by Dominik Wisser, EOS-WSAG.

Grogan says that the Third Pole project doesn't concern flooding, but a lot of the people in WSAG she works with are on the NSF-funded NH EPSCoR (Experimental Program to Stimulate Competitive Research) project doing hydrology modeling and focusing on the interaction between human systems and hydrology in the context of climate change.

"I basically went to Japan to learn how to do the flooding component of hydrology modeling and apply it to the EPSCoR 'Ecosystems and Society' project, as well as add this capability to our group's modeling efforts. The Water Balance Model does stream flow, soil moisture, evaporation, all these aspects of the hydrologic cycle, but we have not yet done any type of flood representation," Grogan says.

Before her ten weeks in Japan, Grogan wasn't sure if she would end up using the flood model as a separate tool that would be paired with the Water Balance Model or if she would completely merge the two by re-coding the flood model into the UNH model.

"I've concluded that I will re-code the flood model into the Water Balance Model, which will take a few weeks, and I expect to have it tested and validated by the end of the semester. I am also very confident that the flood model will apply to the EPSCoR project," Grogan says. Alex Prusevich, a member of WSAG, is also involved in re-coding the flood model.

"… there's a connection between the land cover—such as forest versus agriculture—and how much

water ends up in a river and how that leads to flooding…"

Freedom through funding

She notes that she was able to "sort of attach myself" to the EPSCoR project because she's had additional funding through the NSF Graduate Research Fellowship Program that has allowed her the freedom to participate in multiple projects as they fit into her dissertation.

"I knew flooding aspects were something the EPSCoR researchers want to do. Shannon Rogers at Plymouth State is one of the natural resource economists on the project, and she's very interested in the results from a flood study in terms of the economic side of it and what it might mean to stakeholders." Grogan adds, "There are some ways we've proposed or thought about estimating flooding with our Water Balance Model but it's not as sophisticated as the model I learned in Tokyo."

FEMA aerial preliminary damage assessment over Tennessee following severe storms and floods in May 2010
Photo by David Fine/FEMA.

The UNH Water Balance Model represents the basic dynamics of the hydrologic cycle and moves a known quantity of water from point A to point B. The flood model can show not only *if* a flood occurs, which the UNH model can also do, but what the spatial extent of the flooding is, and how deep the flood waters are at different places in the floodplain.

"In the UNH model, the water is always going in one direction, downstream," Grogan notes, "but once you start flooding you create eddies and it's a more complex representation of water flow. The flood model has the ability to model water backflow."

Grogan hopes to take the modeling work she began in Japan and apply it to what flooding would look like in the EPSCoR project domain under different climate change and land use scenarios. Developing a suite of scenarios that project into the future is a critical component of the Ecosystems and Society work. These scenarios will provide plausible "storylines" on how land cover and climate might change across N.H. over the course of 50 years.

"We generally think of economists as only concerned with money, but I've been working with one who does econometrics—very sophisticated statistical analysis of data…"

"What might development or urban areas look like under these scenarios, where will there be agriculture, what will the forests look like? I want to take those scenarios, put them into the model, and translate that into what floods will look like," Grogan says. "I'll do this especially with regards to where deforestation occurs because there's a connection between the land cover—such as forest versus agriculture—and how much water ends up in a river and how that leads to flooding, and that might indicate what areas might be important for conservation if the goal is to prevent or reduce flooding."

Merging physical and social sciences

At the heart of the Ecosystems and Society and Third Pole projects is the merger of physical and social sciences in an effort to study the big picture and produce research results that impact society. Both projects involve physical scientists and economists working towards the same end—new and challenging territory that Grogan is directly involved in through her work with economists at Penn State, which is also a partner institution in the Third Pole project.

"It's been really interesting working with the economists at Penn State and seeing how these two very different fields that have totally different vocabularies and world views come together to answer questions we really couldn't answer if we each worked on our own," Grogan says.

She adds, "We generally think of economists as only concerned with money, but I've been working with one who does econometrics—very sophisticated statistical analysis of data, a way of understanding how people make their decisions about, for example, irrigation water use. In some way there's this physical linkage between the econometric output data and what I put into my model, but in order to get to that point we had to do a lot of work just to understand each other. Now, we're doing research together and actively running the model and looking at output."

When she wraps up her Ph.D. in the next year or two, Grogan will carry on with her focus on modeling since, as a self-described "very quantitative person," she likes the idea that she can ask questions and test hypothesis in the model world that couldn't be done in the real world.

"We can run so many imaginative scenarios with a model; what happens when you cut down all the forests or double temperatures really fast. As a scientist, I like having that control."

On a personal level, Grogan notes, the best part of her experience in Japan was meeting other students and researchers from a variety of disciplines and countries. "I met researchers from not only Japan, but Malaysia, the Philippines, Korea, Pakistan, Nepal, India, Germany, Switzerland, the U.K., and France, and I will keep in touch with some of them both personally and professionally."

She adds that her time in Japan was more challenging than expected and gave her a new level of respect for foreign students who come to the U.S. to study and do research.

"Unlike an undergraduate study abroad program, like the semester I spent in Hungary when I was at Smith, I was the only American in the Tokyo Water Resources Lab, and often the only person in any given gathering who did not speak Japanese. I really had to be more outgoing than I usually am in order to get to know people, and to allow them to feel comfortable speaking English with me."

by David Sims, Science Writer, Institute for the Study of Earth, Oceans, and Space.

