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Earth & Space Science News

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Earth's Microwave Maps

International Collaboration Amid Policy Challenges

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DEPARTMENTS

On the Cover

A scene from a 2016 wildfire in Alberta, Canada. Credit: Darryl Dyck/Bloomberg/Getty Images.

Eos

Editor in Chief

Barbara T. Richman: AGU, Washington, D. C., USA; eos_ brichman@agu.org

Editors

Christina M. S. Cohen California Institute of Technology, Pasadena, Calif., USA; cohen@srl.caltech.edu

José D. Fuentes Department of Meteorology, Pennsylvania State University, University Park, Pa., USA; juf15@meteo.psu.edu

Wendy S. Gordon Ecologia Consulting, Austin, Texas, USA; wendy@ecologiaconsulting .com

David Halpern Jet Propulsion Laboratory, Pasadena, Calif., USA; davidhalpern29@gmail .com

Carol A. Stein Department of Earth and Environmental Sciences, University of Illinois at Chicago, Chicago, Ill., USA; cstein@uic.edu

Staff

Production and Design: Faith A. Ishii, Production Manager; Melissa A. Tribur, Senior Production Specialist; Travis Frazier and Valerie Friedman, Electronic Graphics Specialists

Editorial: Peter L. Weiss, Manager/Senior News Editor; Mohi Kumar, Scientific Content Editor; Randy Showstack, Senior News Writer; JoAnna Wendel, News Writer; Liz Castenson, Editorial and Production Coordinator

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Advertising: Tracy LaMondue, Director, Development; Tel: +1-202-777-7372; Email: advertising@agu.org

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Christine W. McEntee, Executive Director/CEO

AGU American Geophysical Union

Thousands March Worldwide in Support of Science

On the afternoon of 22 April, Washington, D. C.'s Constitution Avenue filled with scientists and science enthusiasts marching in support of science. Credit: Lily Strelich

Nina Liakos hopes to be a geologist in her next life.

"When I studied geology in college, I was bored," Liakos said. "Then they discovered plate tectonics. I just have this picture of things floating around in a giant bathtub, and it's really cool."

Liakos, a retired teacher of English as a second language, expressed her next-life goals while walking along Constitution Avenue NW on a chilly, wet Saturday in Washington, D. C., surrounded by a column of marchers chanting in the name of science. She was one of thousands of teachers, students, scientists, and science enthusiasts on the National Mall on Earth Day, 22 April, at a demonstration for science and fact-based policy called the March for Science.

"I'm marching because there are not alternative facts," Liakos said. "There are only facts, many of them scientific facts. And we should unmuzzle scientists and let them tell us what the facts are."

Antiscience Frustrations

The march erupted from frustrations about stances of the new administration that critics say are antiscience. President Donald Trump has called climate change a hoax created by the Chinese. On 5 May, a fiscal year (FY) 2017 budget went into effect that leaves funding intact or slightly raises it for many science agencies. However, a preliminary outline of the FY 2018 proposed budget, unveiled on 16 March, would severely slash funding for the Environmental Protection Agency, NASA Earth science, the National Institutes of Health, the National Oceanic and Atmospheric Administration, and other federal science agencies. (The White House had not yet released the complete FY 2018 budget proposal when *Eos* went to press.)

"We're here to stand up for science," nuclear chemist Alison Tamasi, decked out in a glittery lab coat, told *Eos.* "Scientists need to step out of their lab and let the government know that they're people with opinions that need to be heard."

Scientists and environmentalists have also voiced concern about Trump's rolling back environmental policies initiated under former president Barack Obama, approving the Keystone XL pipeline, and even discouraging government scientists from speaking with the media and public. Many scientists are concerned that decades of valuable environmental data will disappear, prompting a wave of data rescue events across the country. Some people equate Trump to Canada's former prime minister Steven Harper, whose government destroyed environmental data. Harper's muzzling of government scientists also prompted Canadian scientists to march in 2012 in a "Death of Evidence" march.

The March for Science was inspired by the 21 January Women's March in Washington, D. C., which drew more than 500,000 people in protest of Trump's history of sexist comments and the administration's promises to roll back civil and reproductive rights protections. In the wake of that march, a small group of scientists started kicking around the idea about a scientists' march. The effort quickly grew online and then attracted the attention of several large scientific institutions like the American Association for the Advancement of Science, AGU (which publishes *Eos*), and The Planetary Society. Those organizations and more than 150 others signed on as partners. They teamed up with the Earth Day Network, which has organized annual Earth Day celebrations since the 1970s, to devote this year's Earth Day to promoting and defending science.

The Rally

A 4-hour rally starting at 10:00 a.m. kicked off Saturday's premiere March for Science event, the march in Washington, which shared the day with hundreds of satellite marches and rallies around the world.

Attendees of the D. C. rally milled around in the rain and mud, huddled under trees, and packed into tents where scientists gave 15-minute lectures about their research, covering topics from ocean conservation to bee biology. Meanwhile, speakers across a wide range of ages and backgrounds, including children, took to a stage to pump up the drenched crowd.

"We're gathered here today to fight for science," said science communicator and emcee of the rally Cara Santa Maria. "We're gathered here to fight for education. To fight for knowledge. And to fight for planet Earth."

Denis Hayes, cofounder of the original Earth Day in 1970, told the crowd, "America has had 45 presidents but never before had a president who is completely indifferent to the truth."

Other speakers included Bill Nye of "The Science Guy" fame, who is now CEO of The Planetary Society; retired astronomer Nancy Roman, who was chief of NASA's Astronomy and Relativity Programs and the first woman to hold an executive position at NASA; Michael Mann, a climate scientist at Pennsylvania State University in University Park; the musician Questlove;

Marcher Nina Liakos, a retired teacher of English as a second language, said she wants to be a geologist in her next life. Credit: Lily Strelich

Mona Hanna-Attisha, a pediatrician who first raised awareness of the high levels of lead in the drinking water of Flint, Mich.; Lydia Villa-Komaroff from the Society for the Advancement of Chicanos/Hispanics and Native Americans in Science; and many more.

During the organizing of the march, internal debate raged about how focused the march should be on diversity. Some critics attacked march organizers for focusing too much on issues of diversity, others for not enough. Some of the original organizers dropped out, claiming that diversity issues were being ignored.

"Science has historically been dominated by white males, and that has led to the oppression of many people," ecologist Theresa Ong told *Eos* at the rally. She and some fellow marchers, displaying a "Decolonize Science" banner, represented Science for the People, a group that advocates for science to fulfill social needs rather than corporate or war-driven ones.

"Science supports the lives of trans people, and we need to also support transgender scientists," Andrea Zekis, who marched representing the National Center for Transgender Equality, told *Eos.*

Not everyone liked hearing and seeing political views at a science rally.

"Science has to rise above politics," federal patent examiner Daniel Hess told *Eos.* Hess toted a handmade sign that said, "Universities are against free speech, against open debate, and demand conformity. Is science dead?"

"My sense is that people are [at the march] mostly because they dislike Trump" rather than in support of science, Hess said.

The March

After a morning filled with inspirational speeches and scientific talks, the attendees took to the streets, where the chanting crowd strode along a prearranged route to the U.S. Capitol Building. Chants included "What do we want? Science! When do we want it? After peer review!" and "Hey, hey, ho, ho, alternative facts have got to go!"

Signs held messages like "Science, not silence," "Make America smart again," "The seas are rising and so are we," and "Polar bears are on thin ice." Some marchers sported lab coats or dressed like famous fictional scientists like The Doctor from the British television show *Doctor Who* or the cantankerous Rick from the American television show *Rick and Morty*. There were at least three people in *Tyrannosaurus rex* costumes, warning onlookers that a fate similar to the dinosaurs' extinction could await humans and many other lifeforms on Earth from unchecked climate change.

"Science is the future, science is the present, science is going into space and saving organisms," said Bec, a teenage marcher sporting lab goggles. She hopes to someday study entomology. "I am marching in support of science because science" explains the things that make up our world, she said.

Caped science "superheroes" display an environmental banner at the Washington march. Credit: Lily Strelich

The banner at the vanguard of the 22 April satellite science march in Vienna, Austria, says, "Together for Science" in German. Credit: Bas den Hond

Satellite Marches

Science enthusiasts also marched in more than 600 locations globally, according to March for Science organizers. Satellite events occurred in New York, Chicago, Seattle, San Francisco, Los Angeles, and many other cities, while in other countries, sister marches advocated for science in Paris, London, Vienna, and Berlin, to name just a few. Scientists even marched at the North Pole.

In Charleston, S.C., chanting crowds converged from three directions on the city's Liberty Square, where marchers listened to Charleston mayor John Tecklenburg and city council member Michael Seekings talk about the threat of climate change.

"Sea level rise is a reality here in coastal South Carolina and around the world," Tecklenburg told *Eos,* stating that the city expects to see an estimated 60 centimeters (2 feet) of sea level rise in the next 35 years. "The need for preparedness in this community is urgent," he added.

"The only place on Earth that I think is denying climate change and sea level rise is 1600 Pennsylvania Avenue," Seekings told *Eos.*

At a satellite march in Vienna, Austria, where the annual meeting of the European Geosciences Union was about to begin, former geologist Birgit Kühnast said she was marching "because I notice more and more that people think science is just an opinion, a belief. I don't like to tell people that I know better than they because I am a scientist. But scientists should tell people more often, in a neutral way, what good they are doing" in the world.

By **JoAnna Wendel** (@JoAnnaScience), Staff Writer; **Randy Showstack,** Staff Writer; **Peter L. Weiss,** Senior News Editor; and **Bas den Hond,** Freelance Science Journalist

"Fingerprinting" Volcanic Tremors May Help Forecast Eruptions

Halema'uma'u, a crater within the larger Kīlauea caldera in Hawaii, glows at night. Kīlauea is one of the volcanoes fingerprinted in a new study. Credit: U.S. National Park Service

Volcanic tremors can mean that an eruption is imminent—or maybe not. When it comes to linking tremors with impending eruptions, researchers are still very much in the dark. In a new study, however, one team of volcanologists revealed the existence of distinct tremor patterns, or tremor "fingerprints," as they call them, shared among different kinds of volcanoes. Observations of such fingerprints may provide a small advance toward improved eruption forecasting. If, in the future, a volcano produces a fingerprint already found to have preceded or accompanied other eruptions, volcanologists might be better able to say whether an eruption will occur.

The team behind the study discovered the fingerprints by looking at seismic signals produced by four volcanoes: Okmok, Redoubt, and Pavlof in Alaska and Kīlauea in Hawaii. Kīlauea and Okmok are shield volcanoes, which are generally broad, gently sloping volcanoes constructed by relatively fluid lava. Pavlof and Redoubt are stratovolcanoes, which are more conical volcanoes made from lava more viscous than that which creates shield volcanoes. Generally, higher viscosity of the molten rock yields more violent eruptions.

"There are definitely different types of tremor, and it looks like they might be associated with different characteristics of these volcanoes," said Katharina Unglert, a volcanologist with the University of Exeter Camborne School of Mines in Penryn, U.K., and lead author of the recent study in the *Journal of Volcanology and Geothermal Research*. "At the very least, it's one step closer to understanding the vital signs that volcanoes are giving us and, maybe, in the long run, that will help us to improve eruption forecasting," she added.

Alaska's Redoubt volcano erupted in 2009. Recently, a team of scientists identified characteristic "fingerprints" in the tremor signals recorded before and during that eruption. Credit: Game McGimsey, USGS

For each type of tremor, Unglert and her coauthor, volcanologist Mark Jellinek of the University of British Columbia in Vancouver, Canada, analyzed the seismic wave fingerprint, the set of seismic waves of various frequencies and strengths that make up the tremor's vibrations. One fingerprint can comprise many frequencies, and the team set out to assess whether the fingerprints they analyzed from different volcanoes shared characteristics like their ranges of frequencies or which frequencies were more or less prevalent, explained Unglert.

How to Fingerprint Tremors

Finding fingerprints in tremor spectra using signals from actual volcanoes is the main accomplishment of Unglert and Jellinek's research, explained Jessica Johnson of the University of East Anglia, in Norwich, U.K., who was not involved in the work. The spectra are like "white noise," she said, and trying to identify the differences between sets of white noise can be a challenge.

In addition, tremors can sometimes last for hours, days, or weeks. In the case of Kīlauea, "since the 2008 summit eruption, there's been tremor going on at the summit for years," said Weston Thelen, a volcano seismologist at the U.S. Geological Survey's Cascades Volcano Observatory in Vancouver, Wash., who also was not involved in the work. If multiple seismometers are recording the shaking, "we've got a firehose of data coming at us," he said. "The problem becomes, How do you characterize that thing?"

To work through the noise, Unglert and Jellinek used a pattern recognition algorithm that they had detailed in previous work. This algorithm can tease out which seismic wave frequencies may be unique to different tremor signals. For example, the team analyzed tremors from the 2009 eruption of Alaska's Redoubt volcano, which lasted from March to July that year. Before the eruption, there was only tremor, "and then eventually a phreatic eruption started, which means an eruption that mostly involved water, and then we went into a phase of magmatic eruptions, where new magma came to the surface and caused these big explosions," Unglert said.

"What our analysis showed was that the tremor, during the initial phase where there wasn't much going on in terms of eruptions, was actually different from the tremor during the time period of phreatic and magmatic eruptions," Unglert explained. Before the eruption, more seismic waves with frequencies of about 3 hertz contributed to the spectrum than waves with other frequencies did.

Then, after the eruption began, the main contributing frequencies were between 1 and 2 hertz. "These are the different fingerprints," she explained.

In 2007 and 2011, mobile magma within Kīlauea caused eruptions and produced fingerprints with main contributing frequencies of around 1 hertz, similar to Redoubt's eruption fingerprint. "This MIGHT suggest that this type of tremor is caused by the movement of magma" within volcanoes in general, wrote Unglert in an email, despite one being a stratovolcano and the other being a shield volcano. Still, she stressed that researchers need to do similar analyses at other volcanoes to explore whether there is really a connection.

Kīlauea's 2008 eruption produced a different set of fingerprints not shared by Redoubt. During this eruption, Kīlauea produced fingerprints with frequencies clustering below 1 hertz, a pattern also observed in eruptions at Pavlof in 2007 and 2013. Because lava poured through open vents during those Kīlauea and Pavlof eruptions, Unglert speculated that the shared fingerprint "may indicate that an open vent process causes this type of tremor."

Fingerprints May Help with Forecasting

Such fingerprints may one day help volcanologists forecast eruptions. For instance, if the fingerprint that arose from Redoubt's 2009 eruption arises again in the future, "that might mean that we have an eruption coming up, or occurring right now, especially in places like Redoubt or in the Aleutians in general," said Unglert. The team's tremor-spotting algorithm is also automated, so "I think they could set it up in a real-time setting and have, for example, an alarm go off when it detects tremor—then that could be really useful for observatories that don't have many staff members," said Johnson.

Before deploying the algorithm in such ways, Unglert said that they need to assess other volcanoes "to reliably say, 'Okay, this tremor is definitely related to this style of eruption, or this type of magma, or things like that,' and this is what we would need to know to use [the algorithm] for eruption forecasting."

Thelen agrees. "If we can tie these spectral fingerprints to a process, that would be a step forward in expanding our forecast window," he said. For now, Unglert hopes that her work illustrates that although volcanoes can indeed be very different from one another, they can also be quite similar in subtle ways.

By **Lucas Joel** (email: lucasvjoel@gmail.com), Freelance Writer

Former NOAA Chief Scientist Warns of Threats to Science

Rick Spinrad, NOAA's former chief scientist, shared his insights on his time at the agency and his concerns for scientific endeavors under the current administration. Here he pauses during training for his walk across the United States. Credit: Rick Spinrad

Walking stick in hand, Rick Spinrad, the former chief scientist for the National Oceanic and Atmospheric Administration (NOAA), has averaged 24 kilometers a day on his postretirement 5091-kilometer trek across the United States.