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Earth Systems Science

Pinpointing a Pint-sized Pest From On High

Working with the US Forest Service, master's student Justin Williams helps develop a way to detect the hemlock woolly adelgid via satellite

The hemlock woolly adelgid is the single greatest threat to hemlock health and sustainability in the East. The potential ecological impacts are comparable to that of Dutch elm disease and chestnut blight. —USDA Forest Service

It would seem like the very definition of looking for the proverbial needle in the haystack: using satellites to hone in on a 1/16-of-an-inch—about the size of the period at the end of this sentence—aphid-like insect under the forest canopy *before* visible signs of its destruction appear.

Justin Williams inspects a hemlock branch.
Photo by Kristi Donahue, UNH/EOS.

But that's precisely what master's student Justin Williams set out to do as he began his thesis work three years ago, and just what he accomplished working with the US Forest Service under the federal Pathways Program.

"Under the Pathways Program, I was employed full-time and paired with a mentor from the Forest Service," Williams says. "By working for the Forest Service I was able to use their resources, such as vehicles and scientific instruments, for my research while a graduate student at UNH."

Although there have been efforts to use satellite imagery to map the damage or defoliation caused by the hemlock woolly adelgid—an invasive Asian insect that first appeared on the East Coast of the U.S. in the early 1950s—Williams' work is unique in that it set out to map the distribution of the pest before major defoliation occurs and do so at a larger scale than previous efforts, almost 9,000 square kilometers using Landsat imagery compared to less than 1,500 square kilometers via other methods.

As of 2011, eighteen states from Maine to Georgia had infestations of hemlock woolly adelgid. The pest can kill a hemlock in just a few years, sucking it dry of the nutrients and starch reserves it needs to survive.

"Justin's work is quite significant," notes Barry Rock of the Earth Systems Research Center and Williams' advisor. "He has documented the ability to remotely detect hemlock woolly adelgid infestation using remote sensing methods and, most importantly, also showed there is an initial increase in needle chlorophyll concentrations before the trees eventually succumb to the disease, which appears to be the initial response in the trees' attempt to 'fight off' the infection."

This increase in needle chlorophyll concentration—indicated by how certain wavelengths of light are reflected back to the sensor—turned out to be the key finding in Williams' work. And it was what made it possible to find the needle in the haystack.

“Justin's work has documented the ability to remotely detect hemlock woolly adelgid infestation using remote sensing methods.”

“We knew the hemlock woolly adelgid was affecting the reflectance properties of individual hemlock needles based on some lab-based measurements that we made,” Williams says, “but we weren’t sure we would be able to pull those differences out with the satellite imagery where you’re dealing with mixed land cover pixels and confusion between coniferous species. So it was a very pleasant surprise.”

Boots on the ground

Before the surprise finding, Williams and colleagues used modeling and groundwork to identify where they would find suitable hemlock habitat in their study area, which ranged from a bit north of Concord and west to Mount Kearsarge in New Hampshire and, in Maine, north to Biddeford.

Hemlock woolly adelgids on eastern hemlock.
Photo by Justin Williams, UNH/EOS.

“For this project to be successful we really needed relevant ground data, so we went to 110 randomly placed points—each point being 30 by 30 meters or the equivalent of one Landsat image pixel—throughout the study region and looked at the percent of hemlock and surveyed for the pest,” Williams says. “This gave us our reference data from which we were able to build our hemlock habitat model.”

The ground-based reference data also allowed them to attempt a Landsat data classification in order to zero in on high-value, high-density hemlock stands. But, Williams notes, the classification based on the percentage of hemlock wasn’t nearly as robust as the classification based on whether or not the pest was present. “So it was at that point we realized that the reflectance differences we observed under laboratory conditions were also being recorded in the satellite data.”

“When you conduct research, many times you end with more questions than answers, and that is what propels the science forward.”

Just why infested needles contain greater amounts of the photosynthetic pigment chlorophyll is a mystery.

Says Williams, “It’s a really interesting question that we are still debating. Is this a compensatory response by hemlock? That is, even with initial, modest defoliation by the pest there would be fewer needles and therefore the trees could increase photosynthetic capacity in the remaining needles. Another possibility could be it has something to do with the feeding mechanisms of the hemlock woolly adelgid itself—perhaps there’s something enzymatic within the needles that’s happening. That’s all just hypothetical; we can’t determine ‘the why’ based on our data.” He adds, “When you conduct research, many times you end with more questions than answers, and that is what propels the science forward.”

Ahead of the damage curve

Williams’ research has indeed propelled work in this area forward and it is his hope that it will eventually lead to formal procedures that could help lessen the damage wrought by the hemlock woolly adelgid.

“This work was done with the Forest Service and they’d really like to see a set of protocols that they can use or that can be given to state agencies as a way to empower these agencies to do it themselves. The significance of this work is early detection; we want to know where this pest is before large-scale infestation and damage occurs so that we can initiate management decisions that might reduce future damage.”

Since early detection has been and still is mostly boots-on-the-ground surveying, the newfound remote sensing technique could become a very powerful and cost-effective tool.

“It could save a lot of time, money, and effort,” Williams notes. But he adds that before the methodology can be rolled out for widespread use, more study would need to be done to determine if his master’s project work is repeatable and can be expanded to other regions with different topography and diversity of trees. Overall, he says, the project served as a good pilot study.

“The significance of this work is early detection; we want to know where this pest is before large-scale

“At some point I’d like to continue this research. I love the fieldwork and data analysis aspects of what we do in terms of forestry and natural *infestation and damage occurs…"*

resource management. In addition, using satellites and other technologies to look at how things are happening at the landscape scale is a unique skill set and it really makes the work more fun and interesting."

But Williams thinks it unlikely he'll be able to take the next step with the adelgid/remote sensing work unless funds are made available, which, he says, "I don't think is in the cards right now."

And going for a doctorate is also not in the cards at the moment for Williams.

"I have entertained thoughts about going for a Ph.D., but I've now been in school for nine years and so I'm looking forward to a bit of an academic break," he says. "You can learn a lot in the classroom and a lot through your research program as a graduate student, but I feel that gaining some real-world experience and developing relationships with other professionals is really important at this point."

Adult hemlock woolly adelgids on hemlock branches. The aphid-like insect covers itself and its eggs with a white, waxy "wool" that acts as a protective coating.
Photo by Justin Williams, UNH/EOS.

As Spheres goes to press, Williams reports he's just landed a job with the U.S. Forest Service Southern Research Station in Starkville, Mississippi.

"As a research forestry technician, I'll be working with scientists on a project that studies the annual variation in bottomland oak species reproduction," he says adding, "and my remote sensing and GIS skills will be put to work through spatial analysis and mapping."

by David Sims, Science Writer, Institute for the Study of Earth, Oceans, and Space.

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Earth Systems Science

Have Funding, Will Travel

Ph.D. student and Fulbright Fellow Sophia Burke has used a sequence of undergraduate research and funding opportunities to trot the globe in pursuit of a scientific career

BELMONT, MASS. native Sophia Burke's decision to come to UNH in September 2009 was pretty much a no-brainer.

Sophie Burke deploys two UNH-developed methane traps in thaw ponds at the Stordalen Mire research site in Abisko, Sweden. The measurements are helping to quantify the powerful greenhouse gas's global budget.
Photo by Justine Ramage, Stockholm University.

"I started my search looking for a small liberal arts college where I could major in environmental sciences-ecosystems. When I discovered that many such schools didn't have environmental science programs of the same caliber as UNH the choice became very clear," says Burke, who generally goes by "Sophie."

It also soon became clear that not only had she chosen the right program at the right school but that an unanticipated wealth of opportunities lay waiting to be tapped.

When she took the class Techniques in Environmental Science taught by Ruth Varner of the Earth Systems Research Center, Burke recalls, "I told her about my interest in doing international research and she mentioned a National Science Foundation grant she was writing that would fund undergraduates to travel to northern Sweden to conduct biogeochemical research of various kinds. I was absolutely floored by the concept that one could apply for funding to travel to cool places and do very cool research!"

And apply she did. Since that initial meeting with Varner, Burke has not only been to Sweden for three stints—from undergraduate researcher to becoming Varner's research assistant last year—but also spent time in New Zealand in her junior year as part of the EcoQuest program. Over the years she has successfully garnered funding through internships, scholarships, and fellowships to make it all possible.

Her Fulbright Fellowship will fund a return to New Zealand this coming January where, for ten months, she will do field research and Ph.D. coursework at the University of Waikato in Hamilton.

Says Burke, "I'll be learning about peatlands that formed in a vastly different climate than what I'm used to—that is, subtropical versus subarctic. And I'll also learn about different ways that carbon flux is monitored in peatland ecosystems by taking measurements from a flux tower for the first time as well as doing incubation work."

The Sweden work is conducted under both a grant from the American-Swedish Institute and the NSF-funded Northern Ecosystems Research for Undergraduates program that focuses on the impacts of climate change on permafrost and lake environments in the Stordalen mire complex some 124 miles north of the Arctic Circle. NERU, which Varner directs, is a collaboration

"I was absolutely floored by the concept that one could apply for funding to travel to cool places and do very cool research!"

between UNH and the Abisko Scientific Research Station in Abisko, Sweden. After three years, NERU has thus far provided 30 undergraduates from colleges around the nation with the opportunity to travel abroad, cut their teeth on state-of-the-art climate change field research, and do coursework at UNH.

"Elevator speech" upward

Burke's Fulbright Fellowship and return to New Zealand is a direct result of her research in Abisko.

In December of 2012 she presented a poster on the her Sweden work at the American Geophysical Union's Fall Meeting where she met David Campbell of the University of Waikato. Much of Campbell's research has been focused on indigenous ecosystems, particularly the peat wetlands of northern New Zealand.

"In what I call my 'elevator speech' I told him right then and there that I would love to come back to New Zealand and work with him," Burke says. "I was considering going to graduate school there but funding was an issue. So with Ruth's encouragement, as well as Dr. Campbell's enthusiastic support, I applied for the Fulbright."

Sophie Burke
Photo by Kristi Donahue, UNH-EOS

Ten UNH applicants competed in the 2014-2015 Fulbright competition, with three advancing as finalists. Burke has just begun her Ph.D. in the UNH Natural Resources and Earth System Science program—Varner is her advisor.

What has sustained Burke's interest and led her to her chosen doctoral work is the desire to gain a scientific understanding of how a warming climate is altering subarctic (as well as subtropical) landscapes and how that in turn influences how carbon is processed and then released to the atmosphere.