Spinrad, 63, started out on 5 March from Cape Henlopen, Del. By 8 April he had already hiked 675 kilometers to McKeesport, Pa., east of Pittsburgh, through a "meteorological smorgasbord" of snow, sleet, driving rain, and clear blue skies. He plans to conclude his trek in early October in Newport, Ore.

During the walk, he is reflecting on his time at NOAA and what's happening now with science under the Trump administration.

An Antiscience Attitude

Spinrad says that there is a critical need right now to understand the Earth system well enough to predict its behavior and response to human activity.

However, he worries that the Trump administration's budget blueprint for fiscal year (FY) 2018 will delay meeting that need or cause it to go unmet. On 5 May, a FY 2017 budget went into effect that provides nearly flat or slightly increased funding for many science agencies. However, a preliminary outline of the FY 2018 proposed budget, unveiled on 16 March, would sharply cut funding for science, including for climate science programs and some Earth-observing satellites. (As *Eos* went to press, the full FY 2018 budget proposal had not yet been released by the White House.) Spinrad also worries about attitudes toward science within the administration.

"It's a code orange," Spinrad told *Eos* over hot chocolate in a restaurant in Washington, D. C., on a cold mid-March day.

"Generally, there's a strong antiscience attitude within this administration. I have heard nothing that suggests support for a scientific agenda," said Spinrad. He expressed specific concern about some administration appointees "who have clear antiscience agendas" and about proposed drastic cuts to the NOAA budget that include slashing the satellite division by 22% and the Office of Oceanic and Atmospheric Research by 26%. Cuts that big are "not something you can recover from," he said.

However, Spinrad says that his concern isn't yet in the red zone because he has confidence in those who are still working diligently on the scientific agenda in U.S. federal agencies.

Promoting Research at NOAA

A political appointee who retired in December, Spinrad served as NOAA chief scientist for about 2.5 years during the Obama administration. It was his second stint at the agency; he had served as an assistant administrator from 2003 until 2010.

The highlights of his tenure as chief scientist include a policy to transition research and development output into operations (http://bit.ly/R-D-transitions), a strategic research guidance memorandum to help direct future research at NOAA (http://bit.ly/strategic-guidance), and a "chief scientist's annual report," issued for the first time in December 2016, that not only documents research at the agency but also focuses on the beneficial impact of scientific investments on the American public (http://bit.ly/chief-sci-report).

Spinrad told *Eos* that he hopes that the Trump administration will retain the position of chief scientist. "Even if the NOAA administrator is an environmental scientist, he or she will never have the bandwidth to focus on just the scientific issues. The administrator needs a trusted agent without a particular agenda or bias, who can advise him or her on strategic scientific issues; that's what a chief scientist can do," he said. (As this issue of *Eos* went to press, the position remained vacant.)

From 2010 to 2014, Spinrad was vice president for research at Oregon State University in Corvallis, where he earlier had received his master's degree and Ph.D. in oceanography. Now he lives in Bend, Ore., and his deep ties to that state made it a good end point for the trek.

During his "long walk home," Spinrad's wife, Alanna, has helped him travel light by driving him to and from lodgings and helping with other logistics.

Targeting Anything About Climate Change

Spinrad told *Eos* that he does not believe NOAA is being particularly targeted by the Trump administration "because I don't think it has risen above the radar." He said the big targets right now are higher-visibility agencies, including the Environmental Protection Agency and the Department of Energy.

However, Spinrad does think that anything associated with climate is being targeted. "You can see that everywhere. This administration has a very different view of climate change, climate research, and the need to address the issues associated with climate change," he said. "I think somebody is probably doing a global search for anything that has climate in the title and saying, 'This is not consistent with administration policies.'"

Meeting some policy priority by "surgically" removing anything from the budget related to climate change "is neglectful of the fact that so much of climate research, climate observations, is integrally connected with the same observations and research that we would use for weather," Spinrad noted. He said, for instance, that data collected on sea surface temperature are as valuable for numerical weather prediction as they are for understanding the climate record.

"This sense that you can somehow segregate components of a research portfolio and therefore align the research with some ideology is woefully ignorant of what research is all about," he said.

Rick Spinrad strides through downtown Washington, D. C., on his "long walk home" from Cape Henlopen, Del., to Newport, Ore. Credit: Randy Showstack

> "It's a code orange," Spinrad said. "Generally, there's a strong antiscience attitude within this administration."

Concern About NOAA Satellites

Spinrad acknowledged that there is some validity to the argument that the commercial sector could help to maintain and operate satellite systems for the government. However, he said that because the Trump administration "emphasizes almost exclusively the transactional nature of everything, there is an assumption that as long as it makes good business sense, it's okay to have commercial entities provide [satellite] data."

Sometimes it's not about the return on investment but about protecting lives and property, Spinrad said. "It's like saying, 'Would you be comfortable with commercializing the military?' Of course not," he commented, adding that Americans want to know that their military forces are aligned with the public interest.

"The same should be true for environmental security," which satellite observations can help to provide, he continued. "The fact that public safety and the economy are so dependent on environmental factors means that absent the capability to understand and predict the environment, we will suffer both economically and in terms of safety."

Communicating the Relevance of Science

Spinrad said that the scientific community is partly to blame for an antiscience attitude and potential big budget cuts. "We have benefited from eras of relatively healthy support and felt that the value of what we did was self-evident," he told *Eos*.

However, Spinrad urged scientists to become better at explaining the value of their work to the public. He said that in the grand scheme of things, the Earth science research portfolio "is viewed as less relevant to the American public than health care research. I don't necessarily disagree with that. But I think it is much more relevant than most people think it is. That's on us to raise the visibility."

He is hopeful that that can happen and that the science will gain more support.

Spinrad also is hopeful about completing his trek. He temporarily halted the walk in Pennsylvania to recover from heel pain caused by plantar fasciitis. However, he restarted the walk in late February.

The delay did not keep him from participating in the 22 April March for Science. Spinrad gave a keynote speech at the march in Newport, Ore. "Any pain that I might endure from the hike won't compare with the suffering that could result from the cuts to research by our federal government," he said.

By **Randy Showstack** (@RandyShowstack), Staff Writer

Iranian Scientist Reflects on Attempted Immigration Ban

President Donald Trump's first 100 days in office shook up the science world. After his inauguration, Trump began to dismantle environmental measures enacted by former president Barack Obama; attempted to severely slash the budgets of NASA, the Environmental Protection Agency, the National Oceanic and Atmospheric Administration, and other scientific agencies; and twice attempted to temporarily ban immigrants, including scientists, from several countries from entering the United States.

Trump's first immigration-related executive order (EO), signed 25 January, implemented a 90-day ban on immigrants traveling from Iran, Iraq, Syria, Sudan, Libya, Somalia, and Yemen. As news of the so-called immigration ban spread, scientists around world spoke out, arguing that international collaboration was key to good science. The order was quickly blocked by U.S. federal courts. Trump attempted to push through a revised immigration ban in March, but federal courts blocked that as well.

When the first EO was signed, *Eos* spoke with several affected scientists from around the world. Solmaz Adeli, an Iranian postdoctoral researcher at the German Aerospace Center in Berlin told *Eos* that when the EO was announced, her interview at the U.S. embassy to acquire a travel visa to the United States was canceled. Adeli, a planetary geologist, was hoping to attend the Lunar and Planetary Science Conference (LPSC) in The Woodlands, Texas, but she was fearful that she would not be able to enter the United States.

Fortunately, Adeli did attend LPSC. *Eos* sat down with her at the meeting and later followed up by email to discuss her experiences in the immediate aftermath of the EO and during the tense days that followed. Her responses have been edited for clarity.

"I was shocked, like most of the people from the countries concerned and those who value peace and freedom in this world."

Protestors gathered at John F. Kennedy International Airport in New York on 28 January to demonstrate against President Donald Trump's first immigration ban. Credit: Associated Press/Craig Ruttle

Eos: *What were you thinking when the executive order was first signed?*

Adeli: I was shocked, of course, like most of the people from the countries concerned and those who value peace and freedom in this world. I felt strongly for my friends who live in the United States, who wanted their relatives to visit them there. I thought about all the Iranian students who had been granted a place at a university in the U.S., who simply had to forget all their efforts to make this opportunity possible and had to start over planning their future.

Eos: *What happened in the days and weeks following?*

Adeli: I was affected by the EO because I wanted to attend LPSC and had already booked an interview appointment at the U.S. embassy in Berlin. The appointment was canceled a few days after the EO was signed. For me, the EO meant that I would not be given a visa. I felt discriminated against. Getting a visa for the U.S. is quite a challenge for me, as I have to apply for a new one each time that I want to attend a conference or a meeting. Therefore, I try to choose wisely which conferences to attend, and I usually do not travel more than once a year across the Atlantic Ocean.

Eos: *Did any of your other colleagues at LPSC have a similar experience?*

Adeli: A U.S.-based Iranian postdoctoral researcher, who as well attended LPSC, told me that he would not attend any European conferences anymore because he was afraid of not being able to go back to the U.S., where he lives and works.

Eos: *What kind of reactions did you see at home and around the world? What did you think of them?*

Adeli: I was amazed by the reaction of people around the world, and particularly the Americans; those people protesting in the airports, those lawyers sitting on the ground with their laptop on their lap, and those journalists writing articles and tweeting to raise awareness. The Alliance of Science Organisations in Germany issued an official statement (see http://bit.ly/science-is-international) on 7 February with the title "Science Is International," in which it expressed its concern about the EO and its impacts on science. That statement was heartwarming for the expatriate young scientist living in Germany that I am.

Eos: *Why did you want to come to LPSC?*

Adeli: Attending an international conference means contributing to science and in

Solmaz Adeli, an Iranian postdoctoral researcher based in Germany, was afraid she wouldn't be able to attend an important scientific meeting in the United States. Credit: DLR-RPIF

science. International exchange is one of the most important matters. I can't be a good scientist without being able to attend one of the largest and most attended conferences in my field of study.

Most collaborations are triggered in such conferences; new ideas are born from these collaborations, which could potentially end up being a new mission discovering new frontiers. By not attending the U.S.-based events, I would miss out on half of the planetary science scene.

Eos: *When did you find out you were going to be able to come to LPSC? What did you think and feel?*

Adeli: A few days after the first EO was halted by a federal judge, I was able again to take an interview appointment at the U.S. embassy in Berlin. My interview was a few days later, and during this time, before the interview day, I was expecting at any moment to receive a new email stating that my appointment had been canceled. It did not happen. I was interviewed on the due day and was issued a visa right away.

I felt grateful to those judges, those lawyers, and all those people who took part in this movement and who cared. I then thought about this well-known poem of the Persian poet Sa'adi, which is also written in the halls of the United Nations, and reads as

Human beings are members of a whole,
In creation of one essence and soul.
If one member is afflicted with pain,
Other members uneasy will remain.
If you have no sympathy for human pain,
The name of human you cannot retain.

By **JoAnna Wendel** (@JoAnnaScience), Staff Writer

Tackling Sexual Harassment in Science: A Long Road Ahead

Do sexual harassment training sessions that are meant to curb inappropriate behavior really work? Once sexual harassment is uncovered, how well equipped are scientific institutions to help victims with the legal and emotional consequences? Do affected institutions, their funders, and related government agencies have policies in place, and are those policies well crafted and useful?

Since two high-profile cases of sexual harassment in the sciences came to light last year, researchers across scientific disciplines have been discussing these questions and others and seeking solutions. Some possible strategies have emerged, ranging from including sexual harassment as "scientific misconduct" in codes of conduct to clearly advertising a no-tolerance policy at scientific meetings to even trying to change the current hierarchical structure of academia itself.

> Sexual harassment training can sometimes have the opposite effect of reinforcing harmful stereotypes.

On 28 March, a committee of the U.S. National Academies of Sciences, Engineering, and Medicine convened an all-day workshop to hear from representatives of professional societies, academia, and others about the issue. The committee, which consists of scientists, researchers, medical professionals, and others, has been conducting a study of sexual harassment. The workshop had three main takeaways:

1. To Train or Not to Train?

One of the workshop panels centered on training meant to prevent sexual harassment and debate about the training's effectiveness. One panelist, Myra Hindus from Creative Diversity Solutions based in Boston, Mass., who has been studying sexual harassment and discrimination for more than 30 years, discussed studies that show that sexual harassment training can sometimes have the opposite effect of reinforcing harmful stereotypes.

For instance, a *Journal of Applied Behavioral Science* study published last year found that training could lead men to become defensive or worry that they'll be subjected to false accusations, or the training could reinforce implicit, gender-based biases.

However, another speaker, organizational psychologist Eden King of George Mason Uni-

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versity in Fairfax, Va., said that training could be effective and that the issue isn't so cut-and-dried. If a training session lasts more than 4 hours or is conducted face to face, she said, it tends to be more effective. One strategy that can backfire is informing trainees that everyone holds implicit biases, King noted. This information could make the behavior seem okay because everyone does or thinks it, which the trainers should try to avoid. Instead, King said, trainers should emphasize that although we all hold implicit biases, everyone has a desire to "do better."

2. Responsibility Without Authority

In another panel on how academic institutions tackle sexual harassment, David Mogk, a geologist at Montana State University in Bozeman, recalled the challenges in 2014 of processing sexual harassment cases in the department that he chaired at the time. Several women came forward that summer with official complaints about two professors within the Department of Earth Sciences. The ensuing investigation lasted more than a year and shook up the department in a permanently damaging way, Mogk said.

"For the affected individuals, [there] are traumatic and irreversible consequences," he said. Affected students requested lock changes for their work spaces or required psychological counseling or medication. Some were afraid to enter the department building or were forced to give up research projects entirely.

> Mogk had "a huge amount of responsibility but not necessarily the authority to deal with many issues."

As for the two perpetrators, Mogk said, they were suspended with full pay. Although the two men were not actively working, Mogk said he was not provided funding to hire new faculty, and the department suffered.

During open discussion with the audience after the panel, Mogk said that neither the president nor the provost of the university offered support or intervened in the situation. He said that a lack of support from his superiors greatly diminished his ability to support students who had suffered trauma.

"I needed someone higher up in the food chain to stand up and say these actions will not be tolerated," Mogk said. As department chair, he had "a huge amount of responsibility but not necessarily the authority to deal with many issues," he said, including gathering and documenting evidence and working with the university's legal team.

Eos asked Montana State University's Office of the President about the case. The school's executive director of university communications, Tracy Ellig, replied that the university promptly "took action upon receipt of the information and handled all complaints in a manner that was consistent with the requirements of our policies and the applicable laws of the state of Montana."

In addition to conducting an investigation, the university took "appropriate actions in response to the investigation," Ellig said. However, because of confidentiality requirements surrounding such cases, "the actions taken by the university would not have been within Dr. Mogk's direct knowledge."

3. Possible Policy Changes?

In another panel, Miriam Goldstein, legal director for Rep. Jackie Speier (D-Calif.), discussed a bill that Speier introduced to Congress last year that would require institutions to report any substantiated cases of sexual harassment, assault, or discrimination to their funding agencies. The bill would then require agencies to consider these reports when awarding future grants to the institution. Goldstein noted the "deafening silence" that came from several large scientific organizations that did not come out in support of the bill.

Panelist Janet Koster from the Association for Women in Science offered reasons her organization chose not to support the bill. One reason, she told *Eos*, was that there is no standard definition for "sexual harassment" and every institution has its own definitions, which could lead to uneven reporting. For instance, if someone made an untoward comment, was reprimanded, and changed his behavior, would that university still be required to report the individual? Does the bill differentiate between harassment of that nature and assault?