"I'm very interested in how interconnected everything is and how the biogeochemical processes I monitor are closely linked to atmospheric conditions, and vise versa over a longer timescale," Burke says. "Peatlands are one of the most effective storage areas of carbon and can be some of the most sensitive ecosystems to environmental change, so I find monitoring how the changing climate is already affecting these landscapes to be a vital piece of environmental research. What's going to happen when these storage areas are no longer working?"

"Peatlands are one of the most effective storage areas of carbon… What's going to happen when these storage areas are no longer working?"

Model mentor

Another sustaining aspect of her work is her long-term interest in teaching and mentoring, the latter which she has both received and delivered working closely in the NERU program and influenced by Varner's style.

Sophie Burke gives a group of 2014 NERU students a tour of the Stordalen Mire and details the various research campaigns taking place at the site 124 miles north of the Arctic Circle.
Photo by Kiley Remiszewski, UNH.

Says Burke, "Ruth is a very special mentor. Her enthusiasm for her research is infectious and she is so genuine in her desire to help her students succeed. I have always admired and appreciated her ability to treat everyone as a colleague whether they are an undergraduate student on their first research experience or a collaborating professor. To her, everyone brings valuable experience and perspectives to the table."

Burke's Fulbright will provide further opportunities for teaching and mentoring as she will again participate in the New Zealand-based EcoQuest program—presenting her work to EQ students as well as giving tours of her research sites.

"I hope to gain valuable experience in place-based education by taking students out into the field and showing them first hand the scientific concepts they are learning in class. As a very visual learner myself, I find this one of the best ways to teach."

by David Sims, Science Writer, Institute for the Study of Earth, Oceans, and Space.

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Earth Systems Science

Carbon Bomb with a Long Fuse

Ph.D. student makes key finding in the climate change puzzle

CLAIRE TREAT funded the bulk of her Ph.D. work by winning a graduate fellowship from the Department of Energy Office of Science for her proposal titled "Future of soil carbon in permafrost regions: The great northern carbon bomb?"

To conduct this bomb detection, Treat gathered a variety of soil samples from sites in Alaska, incubated them, and mimicked various environmental conditions in a lab back at UNH where she finally measured the subsequent amount of carbon. The gist of the research is that the amount of carbon released by the soil, and whether it occurs as carbon dioxide or as methane, will determine how much warming these northern soils will contribute to climate change.

Claire Treat with a frozen soil core in Alaska's remote Innoko National Wildlife Refuge.
Photo by Carmel Johnston, Montana State University.

Four years later, doctorate in hand and now a postdoc with the University of Alaska and the U.S. Geological Survey in Menlo Park, California, Treat says her dissertation work essentially found that not all permafrost is created equal and that the potential bomb appears to have a long fuse.

"That had been one of the assumptions going into the work—that all permafrost was this super labile soil/organic matter that within several decades of thawing would decompose and all this carbon would be released to the atmosphere and enhance climate change," Treat says. "But I found that's not necessarily the case."

To make the needed permafrost comparisons, Treat gathered some 200 samples from several different sites, including two boreal forests—one in Fairbanks and one within the Innoko National Wildlife Refuge 300 miles west of Fairbanks at the tip of Seward Peninsula—and two tundra sites around the University of Alaska Fairbanks Toolik Field Station on the North Slope above the Arctic Circle.

At UNH, for two years one would see Treat traversing between Morse Hall and other campus labs cradling armloads of plastic tubs filled with soil samples.

Her basic methodology was to let the jars of soil samples sit for a month while incubating at a constant temperature before drawing out gas with a syringe to measure how much carbon dioxide *and* methane had been produced.

Notes Treat, "In one case we made an incubation chamber out of an old freezer—took it apart and replaced the power switches to make it turn off and on and regulate the temperature. That was really cool, a real technological feat as far as I was concerned."

Her sample analysis found there were very different carbon losses between the soils collected in the boreal and tundra areas. In the boreal peats, the active layer (the seasonally thawed surface soil layer), when heated up to an ideal incubation temperature released a lot of carbon while the permafrost didn't.

"This matters because it means carbon losses from some northern soils will contribute more than others."

"So that was an interesting finding," says Treat, "and then I had to figure out why."

She thinks it's because the permafrost formation histories are different. That is, in the Arctic, because it's so much colder, the permafrost forms in the soil before it gets a chance to decompose, whereas in the more southern, boreal sites, even small climate variations can cause permafrost degradation and decomposition.

Treat holds a 20-centimeter core drilled from a site with intact permafrost in the Innoko NWR.
Photo by Carmel Johnston, Montana State University.

"So the soils in the permafrost in the more southern, boreal sites are really old and highly decomposed, as opposed to really old and *not* decomposed, which was the thinking going into the research," Treat says. This matters because it means carbon losses from some northern soils will contribute more than others.

The old freezer-turned incubator also came in handy for another part of Treat's dissertation work with Wil Wollheim, co-director of the Water Systems Analysis Group within the Earth Systems Research Center (ESRC). Wollheim was working in the Alaskan tundra to determine whether climate change, through longer thawed seasons and shorter winters, was affecting nutrient cycling in streams. Treat and Wollheim, along with postdoc, Kyle Whittinghill, did field work at Toolik to ultimately measure nutrient concentrations in streams during the fall for the first time.

Says Treat, "There's this seasonal asynchronicity during the fall, in which microbes within the soil continue to decompose soil organic matter but plants are dormant and so the nutrient released during decomposition winds up in streams. For my dissertation work, I tested this using the freezer and some lights to simulate an Arctic summer, and measured the leaching nutrient losses to confirm that the soils could be releasing high amounts of nutrients during the fall."