During the panel, Goldstein responded to this concern. The bill does differentiate between different kinds of harassment, she said, and it considers whether the perpetrator changed his or her behavior.

By **JoAnna Wendel** (@JoAnnaScience), Staff Writer

Geosciences Make Modest Gains but Still Struggle with Diversity

A scientist discusses zooplankton and phytoplankton with high school students visiting the University of Texas Marine Science Institute in Port Aransas in 2011. The students took a field trip to the institute sponsored by GeoFORCE, a program that introduces minority high school students from Houston and southwestern Texas to the geosciences. Credit: Jackson School of Geosciences, University of Texas at Austin

Recent research on diversity indicates that a general underrepresentation of minorities in science and engineering becomes even more pronounced in the geosciences. The findings show also that despite efforts to attract more minorities into the geosciences, their representation has improved only incrementally for more than a decade.

Women, on the other hand, have increased their presence in the geosciences since 2004. Back then, women earned one out of every three doctoral degrees awarded in the geosciences; by 2014, the share of Ph.D.s earned by women rose to 43%. Yet despite gains in educational attainment, women remain deeply underemployed in the geosciences, according to a recently released report from the National Center for Science and Engineering Statistics (NCSES), a division of the National Science Foundation. Across degree levels, women make up only 23% of the geoscience workforce, the report found, although that percentage rises slightly for women with advanced degrees.

The geosciences, as defined by the report, include Earth, atmospheric, and ocean science.

On 29 March, NCSES offered an hour-long webinar about its report "Women, Minorities, and Persons with Disabilities in Science and Engineering 2017." During the webinar, Emilda B. Rivers, deputy director of NCSES, discussed the findings of the report, which had been issued in January. The report draws on data from a variety of sources, including the 2014 American Community Survey, the 2015 National Survey of College Graduates, and degree completion data provided by the National Center for Education Statistics.

The State of Diversity in the Geosciences

Jackie Huntoon, provost and vice president for academic affairs at Michigan Technological University in Houghton, previously researched diversity in the geosciences and addresses it head-on in her current role. Increases in race and ethnicity are just not happening, she said.

The number of Ph.D.s awarded in a field tells an important story because the number indicates what is happening at the leadership levels, according to Huntoon. As reported by NCSES, 861 Ph.D.s were awarded in the geosciences in 2014, of which only 12 (1.4%) were earned by students categorized as "Black or African American." Hispanics represented just 2.4% of the Ph.D. recipients.

In 2004, black or African American students earned 0.93% of the doctorates awarded in the geosciences, whereas Hispanics earned 1.9%. American Indians and Alaska Natives earned a meager 0.12% of doctorates in the field in 2014, down from 2004.

> Increases in race and ethnicity are just not happening in the geosciences.

Huntoon explained that the proportion of whites among all U.S. geoscience doctorate graduates has stayed basically constant since 2004.

These numbers show that diversity programs may not have had the cumulative effect that leaders in the field had hoped for, Huntoon said. Many factors may contribute to this lack of diversity, she added. Underrepresented students may not have the precollege exposure to the geosciences that their white counterparts receive, and underrepresented students lack community in the geosciences at many institutions, Huntoon explained. Often, they are the "lonely only," she said: the only black student, the only Native American student, and so on.

Nicole LaDue, an assistant professor of geology and environmental geoscience at Northern Illinois University in DeKalb, added that many minority-serving institutions, like historically black colleges and universities, may lack the resources to hire sufficient geoscience faculty, further reducing exposure to the field.

LaDue highlighted that a 2014 study of geoscience websites found that most departments feature white males working outdoors, which might not accurately reflect the breadth of geoscience subdisciplines, she said.

Changing the Culture

Although the geosciences are struggling to increase diversity, some programs that pursue that aim have achieved recognized success. They include the Michigan Alliances for Graduate Education and the Professoriate and the Fisk-Vanderbilt Master's-to-Ph.D. Bridge Program, which focus on building community for and mentoring underrepresented students at the college level to foster their sense of belonging.

Another program, called GeoFORCE, received the Presidential Award for Excellence in Science, Mathematics, and Engineering Mentoring in 2015. It takes minority high school students from Houston and southwestern Texas on weeklong geoscience field trips for four consecutive summers. GeoFORCE is run by the Jackson School of Geosciences at the University of Texas at Austin, and 100% of its participants have graduated from high school, with nearly 98% attending some level of college, explained Sharon Mosher, Jackson's dean. Of those attending college, Mosher continued, approximately 58% go on to major in a science, technology, engineering, or math (STEM) field.

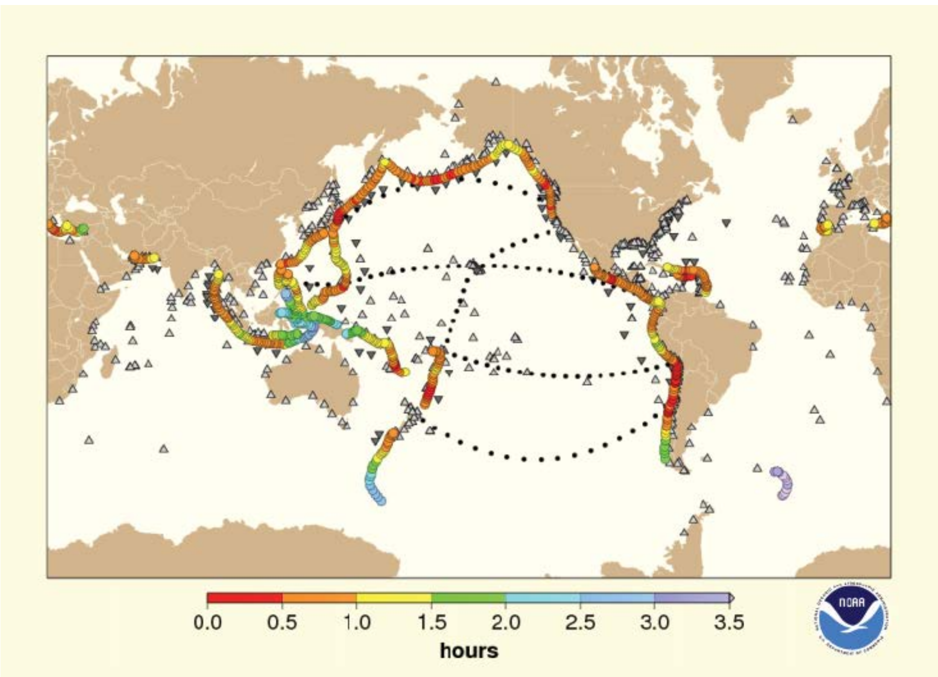
Huntoon argues that diversity in science is something all scientists should embrace. Simply put, she said, the more voices we have at the table, the better and more comprehensive our solutions to 21st-century problems will be.

The full report is available at http://bit.ly/NCSES-Report-2017.

By **Aaron Sidder** (email: aaron.sidder@gmail.com; @sidquan), Freelance Science Writer

Commercial Underwater Cables Could Reduce Disaster Impact

Workshop on SMART Cable Applications in Earthquake and Tsunami Science and Early Warning
Potsdam, Germany, 3–4 November 2016



The color scale shows the time lag between tsunami generation and detection for possible earthquake epicenters along subduction zones in the Pacific Ocean that could be achieved by installing sensors on the cable repeaters (black dots are 500 kilometers apart; separation in actual systems is 50 kilometers) along several existing submarine cables. The paths crossing the South Pacific Ocean are notional future paths, whereas the others are existing routes that are renewed every 10 or so years. Dark gray triangles show existing DART tsunameter buoys, and the light gray triangles represent seismic stations and mainland and island stations that measure sea level. Credit: Nathan Becker and Stuart Weinstein, Pacific Tsunami Warning Center, NWS, NOAA

Every minute counts in the business of tsunami early warning because tsunami waves often arrive less than 30 minutes after offshore earthquakes. Because most massive subduction zone quakes occur offshore, offshore observations are extremely valuable for quickly detecting and characterizing potential tsunamis. At the same time, unnecessary evacuations are costly and can endanger lives, so false warnings must be minimized.

The current Deep-ocean Assessment and Reporting of Tsunamis (DART) system uses ocean bottom pressure sensors to detect ocean-crossing tsunamis. The DART sensors are too sparse and too distant from shore to provide local warnings, and other real-time solutions like dedicated submarine detection cables come with a hefty price tag. Comprehensive coverage of all endangered subduction zones is out of reach using these systems, particularly in the developing world, but another approach that adds new capabilities to an existing resource could be a significant step in the right direction.

Today submarine telecommunications cables cross the world's oceans, and many run through or parallel to margins threatened by subduction zone earthquakes. The cables that currently form this network are not sensing their environment; however, these cables are routinely replaced every 10 to 15 years. Installing suitably modified repeaters along future cables, spaced at nominal 50-kilometer intervals, could provide power and bandwidth for sensors along these cables.

Last November, a group of research scientists, practitioners from earthquake observatories and tsunami warning centers, and engineers gathered for a workshop in Germany to discuss the viability of a new early warning system that uses enhanced telecommunications cables to create a Science Monitoring and Reliable Telecommunications (SMART) network capable of detecting tsunamis and shaking from great earthquakes (see http://bit.ly/SMART-Cable-2016). They further discussed how SMART cable sensor arrays would support research into tsunami excitation and propagation, the physics of great earthquakes, and the structure of Earth.

Given the needs of operational earthquake observatories and tsunami warning centers, attendees were excited about the concept of SMART cable systems equipped with accelerometers, pressure gauges, and temperature sensors. This concept is being advanced by a joint task force of the International Telecommunication Union, the World Meteorological Organization, and the Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization (UNESCO; see http://bit.ly/SMART-JTF). The Potsdam workshop followed two prior NASA workshops focused on applications in climate research and oceanography (see http://bit.ly/SMART-NASA).

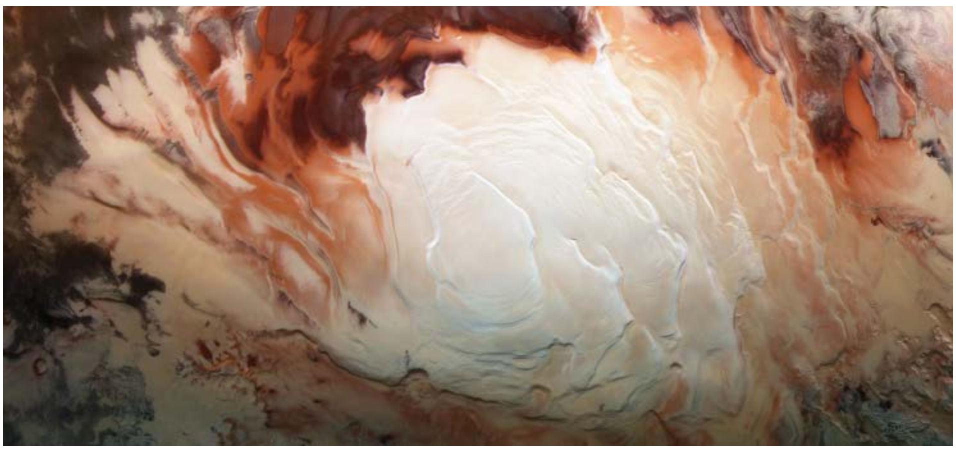
In one of the studies presented at the meeting, models showed that a few cables crossing the Pacific could reduce the time to detection of potentially tsunami inducing earthquakes by approximately 20%. The time to detection of the actual tsunami wave would be similarly reduced. Furthermore, the linear sensor arrays enabled by the SMART cables allow direct measurements of the tsunami wavefield. Such dense sampling could reduce dependence on seismological networks and allow researchers to characterize tsunamis triggered by submarine landslides or other nontectonic sources.

Workshop participants identified several potential targets for a small demonstration system, including existing cabled seafloor observatories. The participants agreed that the demonstration systems should be deployed in a manner equivalent to commercial cable-laying operations to demonstrate the viability of the SMART cable concept and to deliver valuable science data.

By **Frederik Tilmann** (email: tilmann@gfz-potsdam.de), Deutsches GeoForschungsZentrum (GFZ), Potsdam, Germany; **Bruce M. Howe,** Ocean and Resources Engineering, University of Hawai'i at Mānoa, Honolulu; and **Rhett Butler,** Hawai'i Institute of Geophysics and Planetology, University of Hawai'i at Mānoa, Honolulu

Mars Polar Intrigue Spurs Multidisciplinary Collaboration

Sixth International Conference on Mars Polar Science and Exploration
Reykjavík, Iceland, 5–9 September 2016



A view of Mars's south polar ice cap, taken by the European Space Agency's High Resolution Stereo Camera on board Mars Express. Credit: ESA/DLR/FU Berlin/Bill Dunford

Mars's polar regions are of special interest to atmospheric scientists and geologists. The poles exhibit unique atmospheric processes that periodically spill over into the lower latitudes in the form of storms. The polar ice caps (and their extensions in the form of lower-latitude ground ice deposits) are geological deposits intimately connected to the atmosphere. They are also known records of climate variations. Thus, the polar ice caps, atmosphere, and climate are best interpreted as an ensemble.

In this sense, Mars polar science is uniquely multidisciplinary. For the past 2 decades, the research community has benefited from periodic International Conferences on Mars Polar Science and Exploration, the most recent of which was in 2011.

Kvíarjökull, an outlet glacier from Öræfajökull, the 2110-meter glacier-capped stratovolcano that forms the southernmost part of the Vatnajökull ice cap. The Sixth International Conference on Mars Polar Science and Exploration offered several field trips to sites like this one that serve as analogues of Mars's polar regions. This particular site remains puzzling to terrestrial glaciologists because of the large lateral moraines that are higher than the glacier that made them. Credit: Isaac Smith

To discuss recent observations and interpretations since the fifth conference in 2011, more than 100 attendees from 11 countries attended the Sixth International Conference on Mars Polar Science and Exploration. Young scientists make up nearly a quarter of the Mars polar community—22 of the attendees were student participants—which suggests that recent exciting discoveries are attracting new researchers.

Presentations showed evidence of active atmospheric and surface processes that shape the polar layered deposits (PLDs) and nearby landforms. In addition, the north and south PLDs contain many layers of water ice and dust (southern PLDs also have layers of carbon dioxide) that have been used to constrain the history of accumulation at the poles and extract records of climate.

Finally, ongoing geomorphic activity points to widespread volatile transport between the poles and midlatitudes. These volatiles, especially carbon dioxide frost, modify the surface of dunes, gullies, and landforms. Presenters noted that some features on Mars have no terrestrial analogues because they are modified by carbon dioxide ice, which does not form on Earth.

In addition to the oral and poster technical sessions, the conference offered seven field trip options to participants and guests. Visits to Iceland's dramatic Mars glacial and volcanic analogue sites attracted widespread participation.

The conference was organized with the goals of demonstrating what the community has learned in the past 5 years and agreeing on the most important unresolved scientific questions for Mars polar science.

A team of synthesizers collected points of interest from the discussions. The team defined five major categories of questions:

- Polar atmosphere: What are the dynamical and physical atmospheric processes at various spatial and temporal scales in the polar regions, and how do they contribute to the global cycle of volatiles and dust?
- Perennial polar ices: What do the characteristics of the polar ice deposits reveal about their formation and evolution?
- Past climate polar record: How has Mars's climate evolved through geologic history, what are the absolute ages of the observable climate records, and how should we interpret the records of past states?
- Nonpolar ice: What are the history and present state of the middle- and low-latitude volatile reservoirs?
- Present-day surface activity: What are the roles of volatiles and dust in surface processes actively shaping the present polar regions of Mars?

Institutional support for the conference was provided by the NASA Mars Program Office, the European Geosciences Union, and the International Association of Cryospheric Sciences. Additional support came from the Icelandic Meteorological Office, the Planetary Science Institute, and the University of Iceland.