Click here to view a short video of Treat and her Ph.D. advisor Wil Wollheim drilling core samples in Alaska.

Synthesis science, missing microbes

"But then a funny thing happened… I realized that the science hasn't been synthesized and that I was able to bring many pieces from different fields together…"

Another aspect of Treat's Ph.D. work, which was supplemented for a year by a UNH Graduate School Fellowship, was doing a comprehensive synthesis of previous studies similar to her incubation experiments.

"I conducted an anaerobic incubation synthesis where I and several colleagues compiled data from previous studies and looked for large-scale trends," says Treat.

For a while during the process of synthesizing twenty years worth of publications on the subject methane anaerobic incubation, Treat wondered whether or not she was pushing the science forward or simply pushing paper.

Gas-powered auger with a peat corer barrel attached.
Photo by Adam Wlostowski, Penn State University.

"But then a funny thing happened as I was writing the conclusion section of my dissertation. I considered what my work actually meant in a broader context and then realized that the science hasn't been synthesized and that I was able to bring many pieces from different fields together, as well as add some important new understanding.

For example, the incubation work at UNH revealed that carbon losses from the permafrost in particular are dependent on the substrate, specifically, how decomposed it is and its condition—warm, cold, aerobic or anaerobic—and on the inherent microbial communities.

"The research I've done adds an important new element, specifically, now we have a lot better understanding of how microbes play a part, and it turns out they *are* important." She adds, "And that's an area we just don't know too much about. Quantifying the microbial aspect is totally new, and I think my research has been helpful in framing it."

The results from the synthesis project revealed a lag period between the beginning of incubation and maximum methane flux, which is a totally different pattern than carbon dioxide production.

A soil core showing surface peat, which has lots of sphagnum moss bits, and permafrost peat. This core is from the Toolik Field Station on the North Slope above the Arctic Circle.
Photo by Claire Treat, UNH-EOS.

"We were trying to figure out why this lag time occurred because, in the field, it would mean there may not be methane production occurring for awhile after you get the right conditions," says Treat. "I have two working hypotheses—one is that it's simply a function of the biogeochemistry, and the other is that the microbes just aren't there or aren't active. When I was looking for information on that in the synthesis project it was not particularly easy to find."

Although further investigation into this will not be part of her postdoc work, Treat believes it is an important scientific area to investigate.

Modeling methane

As part of her postdoc work, Treat will be working with ESRC's Steve Frolking (a member of her Ph.D. committee), current supervisor Miriam Jones of the USGS, and Katie Walter Anthony of the University of Alaska Fairbanks compiling fossilized wetland vegetation datasets to look at species composition and peatland extent in the panarctic.

"The broad idea of the synthesis is to look at trends in Holocene methane emissions because certain signatures from peat samples indicate there was a higher terrestrial methane source around 7500 years ago. They haven't figured out what caused it but there are a few competing theories—one is peatland expansion and I think another is methane clathrate destabilization."

Methane clathrate, also known as methane ice, is a compound in which a large amount of methane is trapped within a crystal structure of water forming a solid similar to ice.

As for that ominous carbon bomb she initially set out to detect, Treat says,
" I think Steve put it pretty well—it has a long fuse—because there are so many variables and a lot of thermal inertia in the system. I think the expert projections are that it will really start to have an influence on climate in a hundred years and I think that's realistic, I don't think it's going to happen in the next 10 years."

by David Sims, Science Writer, Institute for the Study of Earth, Oceans, and Space.

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Fall 2014
In this Issue of *Spheres*…

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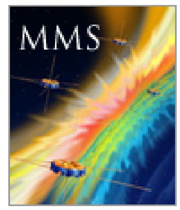
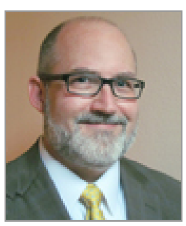
Spring 2014

Faculty, Staff, and Student News

Space Science Center



Program manager **John Macri** reports that the Pre-Ship Review for the Magnetospheric Multiscale (MMS) mission took place at the end of October at NASA's Goddard Space Flight Center and a NASA review panel gave the thumbs up to ship the four MMS observatories to Cape Canaveral, Florida to begin preparations for the March 2015 launch. The MMS mission is comprised of four identically instrumented spacecraft that will use Earth's magnetosphere as a laboratory to study the microphysics of three fundamental plasma processes—magnetic reconnection, energetic particle acceleration, and turbulence. Since 2005, UNH has been leading an international team of seven institutions in the construction of a key instrument suite for the mission. An animation of the MMS launch from Cape Canaveral Air Force Station and deployment in space can be viewed here. Video credit: NASA's Goddard Space Flight Center Conceptual Image Lab.



Joseph Dwyer

Joseph Dwyer arrived in late August from the Florida Institute of Technology to become the Peter T. Paul Chair in Space Sciences within EOS and the College of Engineering and Physical Sciences. Dwyer's primary research is focused on understanding the underlying physics of lightning discharges, which occur about four million times per day. Lightning strikes cause more deaths and injuries in the U.S. than either hurricanes or tornados. And Dwyer recently received the 2014 Karl Berger Award for distinguished achievements in the science and engineering of lightning research, developing new fields in theory and practice, modeling and measurements. The award is given every two years at the International Conference on Lightning Protection. Look for a feature story on Dwyer and his research in an upcoming issue of Spheres Online.