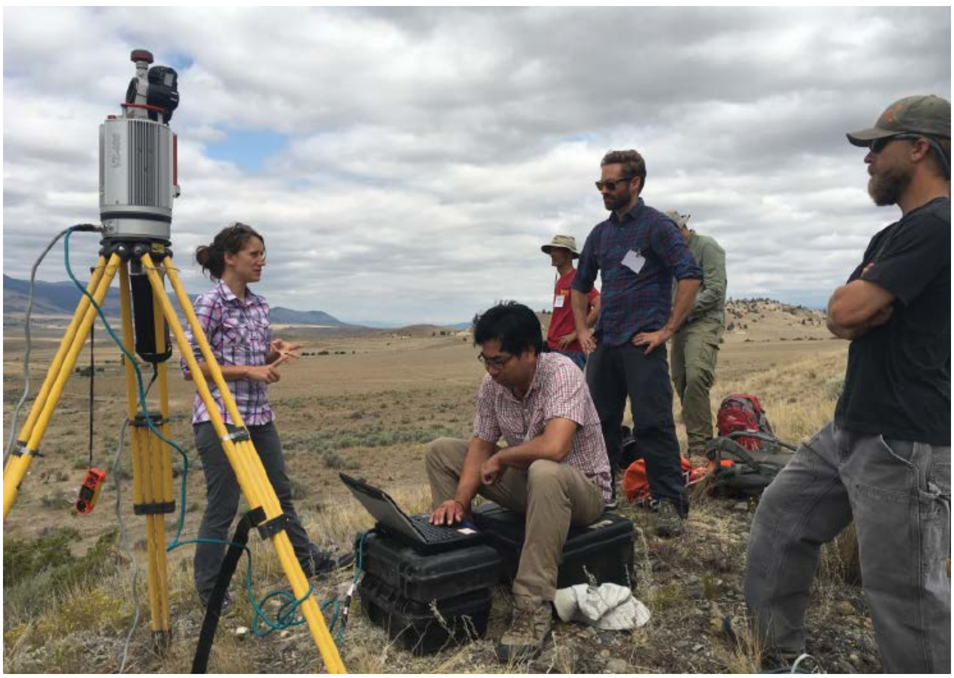
The full conference program and abstracts can be found on the conference's website (http://bit.ly/MarsPolarConf2016).

By **Isaac Smith** (email: ibsmith@psi.edu), Planetary Science Institute, Lakewood, Colo.; **David Beaty,** Jet Propulsion Laboratory, California Institute of Technology, Pasadena; and **Thorsteinn Thorsteinsson,** Icelandic Meteorological Office, Reykjavík, Iceland

Integrating Topographic Imaging into Geoscience Field Courses

Using TLS and Structure from Motion (SfM) Photogrammetry in Undergraduate Field Education

Cardwell, Montana, 16–19 August 2016



Geoscience instructors participating in a 2016 workshop operate a terrestrial laser scanning (TLS) instrument. Credit: UNAVCO

Fieldwork is a fundamental part of the geosciences, and there is a longstanding tradition of teaching field methods as part of the undergraduate curriculum. As the geosciences have become increasingly reliant on technology to acquire data for research, educators are expressing a growing interest in introducing these technologies into field education curricula.

A short course last August at the Indiana University Judson Mead Geologic Field Station in Montana brought together 21 geoscience field instructors to learn about incorporating terrestrial laser scanning (TLS; sometimes called ground-based lidar) and structure from motion (SfM) photogrammetry into geoscience courses with field components (see http://bit.ly/TLSSfM2016). Both methods can be used to generate high-resolution, three-dimensional topographic models that can be applied to hazard assessment, geomorphic change detection, and stratigraphic sequence analysis, to cite a few examples.

The workshop was built around the learning module Analyzing High Resolution Topography with TLS and SfM, the first published component of the Geodesy Tools for Societal Issues (GETSI) Field Collection (see http://bit.ly/GETSItools). This module teaches students to design and execute surveys that answer geoscience questions of societal importance. Instructors can choose to use TLS, SfM, or both methods in their courses. Both techniques have advantages and disadvantages, depending on what equipment the instructor has available and the type of geological problem being investigated. Both techniques produce fundamentally similar point cloud data sets that can be used in analysis. In addition, both methods require students to learn and use new quantitative skills.

> Educators are expressing a growing interest in introducing new technologies into field education curricula.

During the workshop, the field instructor participants completed the basics of the two methods, just as their students would. After introductory lectures on the survey methods, most of the first 2 days was spent in the field applying and practicing the survey methods at different field sites. During the latter part of each day, participants learned how to process data to generate point clouds and derive digital topographic models. The final day was devoted to further work on data analysis for different field applications, discussing and planning potential integration into courses, and becoming more familiar with the learning module's components.

Participants gave positive feedback; survey results showed that many of them intended to use the teaching resources in summer field camps and academic courses with field elements during the coming year.

The Analyzing High Resolution Topography module contains five units. Unit 1 is an introduction to TLS and SfM survey methods. Units 2–4 are each tailored to different scientific applications. Instructors can choose to implement one unit or all three, depending on the aims of the course. The featured applications are sedimentology/stratigraphy, fault scarp analysis, and geomorphic change detection. Unit 5 is a summative assessment of student learning. For courses in which students are unable to collect data in the field, the module also provides prepared data sets.

The teaching module development has been a long-term collaboration between Indiana University and UNAVCO, which runs the National Science Foundation's (NSF) Geodesy Advancing Geosciences and EarthScope (GAGE) Facility. Funding came from NSF through a supplement to the GAGE Facility (EAR-1261833) and the Improving Undergraduate STEM Education collaborative project granted to UNAVCO, Indiana University, and Idaho State University (EHR-1612248). For videos of TLS and SfM in action at the meeting, view this article on Eos.org at http://bit.ly/EOS_TLS_SfM.

By **Beth Pratt-Sitaula** (email: prattsitaula@unavco.org), Education and Community Engagement, UNAVCO, Boulder, Colo.; **Benjamin Crosby,** Department of Geosciences, Idaho State University, Pocatello; and **Christopher Crosby,** Geodetic Imaging, UNAVCO, Boulder, Colo.

Global Significance of the Changing Freshwater Carbon Cycle

As human activities continue to pump carbon into the atmosphere, the backbone of our understanding of the resulting warming is our knowledge of where that carbon is going: into the atmosphere, into the land, and into bodies of water. When it comes to accounting for the carbon absorbed and emitted by water, the role of inland freshwater may appear quite small compared to the vastness of Earth's oceans. After all, inland lakes, rivers, streams, reservoirs, wetlands, and estuaries cover less than 4% of Earth's surface [*Downing,* 2010; *Verpoorter et al.,* 2014].

But recent research shows that the roughly 200 million bodies of inland water play a much larger role in the global carbon cycle than their small footprint suggests. Inland streams and rivers move vast amounts of carbon from the land to the ocean, acting as carbon's busy transit system. They also play a disproportionately large role in the global carbon cycle through their high rates of carbon respiration and sequestration [*Cole et al.,* 2007; *Tranvik et al.,* 2009].

According to recent estimates, the amount of carbon that inland waters emit is comparable to the net amount of carbon absorbed by living organisms on Earth's land surface and in its oceans. Moreover, bodies of freshwater bury more carbon in sediments each year than the vast ocean floor [*Battin et al.,* 2009; *Aufdenkampe et al.,* 2011].

Nevertheless, there is great uncertainty in these figures, and scant data exist on continental and global scales. The changing climate is putting freshwater ecosystems at great risk: They are warming at an alarming rate, outpacing warming of the atmosphere and oceans. It's crucial that scientists dedicate more resources to understanding the global impact of the freshwater continuum on the carbon cycle.

Small inland freshwater bodies play a large role in the global carbon cycle. Here Ruddiman Lagoon, a small freshwater lake, joins Muskegon Lake, a freshwater estuary in Michigan that drains the extensive Muskegon River watershed into Lake Michigan. This North American Great Lake feeds the Saint Lawrence River, which drains into the Atlantic Ocean. Credit: Janet H. Vail

Emerging Role of Freshwater in the Global Theater

The latest models of the carbon cycle in land, ocean, and atmosphere show that the biosphere exchanges more than 400 billion metric tons of carbon every year: The land and oceans absorb 212 billion metric tons of carbon each year, and they release 206 billion tons [*Schlesinger and Bernhardt,* 2013]. Human activities emit around 10 billion metric tons of carbon each year, of which about half accumulates in the atmosphere. The other half is absorbed by the land and the ocean, 80% of which is accounted for, but the rest is still unknown.

The biggest absorbers of carbon are terrestrial ecosystems. Each year, they take up roughly 120 billion metric tons of carbon dioxide (CO_2) from the atmosphere and release back only 115 billion metric tons. The net balance of 5 billion metric tons is known as net primary production (NPP), and it represents carbon that is removed from the atmosphere. The oceanic ecosystem NPP is about 1 billion metric tons per year. The large net terrestrial carbon sink, together with the slightly smaller oceanic sink, helps mitigate the buildup of anthropogenic CO_2 from fossil fuel and biomass burning.

> The carbon absorbed by land doesn't necessarily stay there.

But the carbon absorbed by land doesn't necessarily stay there. Recent global estimates suggest that more than half of that carbon every year winds up in inland waters, roughly 2.7 billion metric tons. This area is where inland waters play a key role, with both positive and negative effects. Half of the carbon is respired and returned to the atmosphere as CO_2—enough to wipe out the helpful effects of the oceanic sink and on the same order of magnitude as the terrestrial sink [*Bastviken et al.,* 2011; *Raymond et al.,* 2013]. On the other hand, roughly 0.4 billion tons get buried in freshwater sediments. Although this is a much smaller fraction, it amounts to more than all

Freshwater waves lap against dune grass on Lake Michigan's eastern shoreline. The North American Great Lakes are the world's largest contiguous body of freshwater, and their vast continental basin encompasses rivers, lakes, streams, reservoirs, and wetlands. Credit: Janet H. Vail

the carbon burial in oceanic sediments [*Battin et al.,* 2009; *Aufdenkampe et al.,* 2011]. The remaining carbon (roughly 0.9 billion tons) is exported to the oceans.

The global importance of the freshwater carbon cycle has been recognized for some time now [*Cole et al.,* 2007], but scientists rarely identify it separately in diagrams of the global carbon budget. Moreover, the freshwater carbon cycle is usually lumped in with that of the land. Recent textbooks on global biogeochemistry completely overlook the revised role of inland waters in the global carbon cycle [*Schlesinger and Bernhardt,* 2013].

As a result, we lack adequate data and proper models to evaluate how global warming will affect the ways that freshwater interacts with the land, atmosphere, and oceans. Among these key uncertainties is our understanding of carbon transformations (e.g., NPP, respiration, and storage) taking place in inland waters [*Biddanda and Koopmans,* 2016].

What We Know and Don't Know About Freshwater's Role

Fortunately, our understanding of the carbon cycle in inland waters has improved since several recent studies have highlighted the issue. In 2013, for the first time, the report from the Intergovernmental Panel on Climate Change contained a brief description of the highly reactive freshwater ecosystems and included conservative estimates of carbon emission and burial (see http://bit.ly/IPCC-2013-report). However, much uncertainty still remains in those estimates for inland waters in general. Especially uncertain is how extensively human activity—like land use changes and runoff pollution of fertilizers into freshwater ecosystems—changes the carbon emission and storage process [*Regnier et al.,* 2013].

> Scientists must coordinate international studies to reduce uncertainty in estimates of carbon emissions from and sequestration in freshwater ecosystems.

In general, because rivers and streams import CO_2 from soils and groundwater in their watershed, they emit substantially more CO_2 than lakes do [*Raymond et al.,* 2013]. Furthermore, there is particular concern that climate-sensitive northern lakes and streams are emitting more carbon in response to thawing permafrost and changing hydrology that frees up the movement of carbon from the land [*Leach et al.,* 2016].

Mounting evidence also indicates that agriculture and urbanization-driven pollution are playing an important role. Fertilizers induce algae blooms and plant growth that take up carbon. This uptake decreases the amount of carbon emitted into the atmosphere and increases carbon sequestration in inland and coastal waters [*Pacheco et al.,* 2013; *Weinke et al.,* 2014]. However, as these organisms decay, the process of eutrophication depletes the supply of oxygen above lake beds and riverbeds, which increases the activity of anaerobic microbes that produce greenhouse gases such as methane [*Bastviken et al.,* 2011; *Campeau and del Giorgio,* 2014; *Borges et al.,* 2015].

Furthermore, the world's reservoirs—an exclusively human construct over the past century or so—are now estimated to collectively bury as much carbon and generate as much methane as the rest of the freshwater ecosystems combined [*Clow et al.,* 2015].

Last, there is justifiable concern that current models don't adequately account for the role of small ponds and streams, which store and transform relatively more carbon per unit area than larger bodies of water [*Hotchkiss et al.,* 2015; *Holgerson and Raymond,* 2016].

Freshwater Continuum in a Warming World

In recent decades, the surface waters of lakes across the world have been warming at an alarming rate of 0.3°C per decade [*O'Reilly et al.,* 2015]. In a CO_2-rich world with a growing human population, rising heat and per capita water use are placing freshwater ecosystems under increasing stress.

How this will affect the global carbon cycle—and climate change writ large—is still uncertain. Higher temperatures will likely intensify the microbial respiration of carbon, which will increase CO_2 emissions. However, ongoing eutrophication and warming of water bodies around the world may also lead to increased phytoplankton blooms, which would sequester additional carbon.

Because of their newly recognized role as a globally significant processor of carbon, the world's inland waters and what happens in them will play a critical role in the biosphere's feedback on future climate. However, despite the importance of inland waters as pivotal regulators of the global carbon cycle and as sensitive sentinels of environmental change, very few comprehensive studies of carbon flux among the variety of freshwater ecosystems on continental to global scales exist—and even those are limited [*Regnier et al.*, 2013].

Scientists must coordinate international studies to address the challenge of reducing uncertainty in estimates of carbon emissions from and sequestration in freshwater ecosystems. One way they can do this is by quantifying the rapidly changing carbon cycle among the 100–300 million inland freshwater bodies that bridge Earth's land-ocean continuum.

Acknowledgments

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By **Bopaiah A. Biddanda** (email: biddandb@gvsu.edu), Annis Water Resources Institute, Grand Valley State University, Muskegon, Mich.

METEOROLOGISTS TRACK WILDFIRES USING SATELLITE SMOKE IMAGES

By Amy K. Huff and Shobha Kondragunta

Wildfires and controlled burns place special demands on the people who decide where and when to deploy firefighters, how to keep controlled burns contained, and how best to protect life and property. Meteorologists from the National Weather Service, fire incident meteorologists, and state and local air quality forecasters provide information that is vital to assisting these decision makers. These meteorologists must determine the effects of smoke and quickly incorporate them into their forecasts related to visibility and air quality.

Fortunately, a new fire and smoke data resource from the National Oceanic and Atmospheric Administration (NOAA) makes a new generation of high-accuracy, high-resolution aerosol data products readily available to these forecasters. The new website, called enhanced Infusing satellite Data into Environmental Applications (eIDEA; http://bit.ly/eIDEA), gives meteorologists and other interested parties access to the latest generation of satellite aerosol products.

These new capabilities were put to the test in May 2016, when a monthlong fire broke out in Fort McMurray in northeastern Alberta, Canada (Figure 1). The fire forced almost 88,000 people to evacuate their homes.

This wildfire threatened Fort McMurray, Alberta, Canada, in May 2016. Forecasters used this fire to test the capabilities of a new fire and smoke data resource from NOAA. Credit: Darryl Dyck/Bloomberg/Getty Images

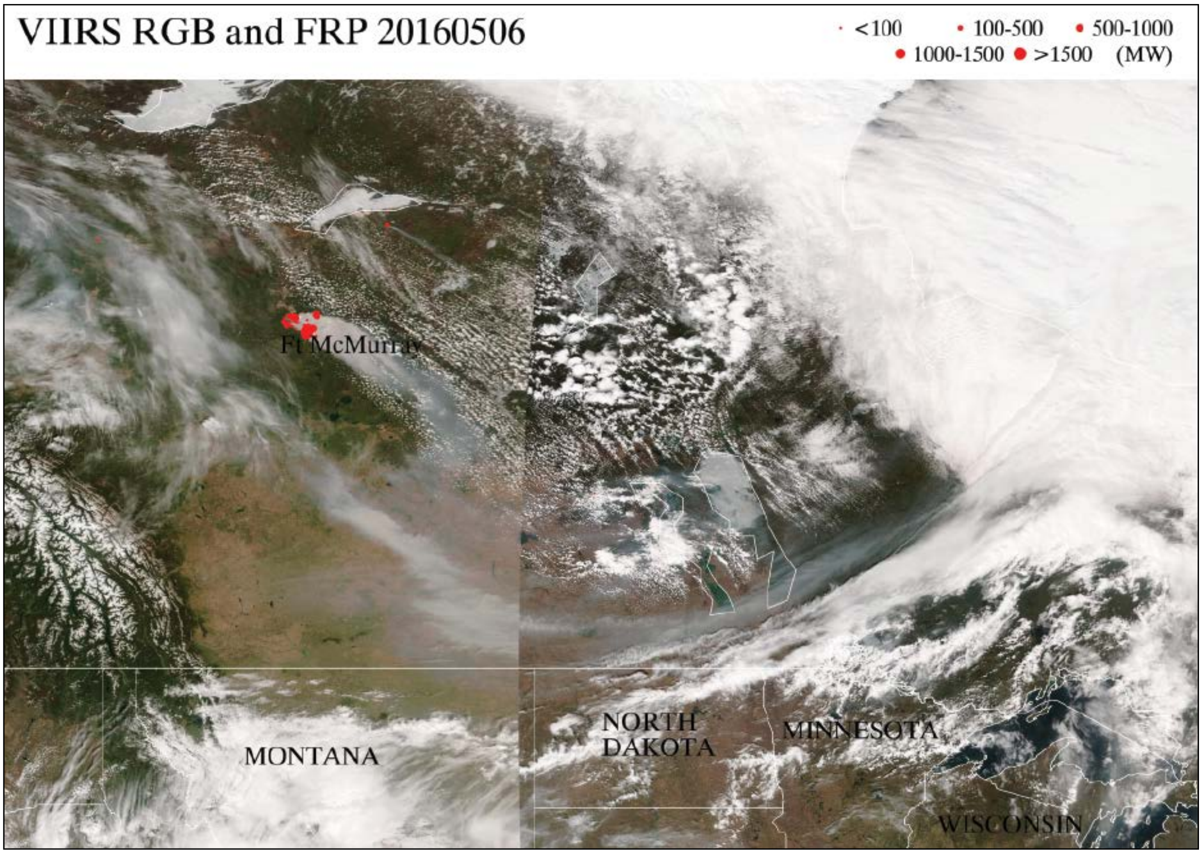


Fig. 1. True-color VIIRS satellite imagery (RGB) for 6 May 2016, displayed on the eIDEA website, shows plumes of thick, gray smoke streaming southeastward from the Fort McMurray fire in Alberta, Canada. Red dots are fire radiative power (FRP) hot spot detections, and clouds appear as bright white features. Credit: eIDEA

eIDEA: An Easy Interface for Data in Near Real Time

Observations made by the Visible Infrared Imaging Radiometer Suite (VIIRS) aboard NOAA and NASA's Suomi National Polar-orbiting Partnership (NPP; https://go.nasa.gov/2oJBkhn) Earth-observing satellite are used to generate eIDEA's products and images. These VIIRS aerosol data products and images feature high accuracy and high spatial resolution, making them particularly useful for monitoring the effects of smoke from wildfires and controlled burns.

The eIDEA website was designed specifically to address the needs of forecasters, who require timely data and imagery in a simple, easy to use interface. The VIIRS instrument provides forecasters with a variety of aerosol products that feature multiple layers of information, all of which are available on eIDEA in near real time, less than 2 hours from when the data were collected.

The area covered by eIDEA spans the continental United States, Alaska, and Canada. Recently, coverage was extended to include the part of the Pacific Ocean along the West Coast of the United States, the Caribbean Sea, and northern Mexico. During the 2016 fire season, fire incident meteorologists and air quality forecasters used this new decision support tool to track the effects of wildfire emissions.

Following the Smoke Signals

Because smoke has a very high concentration of aerosol particles, forecasters can use the information on eIDEA to track the geographic extent and transport of smoke plumes. One of the most useful data products on eIDEA is aerosol optical thickness (AOT), sometimes called aerosol optical depth. AOT is a measure of the scattering and absorption of visible light by particles in a vertical column of the atmosphere.

AOT is unitless and typically varies from 0 to 1 in the United States, although individual smoke plumes can have AOT values as high as 4. This data product is often represented by color codes in imagery, with cool colors (blues and greens) corresponding to lower AOT and warm colors (yellows, oranges, and reds) corresponding to higher AOT.

This measurement has certain limitations. Clouds block the measurement of AOT, so there are no measurements in cloudy regions, and data are not retrieved over areas covered by snow. AOT measures the total light absorption and scattering for a given air column, so it does not provide any information about the height of the aerosols within this column. Nor does it tell us how likely the particles are to reach the ground.

However, a NOAA trajectory product based on AOT measurements has proven useful in situations when forecasters need to predict how a smoke plume will affect surface conditions. In this trajectory product, AOT measurements serve as the basis for monitoring the plume vertically and horizontally as it moves forward through Earth's atmosphere. Forecasts of a smoke plume's forward trajectory are initiated in areas of high observed AOT (greater than 0.4), and they run 48 hours into the future in 3-hour time steps. The trajectory product on eIDEA maps the forward movement of the smoke plumes using a color-coded scale.

As the forecast maps change over time, the color coding helps forecasters track the flow of aerosol-laden air toward or away from the surface, as well as the smoke plume's horizontal trajectory. Wind field vectors are plotted as white arrows to show wind direction and speed. The maps also show areas where precipitation is forecast because rain or snow can remove aerosol particles from the atmosphere.

NOAA's trajectory product is vital to making smoke forecasts. Smoke particles can be at any height in the atmosphere, but they are usually lofted up above the surface as the smoke plume moves away from the fire. Once the smoke is aloft, it can be transported tens to hundreds of kilometers downwind. If the smoke stays aloft, it doesn't affect ground-level air quality or visibility, although it can affect aircraft visibility. However, if some weather system downwind pulls or mixes the smoke plume to the surface, it can affect local air quality and visibility at that downwind location, far from the fire. The vertical movement of the smoke from aloft in the atmosphere down to ground level is very difficult to forecast, and this process is what the trajectories help to predict.

Another data product available from eIDEA is a VIIRS smoke mask, which gives a qualitative indication of smoke that originates from burning fires in the region or that has been transported to the region from upwind, providing a quick way to see the location and extent of smoke plumes. The smoke mask is derived using spectral and spatial threshold tests based on VIIRS measurements in the visible and infrared wavelengths.

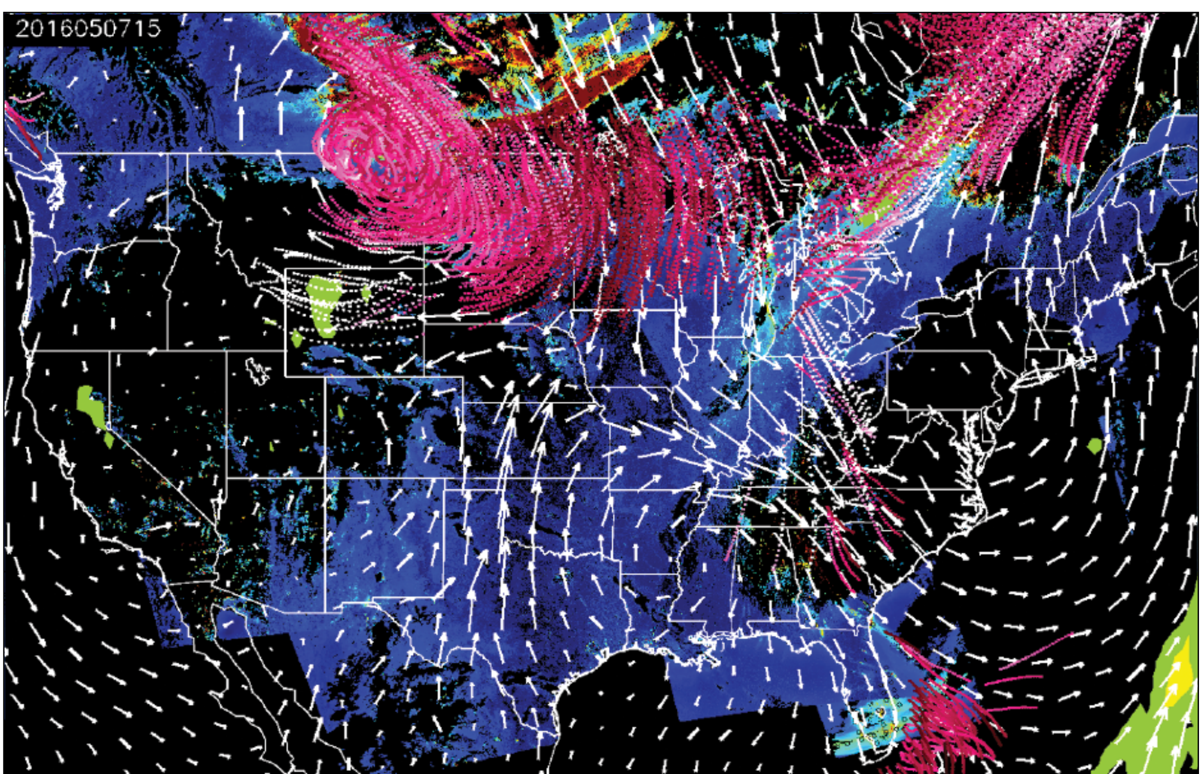
VIIRS also senses the locations of fires as hot spots, represented in imagery by red dots on eIDEA. The sizes of these dots indicate the quantitative intensity of the fire as the VIIRS fire radiative power, and eIDEA provides an easy way to view these hot spots and track them over time.

Putting the Capabilities to Use for the 2016 Fort McMurray Fire

Last year's Fort McMurray fire in northeastern Alberta is a case study in how the VIIRS aerosol products on eIDEA can provide information on smoke transport and its potential for affecting surface conditions. The fire started on 1 May 2016 and burned for more than a month, consuming more than 600,000 hectares and forcing the evacuation of almost 88,000 residents from the city of Fort McMurray in early May. By 6 May, thick smoke from the fire was moving southeastward toward the northern plains of the United States.

On that day, the eIDEA trajectory forecast (Figure 2) predicted that the Fort McMurray smoke plume would reach the northern plains states and mix down to the surface from aloft in the atmosphere on 7 May.

Fig. 2. Static representation of 48-hour aerosol trajectories from eIDEA showing transport of aerosol-rich air into the northern U.S. plains states on 7 May 2016 at 15:00 UTC. The trajectories, represented by magenta and pink lines, originate at locations of high VIIRS aerosol optical depth (red, orange, and yellow shading in top middle of image). The trajectories show the direction of transport (south–southeast and then curving to the west); the magenta color indicates that aerosol-rich air will remain close to the surface. White arrows are wind vectors at 850-millibar atmospheric pressure. Credit: eIDEA



The trajectories forecast, presented on eIDEA as a dynamic animation, recalculates images in 3-hour increments; Figure 2 shows a snapshot from 7 May at 15:00 UTC as a representative example. The magenta and pink lines show the southward and southeastward movement of the aerosol-rich plume, located over southern Saskatchewan and Manitoba on 6 May (red, orange, and yellow region). The magenta and pink colors of the trajectory lines indicated that the smoke plume would remain close to Earth's surface as it moved into eastern Montana, North Dakota, South Dakota, Minnesota, and Iowa on 7 May.

The VIIRS aerosol observations from eIDEA demonstrate that the trajectory predictions were accurate. Figure 3 shows plumes of high AOT associated with smoke from the Fort McMurray fire over the northern plains on 7 May. This transported smoke blanketed the ground surface; fine particulate matter exceeded National Ambient Air Quality Standards (NAAQS; http://bit.ly/NAAQS-Table) across Iowa, Minnesota, eastern Nebraska, and North Dakota (Figure 4). Locations where smoke affected ground-level air quality are evident from this eIDEA display, which overlays daily average fine particulate matter concentrations ($PM_{2.5}$) from the U.S. Environmental Protection Agency's (EPA) AirNow network (https://www.airnow.gov) onto a map of the area.

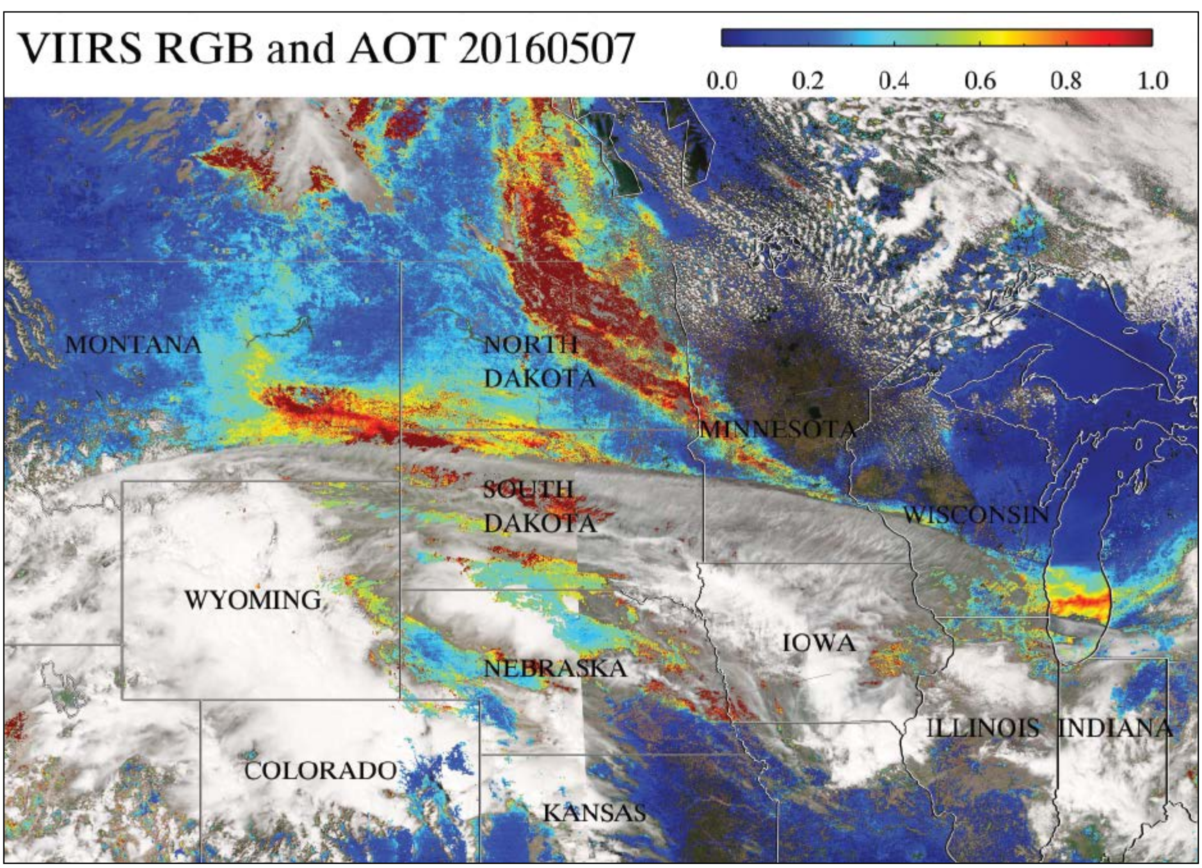
The $PM_{2.5}$ concentration measurements from the AirNow network are represented as colored dots. The colors of the dots match the colors of EPA's Air Quality Index (AQI; http://bit.ly/Air-Quality-Index). Code Orange and Code Red values represent particulate concentrations in excess of the daily NAAQS. The 24-hour average $PM_{2.5}$ concentrations on 7 May in the northern plains (Figure 4) ranged from Code Red in northwestern Iowa and metropolitan Minneapolis–Saint Paul, Minn., to Code Orange in metropolitan Omaha and Lincoln, Neb., and Bismarck, N.D. This event lasted only 1 day, with $PM_{2.5}$ concentrations dropping down into the safer Code Yellow range across the northern plains on 8 May.