In early October, EOS director **Harlan Spence** and NH Space Grant Consortium director **Toni Galvin** took part in the Portsmouth Science Café's discussion on "Space weather: Radiation with a chance of solar flares" at the Portsmouth Brewery. The two astrophysicists shared their expertise with the audience and fielded questions about phenomena that can create aurora and disrupt satellites. Says Spence, "People invariably revel in and thirst for that firsthand contact with scientific discovery and exploration, and the café' venue facilitated an engaging discussion of space weather with a range of citizen scientists." Notes Galvin, "The scope of knowledge, as well as the interest exhibited by the audience was impressive and gratifying.

From the Director

EOS Graduate Research Scholars

Harlan Spence

The Institute for the Study of Earth, Oceans, and Space is a vibrant academic unit on campus and, unlike our college partners who focus on delivering undergraduate education, our prime mission is scholarly research, which in turn promotes and provides remarkable opportunities for graduate students across a broad spectrum of disciplines.

External research at UNH represents approximately one-third of all funding that fuels the university, and EOS contributes significantly toward that percentage, supporting a robust cohort of graduate students who earn their degrees in physics, Earth sciences, natural resources and the environment, etcetera.

In this issue of Spheres, we do something a little different and highlight graduate research within our Earth Systems Research Center by featuring the careers of four young professionals—from master's to postdoc. It is a small, focused sampling that represents well the many graduate scholars within EOS who contribute similarly across solar and space science as well as marine science and ocean engineering.

Original, independent research undergirds every graduate student's experience and, at EOS, it is the highly competitive external awards secured by our faculty and staff that fuel these experiences. The students, in turn, often provide the innovation and hard intellectual work needed to convert an interesting idea into a great scientific result and, more often than not, an important scientific discovery.

Their questions showed that they understood how space weather affects their daily lives and I was particularly pleased to see high school teachers in the audience."

Peter Bloser had two proposals selected for funding that will start early next year. One is from the Defense Threat Reduction Agency, part of the Department of Defense, for a "Field Deployable Neutron Camera for Special Nuclear Materials." It will be an instrument development effort for a portable imaging system for fast neutrons and builds off of **Jim Ryan's** Portable Neutron Spectroscope, or NSPECT, project but uses more robust, portable detector technology. The project includes **Jason Legere**, **Ryan**, **Mark McConnell**, **Sonya Smith**, and **Chris Bancroft**.

Bloser's second award is from NASA for "A Balloon-Borne, Advanced Scintillator Compton Telescope with Silicon Photomultiplier Readout." The project will fly a new gamma-ray instrument, the Advanced Scintillator Compton Telescope, or ASCOT, on a scientific balloon flight about two years from now. The project includes McConnell, Ryan, Legere, and a host of SSC engineers and students.

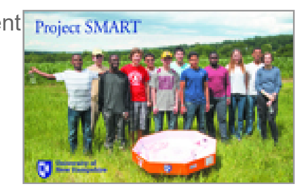
Every day and in every way our students bring scientific light to the otherwise dark mysteries of the world in which we live. As you read these stories, another theme emerges, namely, the way by which our students extend these discoveries to provide broader impact. Not only do they expand our fundamental knowledge about the complex Earth system but invariably these results add value in many ways beyond this noble cause—they inform policy makers, improve our lives, and educate and inspire both experts and lay people.
– *Harlan Spence*

Jichun Zhang was promoted to research assistant professor. Zhang, along with his graduate student **Anthony Saikin** and several SSC colleagues, published a paper in Geophysical Research Letters titled "Excitation of EMIC waves detected by the Van Allen Probes on 28 April 2013."

Cristian Ferradas

Ph.D. students **Jason Shuster** and **Cristian Ferradas** received prizes for their poster presentations at the annual Geospace Environment Modeling summer workshop in Portsmouth, Virginia this past June. Shuster won top prize for work targeting questions on the most fundamental aspects of magnetic reconnection and enabled by state-of-the-art supercomputer simulations performed in collaboration with the Los Alamos National Laboratory. His research helps to prepare for NASA's upcoming MMS mission. His advisors are **Roy Torbert** and **Li-Jen Chen**, the latter who is now at the NASA Goddard Space Flight Center. Ferradas was awarded second prize for his poster titled "Heavy ion dominance near Cluster perigees." Measuring the ion composition of space plasmas is a key step towards understanding where the different ion species come from and how they are energized, transported and lost in the Earth's magnetosphere. The poster presentation reports for the first time a statistical study of over ten years of observations of heavy ion dominance made by the Cluster mission in the inner region of the Earth's magnetosphere. Ferradas' advisor is Jichun Zhang.

Twelve high school students completed the space physics component of the **Project SMART** program this past summer, reports faculty advisor **Charles Smith**. In addition to performing seven research projects with faculty, the students learned basic circuitry for building small payload experiments, built five new compact instruments, and successfully launched a weather balloon to 100,000 feet. One instrument, a multi-spectrum analyzer prototype, is under continued development for future flights. "As in the past," Smith says, "EOS provided considerable funding from its own resources to make this program happen, and we hope to see some of these excellent students return as undergraduates in the future."