A New Satellite Means Faster Updates in eIDEA's Future

Last November, NASA launched NOAA's Geostationary Operational Environmental Satellite–R Series (GOES-R; http://www.goes-r.gov) geostationary weather satellite, now known as GOES-16. The eIDEA website will be updated to include new aerosol products derived from GOES-16 data as soon as they become available, sometime in late summer or early autumn of 2017.

GOES-16 is the first in the next generation of geostationary Earth-observing satellites. It has a sensor similar to VIIRS, called the Advanced Baseline Imager (ABI), that

Fig. 3. VIIRS aerosol optical thickness (AOT) measurements are overlaid with VIIRS true-color imagery (RGB) from eIDEA for 7 May 2016. The red, orange, and yellow areas indicate high AOT associated with smoke plumes from the Fort McMurray fire that were transported into the northern plains of the United States. Clouds (white areas) block the measurement of AOT, so there are no AOT measurements for these areas. Credit: eIDEA



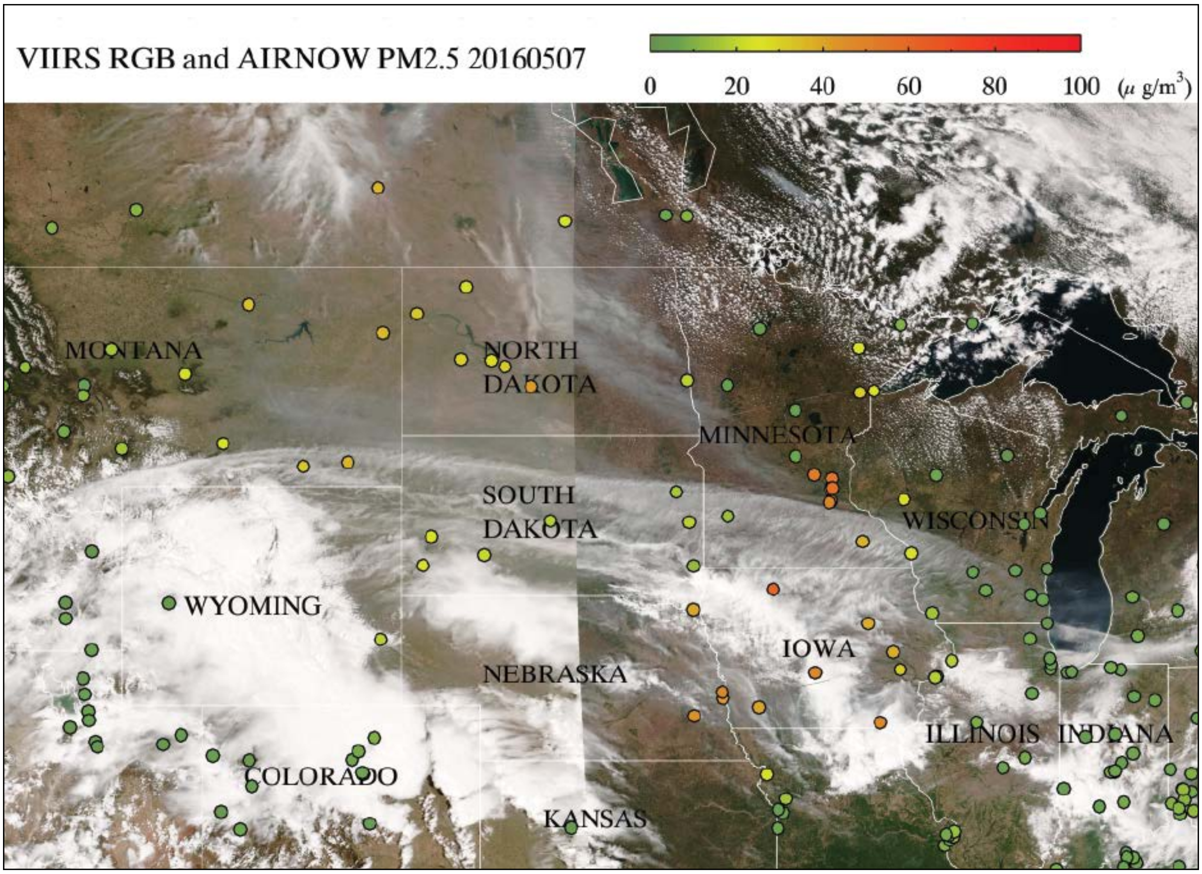


Fig. 4. An eIDEA image for 7 May 2016 showing VIIRS true-color imagery (RGB) overlaid with colored dots representing daily $PM_{2.5}$ (fine particulates) Air Quality Index values from the U.S. EPA's AirNow network. Red and orange dots in Iowa, Minnesota, Nebraska, and North Dakota indicate exceedances of the $PM_{2.5}$ National Ambient Air Quality Standard (NAAQS). Smoke plumes from the Fort McMurray wildfire are visible as gray wispy features, and clouds are bright white. Credit: eIDEA

will routinely provide aerosol observations every 15 minutes over the full disk of the Earth, covering North and South America, and every 5 minutes over the continental United States. In this way, the GOES-16 ABI will provide nearly continuous, high-accuracy aerosol observations of the atmosphere over the entire Western Hemisphere, in contrast to the once-daily afternoon snapshots available using VIIRS.

When GOES-16 satellite data are incorporated into eIDEA, forecasters will have nearly continuous observations of smoke plumes in the atmosphere.

The GOES-16 ABI can also scan a small mesoscale subsection of the continental United States every 30 seconds. This mesoscale region will vary depending on current conditions; it will be an area of intense weather or fire activity where conditions are changing rapidly. With aerosol and cloud imagery routinely available at 5-minute intervals, data from GOES-16 will become indispensable for forecasters who need to assess the effects of smoke to help protect public safety and air quality.

When GOES-16 data are incorporated into eIDEA, forecasters will have nearly continuous observations of smoke plumes in the atmosphere. The eIDEA website will include animations of GOES-16 AOT, smoke mask, and true-color imagery. Composites of daily GOES-16 imagery will compensate for AOT data that are missing because of cloud cover. Using these new capabilities, forecasters will be able to provide more detailed information than ever before to the agencies and organizations responsible for protecting lives and property.

Author Information

Amy K. Huff (email: akh157@psu.edu), Meteorology Department, Pennsylvania State University, University Park; and **Shobha Kondragunta,** Center for Satellite Applications and Research, National Environmental Satellite, Data, and Information Service, NOAA, College Park, Md.

FOUR STEPS TO FINDING YOUR CAREER FIT

By David Harwell and Nathaniel Janick

Just as there are many kinds of outfits, there are many career options, but they won't all fit you equally well. To find your ideal fit, cut from the same cloth as a personal stylist.

First, you'll need to work with what you've got: What are your skills? Next, find your style: What factors drive you? Finally, take stock of what's in store: What jobs are available? You'll find your best fit where these three factors meet.

You should avoid areas where only two of the three factors for fit align. For example, when you find something that maps well with your passions and skills but no one will pay you to do it, that's a hobby. When someone wants to pay you for a job that matches your skills but not your drivers, that's misery. And when you find a job that matches your drivers and pay requirements but not your skills, you're likely to be incompetent at it. You can exist in a job where only two vectors align for short periods, but it is unlikely that you will perform well or be motivated enough to advance.

But when all three align? Magnifique! Below is a four-step exercise to help you find your best career fit.

1. Evaluate Your Technical Skills

This seems easy. After all, one would hope that you know what you're good at. However, there are some nuances to explore here.

The exact makeup of the skills required will depend on the specific job and industry. Specific skills for a given job will be embedded in the job listing, either explicitly or implicitly.

Skills can be broken down into two categories: technical and nontechnical. Even though this exercise is about finding *your* fit, any time you're looking for work, you have to meet on the employers' terms. For that reason, we're going to explore skills by looking at a sample text from a job posting.

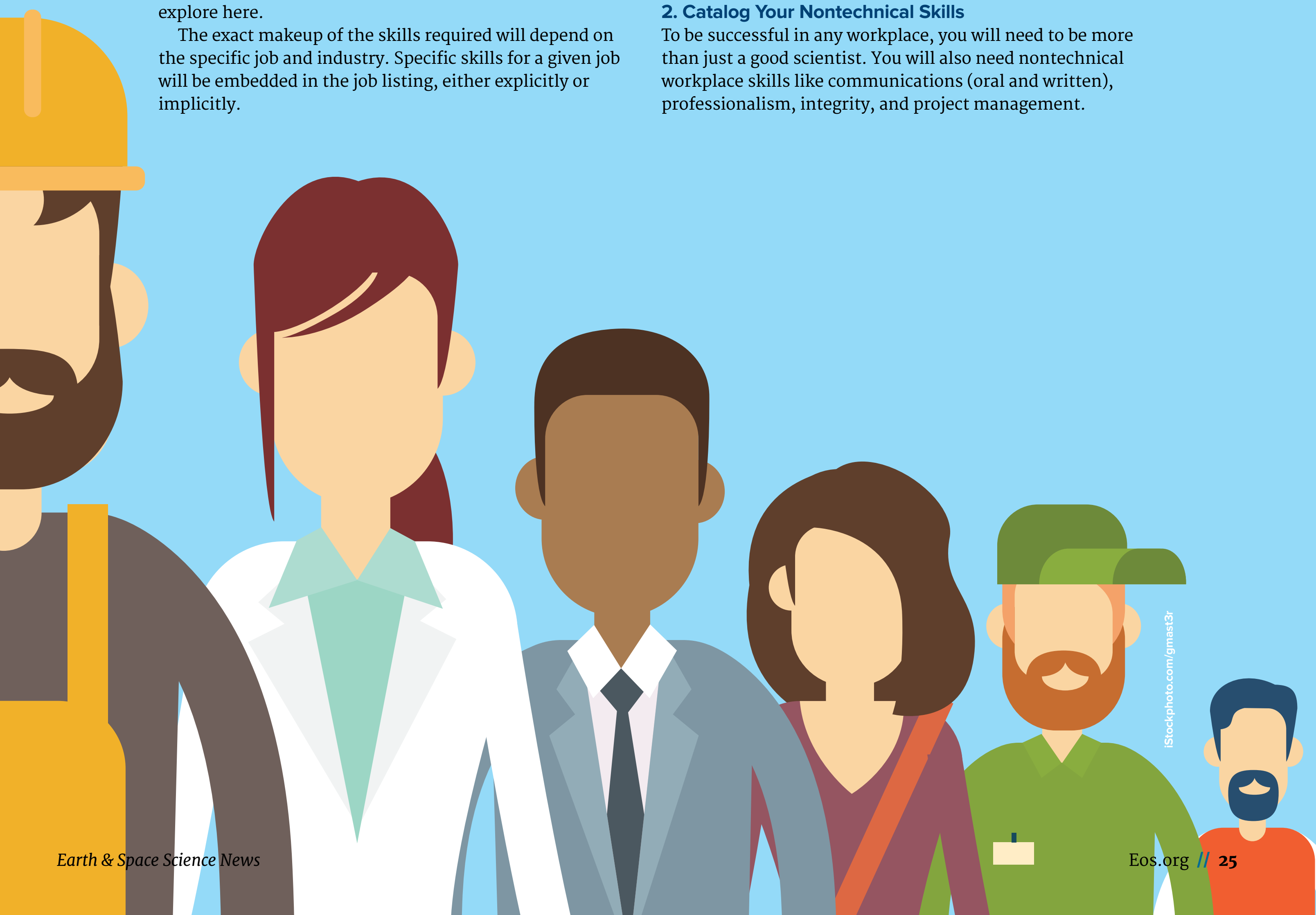
REQUIRED QUALIFICATIONS

- M.S. with a focus on remote sensing, hydrology, agriculture, atmospheric science, or a related field from an accredited institution
- Experience with GIS and remote sensing of evapotranspiration
- Demonstrated experience in spatial analysis and modeling software platforms such as ArcGIS

Competency in baseline technical skills is implied from your degree. Instead of providing a full list of skill requirements, employers will specify the level and area for the degree required. Technical skills outside of the standard curriculum will be listed separately, like the second and third bullet points in the example listing. No surprises here: Either you can do these things or you can't.

2. Catalog Your Nontechnical Skills

To be successful in any workplace, you will need to be more than just a good scientist. You will also need nontechnical workplace skills like communications (oral and written), professionalism, integrity, and project management.



iStockphoto.com/gmast3r

Although the exact composition of nontechnical skills needed for any given employer or job description may differ slightly, here is a list of nontechnical skills valued most often by employers:

- Effective communications (oral and written): imparting or exchanging information or news with team members, supervisors, and customers
- Adaptability: successfully responding to changes in workplace priorities and structures
- Systems thinking: understanding why you are working on a particular project and its importance to the organization
- Proactive nature: anticipating problems and solving them before detrimental effects are apparent
- Professionalism: displaying the behaviors, attitudes, and characteristics consistent with a profession
- Persistence: being able to overcome obstacles and adversity to achieve the desired outcome
- Cultural and social awareness: having an awareness of the value of diversity and inclusion in the workplace, as well as a respect for the customs and practices of different cultures
- Teamwork: getting along and working with others to accomplish a common goal
- Ethical practices: doing the right thing and doing it right
- Time, project, and financial management: effectively scheduling and using resources in the accomplishment of a goal

Nontechnical workplace skills are sometimes labeled as soft skills. "Soft" might imply that they are somehow less important than "hard" skills like science, but don't be misled: These skills are certainly a requirement for success. Rather than think of these skills as soft, you should consider them to be essential.

Look at the following list of sample qualifications taken from another job description:

- Excellent oral and written communication skills
- Evidence of the ability to participate in collaborative research
- Ability to participate in the development of research proposals
- Ability to work independently to fulfill project goals and meet project deadlines

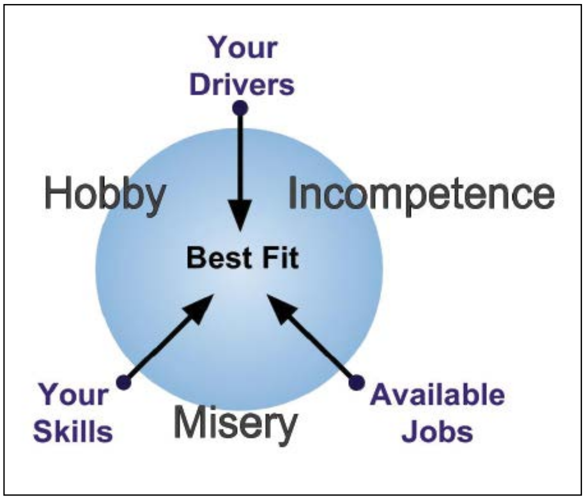
Although technical skills often seem self-explanatory, nontechnical skills require some imagination. These nontechnical skills are often gained through experience rather than formal training.

Now freeze: When you looked at the list of qualifications above, did you quickly skim through them or think about ways that you have demonstrated those skills in the past? Don't fall into the trap of writing off nontechnical skills. You may be hired on the basis of your technical skills, but if you get fired, it will likely be a result of the nontechnical skills that you lack.

As an exercise, consider each of the required qualifications and list a handful of projects where you used that skill. Seriously—look at the job requirements above and write some things down. Then hold on to your lists! You'll need concrete examples of your nontechnical skills for your resume, cover letter, and interviews.

3. Figure Out What Drives You

Having a firm grasp of your skill set is important, but skills are only the first step in successfully landing a well-fitting job. As mentioned earlier, it is possible to find a job where you match the skill requirements and still be miserable. You will need to identify skills that you are able *and* willing to consistently execute. You need to identify the activities and outcomes that will drive you toward successfully completing tasks.



Finding your best fit requires considering how your skills and drivers align with the job market. Credit: David Harwell

The things that we value in life drive our behaviors. Simply put, your drivers are what reward and stimulate you. Drivers vary from person to person, but there are a few that we find common to the workplace.

___ Advancement: opportunity for promotion or recognition
___ Altruism: opportunity to contribute to the welfare of others
___ Autonomy: freedom and ability to be self-directed
___ Balance: ability to prioritize personal and business matters
___ Challenge: drive to overcome obstacles and solve problems
___ Discovery: developing understanding for its own sake
___ Money: abundant financial compensation
___ Structure: clear organizational goals and responsibilities, no ambiguity
___ Perfectionism: doing things exactly right, no matter how long it takes
___ Security: stability and predictability

Although all the drivers above are important, some will be more important to you than others at this stage of your career. Look at the list and rank your drivers from 1 to 10, with 1 being what you currently value most and 10 being the least.

Your order of these drivers will change over your lifetime. For example, younger people who have few financial commitments might not rank security as highly as mid-career people who have greater financial responsibilities, like a mortgage or hungry children. For this reason, it is important to revisit the ranking of your personal drivers each time you go through a life transition.

Search your soul. Self-reflect. Ask yourself what you truly want.

Now that you've taken time to assess your drivers, revisit that list of skills you compiled. How do those skills match up with your driver rankings? Is there any clear alignment?

4. Search Available Jobs

Finding available jobs is easy. Our goal here is not just to find a job, however; it is to find a job in which you will thrive.

In the diagram on page 26, you were warned against finding yourself in the hobby zone, when something maps well with your passions and skills but nobody will pay you to do it. The obvious remedy? Find someone who will.

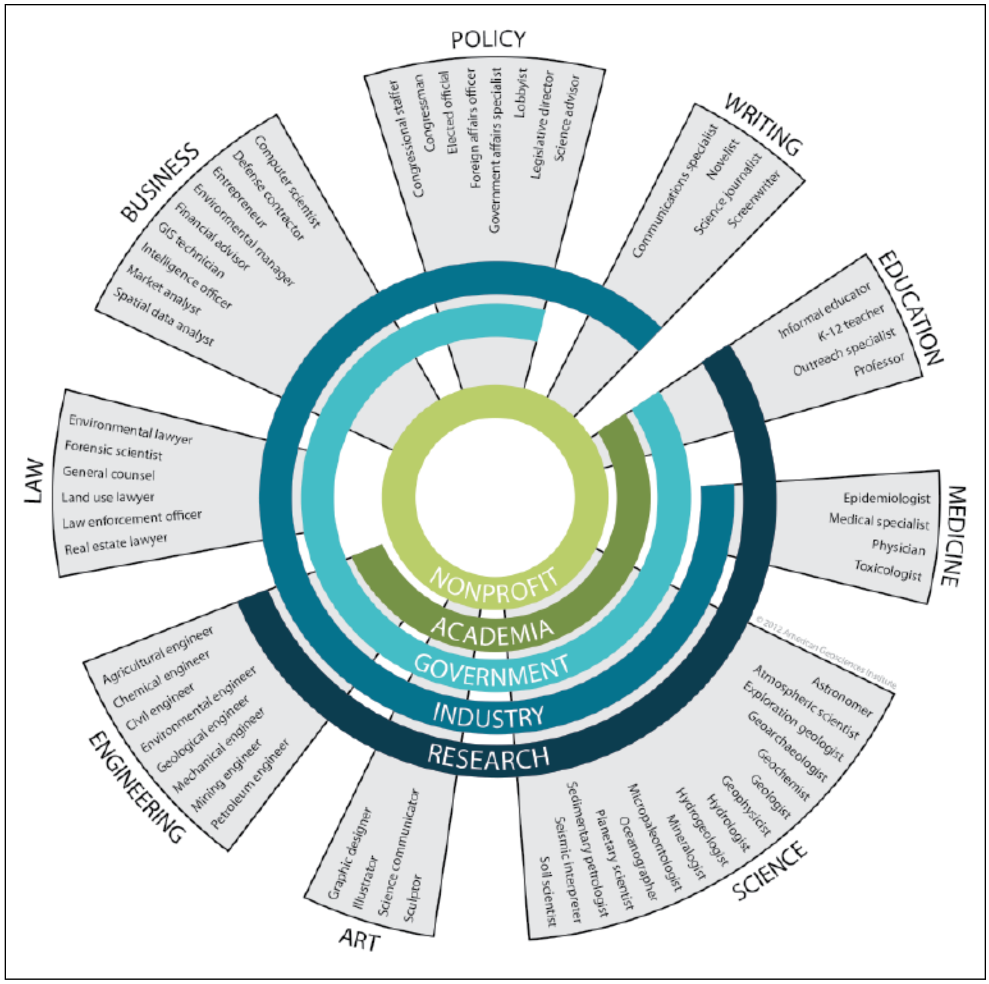


Fig. 1. Infographic created by the American Geosciences Institute (AGI) Preparing Our Workforce Initiative to help students entering the workforce redefine what it means to have a career in the geosciences. Credit: Kathleen Cantner/Heather Houlton & Abigail Seadler, ©AGI, 2016

Figure 1 is an infographic from the American Geosciences Institute (AGI) that shows the many occupations that can be found in the Earth and space sciences. Each spoke represents a particular field that includes geoscience professionals; the inner circles demonstrate the employment sectors where particular geoscience professions can be found. As you can see, several fields bridge more than one employment sector. For example, you can be a soil scientist in industry, academia, government, or a nonprofit. You could even be an independent consultant who specializes in soil science and work for yourself.

More information about each job in the infographic, including job descriptions and profiles of Earth and space scientists, can be found on the AGU Career Center website in the Paths Through Science section (http://careers.agu.org/paths/).

After browsing through the possible routes a career in the geosciences can take in Figure 1, think about which jobs mesh well with your skills and drivers. Look on a job board, and see whether you can find something available in that occupation. If there are no current openings for a particular profession, are there listings for similar occupations in the same field? Sometimes in the sciences, we can become so focused on our specialties that we forget that our core competencies often overlap many disciplines. If nothing is available now, look for positions that will make it simpler to get there when something does become available.

The Dream: A Job That Fits You Right

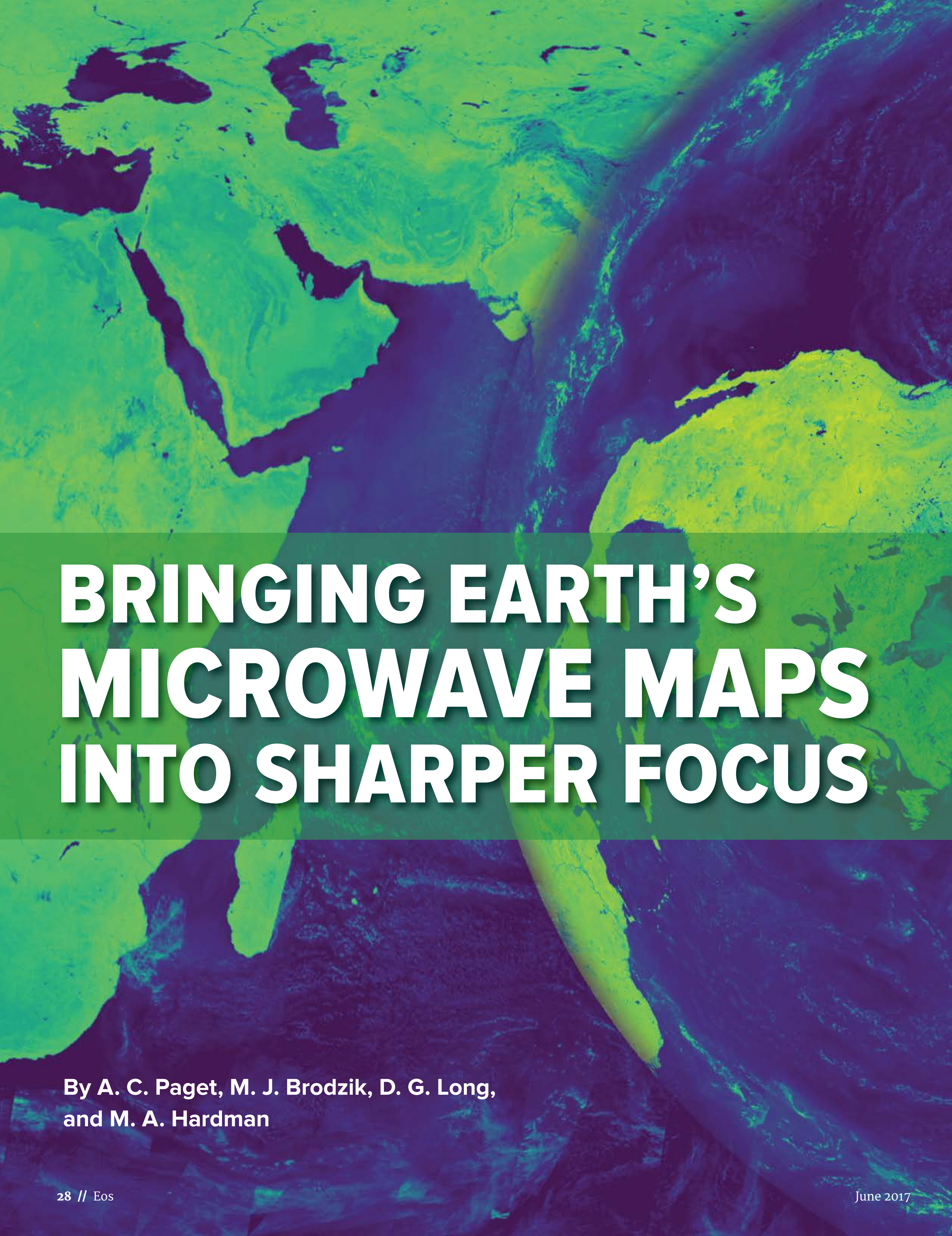
In the end, the career that you pursue is your choice. The better you know yourself and your options, the better your chances are of finding the career path that fits you best.

Last, don't be discouraged if it takes a while to find your path. Finding your fit isn't always a simple process. Even tailor-made pants have to be broken in!

Author Information

David Harwell, Assistant Director, Talent Pool, AGU; and **Nathaniel Janick** (email: njanick@agu.org), Career Services Coordinator, AGU

Editor's Note: For more career advice or to see listings of jobs available in the Earth and space sciences, visit the AGU Career Center (http://sites.agu.org/careers/).



BRINGING EARTH'S MICROWAVE MAPS INTO SHARPER FOCUS

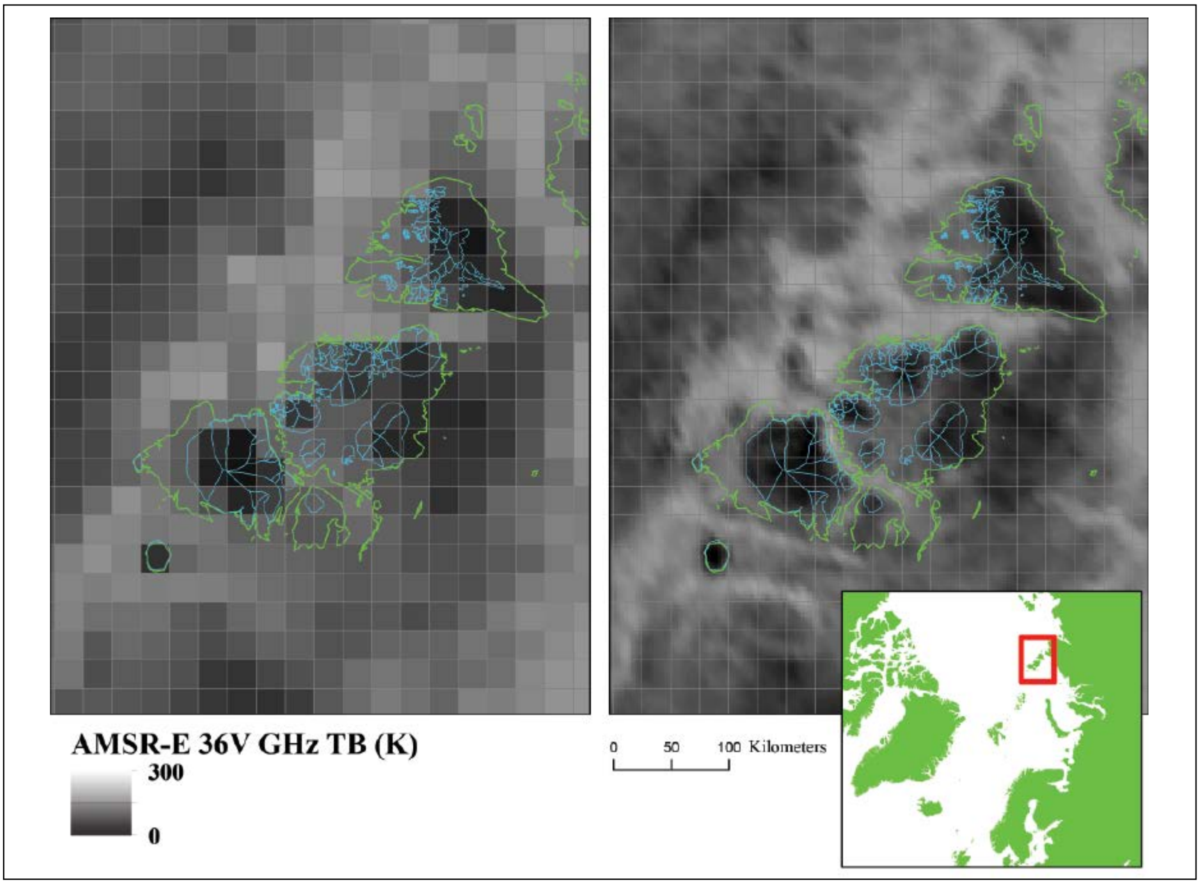
By A. C. Paget, M. J. Brodzik, D. G. Long, and M. A. Hardman

New processing capabilities improve the spatial resolution of satellite microwave data, enabling scientists to analyze trends in coastal regions and marginal ice zones.

Since the launch of the first passive microwave radiometers in the 1970s, satellites have almost continuously observed the microwave radiation traveling upward from the Earth, the "brightness temperature" of the planet. Passive microwave sensors can see through most clouds and collect measurements day and night. This information enables researchers to monitor land surface conditions even in hazardous, remote locations and during the long polar night.

Passive sensors are those that only receive radiation coming up through the atmosphere, distinct from active sensors, like radar, which emit their own signals and receive a reflected echo of that signal. Scientists have mined Earth's long, reliable passive microwave emissions record to derive significant and meaningful climate records of many parameters, including the dramatic decline in Arctic sea ice, even though passive micro-

Color montage of brightness temperatures, a measure of the microwave radiation traveling upward from the Earth, for 29–30 June 2003. Credit: M. J. Brodzik



wave sensors provide measurements at relatively coarse spatial resolutions [*Bhatt et al.,* 2014].