Project SMART

Eberhard Möbius reports that the IBEX Science Working Team Meeting hosted at UNH took place July 14-17 in DeMeritt Hall. The Interstellar Boundary Explorer was launched October 19, 2008 and carries two ultra-high sensitivity cameras containing important components designed and built at UNH. The cameras have helped map the edge of our solar system for the first time and are sampling the interstellar wind that blows through our solar system. Notes Möbius, "We are hoping to have many more years conducting science in concert with the two Voyager spacecraft that are venturing the heliospheric boundary at distance of 130 and 160 astronomical units, respectively, right now." One astronomical unit is equivalent to 150 million kilometers (93 million miles).

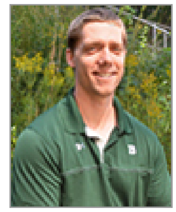
Jun Hong Chen, a Ph.D. student of Möbius, recently published his second first-author paper on pickup ions from the interstellar medium in the Journal of Geophysical Research and has submitted a third. His work concerns interstellar gas atoms that flow through our solar system and are turned into "pickup ions" that are created when the sun's ultraviolet radiation or the solar wind strips them of an electron. The solar wind and the embedded magnetic field picks them up and sweeps them out of the solar system.

SSC and department of physics alumna **Sandy Fletcher** '95G was a guest speaker at the New England Fall Astronomy Festival held in mid-October. Fletcher, a former student of **Mark McConnell,** is currently a NASA flight controller and astronaut trainer in the Extra-Vehicular Activity (EVA) Division at NASA's Johnson Space Flight Center in Houston, Texas. She gave a talk titled "U.S. Spacewalks—Past, Present, and Future of American EVAs."

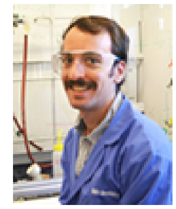
Kristi Donahue was appointed assistant director of the NH Space Grant Consortium (NHSGC).

Joseph Jensen

Natalie Kashi



Devon O'Rourke



Christopher Lyon

NHSGC recently awarded UNH Graduate Fellowships for Academic Year 2014-15 to five Ph.D. students who will work in respective faculty labs. They are, **Joseph Jensen**, a second-year student in space physics (**Jimmy Raeder**), **Natalie Kashi**, a first-year student in UNH's natural resources and the environment program (**Ruth Varner**), fourth-year chemistry student **Christopher Lyon** (**Erik Berda**), **Amanda Madden**, a fourth-year student in space physics (**Jim Ryan**), and first-year student in microbiology **Devon O'Rourke** (**Vaughn Cooper**).

NHSGC also supported three UNH Summer 2014 Interns. Mechanical engineering senior **Kiley Donohue** was an intern at the NASA AMES Academy, **Daniel Newell**, an electrical engineering senior, interned at NASA Langley Academy, and computer science sophomore **Tyler Slabinski** interned in the UNH Laboratory for Remote Sensing and Spatial Analysis in Morse Hall.

Ocean Process Analysis Laboratory

Amanda Madden

Joe Salisbury was appointed to the Maine State Commission to Study the Effects of Coastal and Ocean Acidification on Commercially Harvested and Grown Species—the first such scientific panel on the East Coast. The commission will study the negative effects of ocean acidification and make recommendations to the legislature on how to address the threat. Commission members include fishermen, aquaculturalists, scientists, and legislators. Growing acidification poses a significant threat in the Gulf of Maine as it can inhibit shell production of lobsters, crabs, clams, shrimp, oysters, scallops, mussels, and sea urchins.

Salisbury also contributed to the Global Carbon Budget 2014 paper published in the journal Earth System Science Data Discussions. Produced by dozens of scientists from around the world, the report states that carbon dioxide emissions are expected to reach a record high of 40 billion tons in 2014—evidence that global emissions are accelerating rather than slowing down.

Doug Vandemark

Jamie Pringle

Doug Vandemark had a four-year award granted this summer to continue work on NASA's International Ocean Vector Wind Science Team in conjunction with Jim Edson of the University of Connecticut. The study, titled "A multi-sensor view of satellite ocean wind stress estimation and its application to atmosphere-ocean coupling," involves comparison of moored buoy measurements of air-sea fluxes in the Gulf of Maine and North Atlantic to global satellite wind data measurements.

Jamie Pringle published the paper "The location, strength, and mechanisms behind marine biogeographic boundaries of the east coast of North America" in the journal Ecography, which highlights work on pattern and diversity in ecology. The paper examines what sets species boundaries at very high resolution by using four million-plus observations entered it into standard databases. The processes that affect the location of biogeographic boundaries are important to predictions of how the distribution and co-distribution of species might change in response to climate change (warmer waters) or the spread of invasive species.

Tim Moore is part of a new NASA grant that will address the inherent optical properties of oceanic particle absorption and backscattering as part of the upcoming Pre-Aerosol, Clouds, and ocean Ecosystem, or PACE, mission. Accurate values of absorption and backscattering, and estimates of their uncertainties, are critical for remote sensing validation and development. Moore also presented data from his Lake Erie toxic algae study at the Ocean Optics Conference in Portland, Maine at the end of October.

Earth Systems Research Center

Heidi Asbjornsen is the principal investigator on one of two National Science Foundation Major Research Instrumentation Program awards recently won by UNH. Asbjornsen's project is the installation of an Elemental Analyzer stable Isotope Ratio Mass Spectrometer in a dedicated Morse Hall laboratory. The spectrometer can examine stable isotopes of

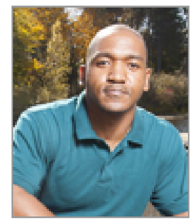

Heidi Asbjornsen

carbon, nitrogen, sulfur, oxygen, and hydrogen, allowing researchers to track the individual element progressions through the environment in an effort to understand how ecosystems respond to change over time. **Ruth Varner** and **Andrew Ouimette** are co-investigators, and **Linda Kalnejais**, **Wil Wollheim**, **Rossella Guerrieri**, **Michael Palace**, **Matthew Vadeboncoeur**, and **Erik Hobbie** are collaborators on the project. A total of twenty-four UNH faculty members, including postdoctoral scholars, and graduate students compose the diverse team of scientists who will use the spectrometer to further their current research projects on the impacts of climate change, human-environment interactions, and nutritional health.

Madeleine Mineau was promoted to research assistant professor. Mineau is currently working on applying UNH-developed coupled terrestrial and aquatic ecosystem models as part of the NH EPSCoR Ecosystems and Society project.

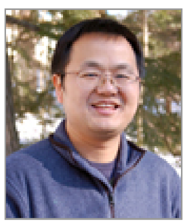

Madeline Mineau

Richard Carey was promoted to research scientist II. Carey published a paper in Environmental Science and Technology titled "Characterizing Storm-Event Nitrate Fluxes in a Fifth Order Suburbanizing Watershed Using In Situ Sensors" with coauthors **Wil Wollheim**, **Gopal Mulukutla**, and **Madeleine Mineau**.


Richard Carey

Wollheim, along with **Bill McDowell** of the UNH department of natural resources and the environment, was guest editor of a synthesis paper in a special issue of the journal Biogeochemistry on urban stream biogeochemistry. The issue is titled "Tracking evolution of urban biogeochemical cycles: past, present, and future."

Ph.D. student **Nathaniel Morse** published the first chapter of his dissertation in the same Biogeochemistry special issue. The paper is titled "Climate variability masks the impacts of land use change on nutrient export in a suburbanizing watershed." Wollheim, Morse's advisor, was coauthor. Morse also successfully defended his Ph.D. and is now a student of environmental law at the Boston University School of Law.


Jingfeng Xiao

Jingfeng Xiao was awarded $1.1 million from NASA for a three-year project titled "Exploring the interactions between carbon cycling, land use and climate change within mixed agricultural, forested, suburban, and urban landscapes." Co-investigators on the project are **Changsheng Li**, **Alexandra Contosta**, and **Ruth Varner**.

Xiao published a paper in Agricultural and Forest Meteorology with co-authors **Scott Ollinger** and **Steve Frolking** on a study that assessed the magnitude, distribution, and interannual variability of carbon sinks and sources over North America 2000-2012. And this summer Xiao was elected co-chair of the United States-China Carbon Consortium at the 11th USCCC Annual Meeting in Lanzhou, Gansu, China and gave invited talks at Tsinghua University and the Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences.

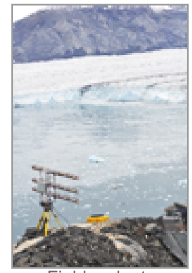
In early September, **Matt Huber** was one of 30 delegates at the "Early Cenozoic Tropical Climate: Report from the Tanzania Onshore Paleoclimate Integrated Coring (TOPIC) Workshop" in Dar-es-Salaam, Tanzania. The three-day gathering of scientists was an effort to develop a proposal for a new International Continental Scientific Drilling Program project to recover a stratigraphic and paleoclimatic record from the full succession of Eocene coastal marine sediments now uplifted and exposed on land in southern Tanzania.

Notes Huber, "New sea surface temperature data have revolutionized our view on how hot the tropics can get in a globally warm world. More data from these regions will add to the body of knowledge and help us better predict the future of the tropics, including heat stress, droughts, and food security issues. My role in this is as a climate modeler who uses this geological data and places it within a broader terrestrial and marine context for the past and future." For an inside look at the drilling project, see this video featuring Huber.

Carmody McCalley was lead author on a paper published in Nature titled "Methane dynamics regulated by microbial community response to permafrost thaw." The paper was based on work McCalley did as a postdoctoral researcher at the University of Arizona.

Steve Frolking was second author on a paper published in Nature titled "Direct human influence on atmospheric CO2 seasonality from increased cropland productivity."

In early October, Ph.D. student **Ryan Cassotto** concluded a week of fieldwork at the terminus of Columbia Glacier in Prince William Sound, Alaska with researchers from the USGS, the University of Alaska Fairbanks, and the Prince William Sound Science Center. They conducted radar scans of the glacier and fjord to monitor changes in the velocity in response to perturbations along the terminus. The data will also be used to analyze the trajectories and transit time of icebergs leaving the fjord, which could pose a hazard to ships and boats en route to Valdez. To view real-time images via the time-lapse camera the researchers installed at Columbia Glacier, see http://glacierresearch.org.


Fieldwork at Columbia Glacier

Following the fieldwork, Cassotto presented data from his studies at Jakobshavn Isbrae—a large glacier in Greenland, and Columbia Glacier at the 2014 Northwest Glaciologists meeting. The meeting was held at the Geophysical Institute at the University of Alaska Fairbanks where more than 50 researchers presented results from work in Alaska, Greenland, and Antarctica.

by David Sims, Science Writer, Institute for the Study of Earth, Oceans, and Space.

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