We are now completely reprocessing data from the historical passive microwave record, taking advantage of recent sensor intercalibration efforts [*Berg et al.,* 2013; *Hilburn and Wentz,* 2008] and using state-of-the-art numerical methods to increase image spatial resolution. The resulting 38-year Calibrated Passive Microwave Daily EASE-Grid 2.0 Brightness Temperature (CETB) Earth System Data Record (ESDR) will be freely available to researchers this month.

Fig. 1. Glaciated islands in the High Arctic appear as dark regions in this passive microwave brightness temperature map. (left) Ice, ocean, and land boundary features are indistinct at nominal, 25-kilometer resolution, but (right) they show up more clearly at enhanced, 3.125-kilometer resolution. The mesh overlay (gray) indicates 25-kilometer pixel boundaries. These images are derived from AMSR-E 36-gigahertz, vertically polarized brightness temperatures from evening passes on 1 January 2004. The image was derived from results presented by Ramage et al. *[2016]. Coastlines (green) are from the Global Self-Consistent Hierarchical High-Resolution Geography Database (GSHHG) [*Wessel and Smith, *2015]; glacier outlines (blue) are from the Global Land Ice Measurements from Space (GLIMS) glacier database [*Raup et al., *2007].*

The Satellite Missions

Engineers have built and launched several different radiometers on satellite platforms, and multiple instruments have been in orbit simultaneously since the early 1990s. The CETB product includes observations from four different types of radiometers on 11 satellite platforms:

- Scanning Multichannel Microwave Radiometer on Nimbus 7
- Special Sensor Microwave Imagers on the Defense Meteorological Satellite Program (DMSP) satellites F08, F10, F11, F13, F14, and F15
- Advanced Microwave Scanning Radiometer–Earth Observing System on the Aqua satellite
- Special Sensor Microwave Imager/Sounders on DMSP F16, F17, and F18

Each sensor can detect multiple frequencies in the 6- to 90-gigahertz range (centimeter-scale wavelengths); the improvement in spatial resolution varies by frequency and sensor.

Better Spatial Resolution

Satellite visible imagery can provide images at resolutions of a meter or better, but passive microwave sensors are limited to resolutions of tens of kilometers. For comparison, a photograph from a microwave sensor looking across the Grand Canyon, taken at 10-kilometer resolution, would contain only one pixel instead of the whole, detailed, magnificent scene. A satellite collecting these 10-kilometer pixels across a broad swath of Earth can supply scientists with enough information to track regional changes in physical environments and ecosystems. However, pixels that cover heterogeneous areas (e.g., where water meets land or where ice meets ocean) and the current limitations of data averaging techniques have limited the use of information in these areas (Figure 1).

Despite these limitations, microwave sensors are remarkably stable engineering instruments, and measurements from a single instrument remain consistent over time. However, measurement records from each satellite require careful cross calibration between that satellite and records from the next satellite in the mission sequence to separate real changes in the measured phenomena from artifacts caused by variations in satellite orbits over time.

As a part of the CETB project, our group of researchers from the Microwave Earth Remote Sensing Laboratory at Brigham Young University and the National Snow and Ice Data Center (NSIDC) at the Cooperative Institute for Research in Environmental Sciences of the University of Colorado Boulder has developed techniques to produce global brightness temperature (T_B) maps. Even though the sensors have 10-kilometer resolution, these maps resolve features as small as 3 kilometers on a set of standard map projections known as EASE-Grid 2.0 (see http://bit.ly/EASE-Grid) [*Brodzik et al.*, 2012].

The enhanced spatial resolution will allow scientists to analyze trends in coastal regions and marginal ice zones. Using EASE-Grid 2.0 projections removes formatting barriers that have previously plagued data users wanting to work in the popular GeoTIFF standard (see http://bit.ly/GeoTIFF), simplifying the steps needed to overlay coastlines and compare with other data sources.

Spatial Resolution Enhancement

To produce the CETB Earth-gridded microwave temperatures, researchers must use computational resampling techniques to transform a continuous stream of swath measurements to fixed, daily Earth locations. Resampling techniques range from the computationally simple and fast to the sophisticated and expensive. Simple resampling techniques, including nearest-neighbor sampling, are fast, but they alter the geolocation information. Other simple averaging techniques smooth the data and obscure real temporal and spatial variability.

To circumvent these sources of imprecision, past approaches to processing historical gridded passive microwave data have used more complicated techniques that take into account engineering parameters, including the size and shape of the sensor antenna and scanning geometry. However, these techniques were extremely computationally expensive and required large allocations of supercomputing resources.

The CETB resampling algorithm, called Radiometer Scatterometer Image Reconstruction (rSIR), uses an innovative numerical technique to produce high-quality, enhanced-resolution imagery at a fraction of the computational cost of previously available techniques [*Long and Brodzik*, 2016]. Comparing simple averaged images to enhanced-resolution versions of the same data (Figure 1) illustrates greater feature details, especially along transition zones at ice edges and land-water boundaries. The enhanced-resolution CETB data reveal details of ice sheets and sea ice and atmospheric and ocean features (Figure 2) for the complete available sensor record and at higher spa-

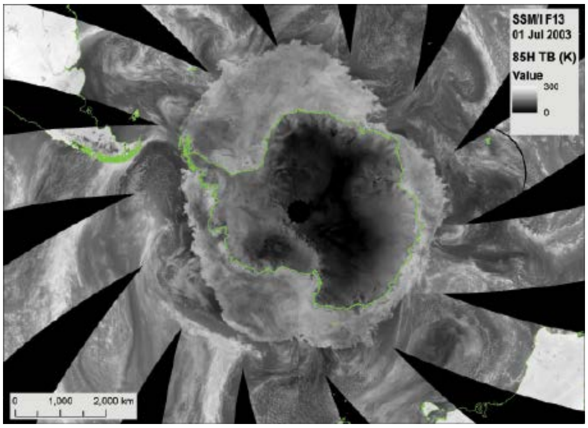


*Fig. 2. Detail of midwinter land ice, sea ice, ocean, and atmospheric features in the Southern Hemisphere. This enhanced-resolution image is derived from Special Sensor Microwave Imager 85-gigahertz, horizontally polarized brightness temperatures from 1 July 2003 evening passes, using rSIR image reconstruction at 3.125-kilometer resolution. Coastlines are from GSHHG [*Wessel and Smith, *2015].*

tial resolutions than have previously been discernible from these instruments.

Applications

The real benefits of the enhanced-resolution CETB product will be demonstrated now that the complete CETB data set is available. Consistently mapped T_B measurements for the complete satellite record will facilitate the use of satellite radiometer observations to enable researchers to better distinguish real climate signals from intersensor artifacts. This data product will support such studies of geophysical parameters as the following:

- snow extent and water equivalent [*Takala et al.,* 2011]
- ice field and ice sheet melt onset and freeze timing [*Ramage and Isacks,* 2002; *Tedesco,* 2007]
- soil moisture analysis [*Seuffert et al.,* 2004]
- vegetation index [*Kustas et al.,* 1993]
- land surface temperature [*McFarland et al.,* 1990]
- oceanic whitecap detection [*Anguelova and Webster,* 2006]
- observing terrestrial features in general [*Farrar and Smith,* 1992]

The enhanced-resolution CETB product will also enable studies over a longer research period than has previously been possible, with data that have been vetted, quality controlled, and consistently gridded at the highest possible resolution.

Early Adopters

A volunteer community, whom we call early adopters, has recently finished an initial evaluation of prototype CETB data, and the complete CETB product will be available this month. The NASA NSIDC Distributed Active Archive Center will provide data management and distribution services.

As part of the NASA Making Earth System Data Records for Use in Research Environments (MEaSUREs) initiative and to encourage informed analysis of the data set, we have provided extensive documentation regarding the development and characteristics of the CETB product (see http://bit.ly/EASE-Grid-docs). Additional details on the optimum image formation are also available [*Long and Brodzik,* 2016]. The data producers encourage exploration and research using this new product and invite suggestions and comments.

Acknowledgments

This research is supported by NASA MEaSUREs grant NNX13AI23A at NSIDC and NASA MEaSUREs grant NNX13AI26A at Brigham Young University. The CETB product is produced on the Janus supercomputer, which is supported by the National Science Foundation (award CNS-0821794) and the University of Colorado Boulder. The Janus supercomputer is a joint effort of the University of Colorado Boulder, the University of Colorado Denver, and the National Center for Atmospheric Research.

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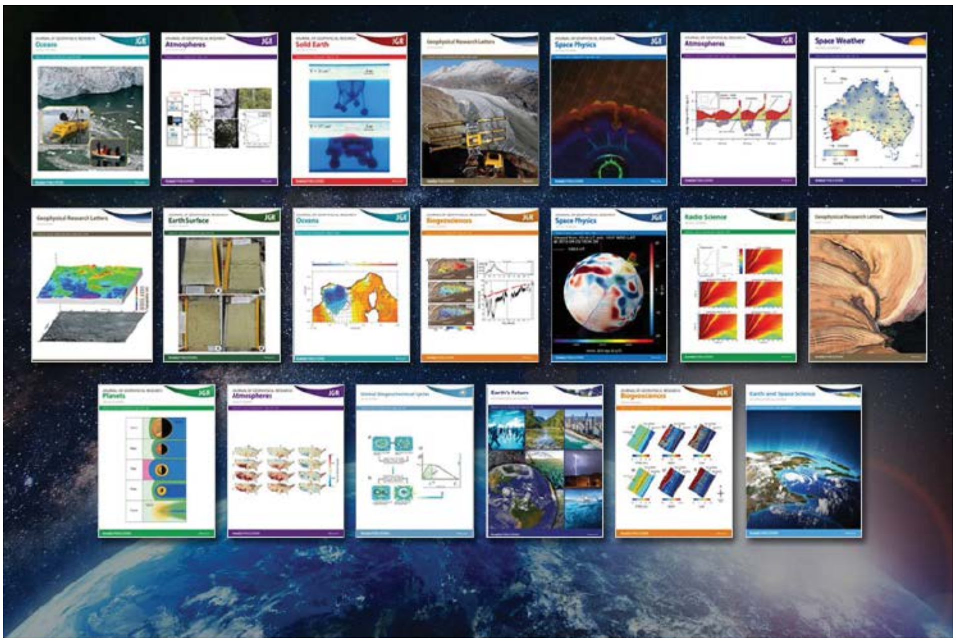
Author Information

A. C. Paget, Department of Marine Sciences, University of Connecticut, Groton; **M. J. Brodzik** (email: brodzik@nsidc.org), National Snow and Ice Data Center, Cooperative Institute for Research in Environmental Science (CIRES), University of Colorado Boulder; **D. G. Long,** Microwave Earth Remote Sensing Laboratory, Brigham Young University, Provo, Utah; and **M. A. Hardman,** National Snow and Ice Data Center, CIRES, University of Colorado Boulder

Providing Greater Context for Earth and Space Science Research



Recent covers of some of the 20 journals that AGU currently publishes. Credit: AGU

An article published last August on Eos .org described how AGU had expanded communications related to new journal articles to provide more context around AGU-published science (see http://bit.ly/eos-context). Now AGU has added yet more forms of content and collections to provide even richer context for both AGU journal articles and books.

On Eos.org, scientific press releases about AGU journal papers have recently joined the publication's news, opinions, and other content. On Eos.org as well, *Editors' Vox* blog posts offer discussions of hot topics in different scientific fields, interviews with authors of recent papers and books, and other contributions from the editors of AGU journals and books. Meanwhile, Research Spotlights continue to summarize some of the most interesting papers from across AGU journals and to rank among the most widely read items on the website.

Added as a regular enhancement of AGU journal content last year, close to 100 commentaries presented the views of Earth and space science researchers on recent science, publications, meetings, and policy in 2016. Commentaries now reside in a special collection organized by topic (see http://bit.ly/comm-collection). The journal editors are continually commissioning more.

Synoptic View of Enhancements

To help readers better navigate these and other enhancements that build upon our journal content, we've pulled together recently featured papers across all of AGU's journals onto one highlights page (http://bit.ly/jnl-enhanced). This synoptic view includes the content types mentioned above, as well as links to recent AGU papers mentioned in the mainstream news media and to those trending on social media. The page also notes recently published AGU books and special issues across AGU journals and displays journal cover images.

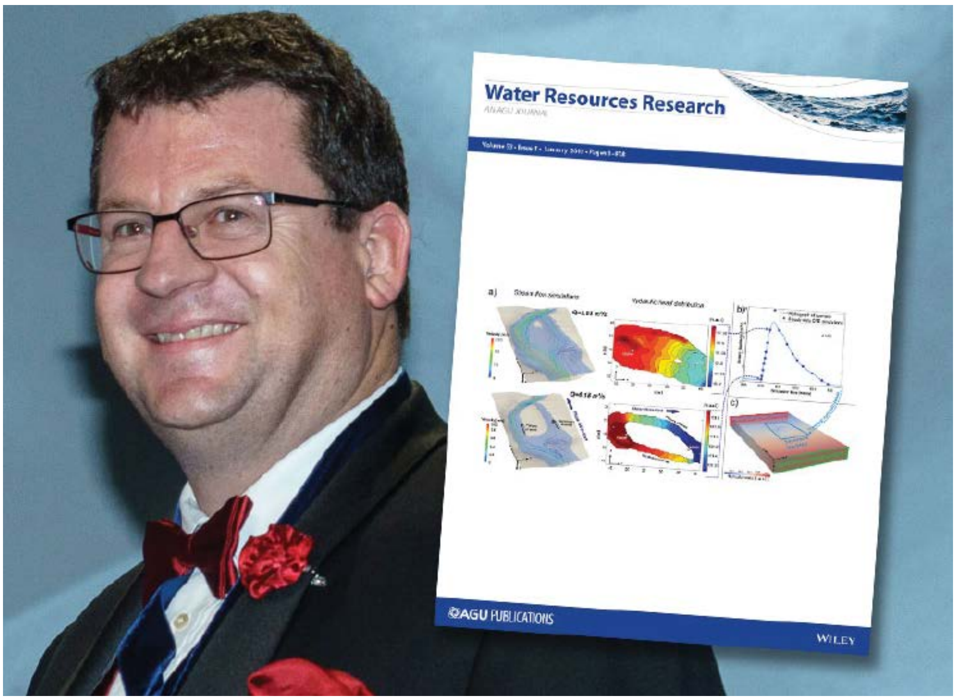
In addition, many authors are now providing plain-language summaries of their papers. Each summary appears as an additional abstract in both the HTML and PDF versions of the journal article. Those summaries that best explain the science in a straightforward and jargon-free way for a public audience are featured on social media. The highlights page soon will include those outstanding summaries as well.

We encourage authors to use their plain-language summaries in their outreach, including via their social media platforms. We have compiled a guide for authors (http://bit.ly/promote-paper) that offers resources and suggestions to help them explain their science to the public.

Overall, about 15% of AGU's content now receives some type of additional coverage, with the goals of making the Earth and space sciences more accessible and interesting and demonstrating the relevance of those sciences to society. Assistant director of publications Jenny Lunn coordinates and leads these efforts by AGU staff.

By **Jenny Lunn** (email: jlunn@agu.org), Assistant Director of Publications, AGU; and **Brooks Hanson,** Director of Publications, AGU

Incoming Editor Seeks Interdisciplinary, Collaborative Research



Martyn Clark of the National Center for Atmospheric Research is the new editor in chief of Water Resources Research *(*WRR*). Credit: Gary Wagner (photo), Travis Frazier (graphic design)*

Martyn Clark of the National Center for Atmospheric Research (NCAR) has been appointed to lead AGU's journal *Water Resources Research* (*WRR*). In April, he took over as editor in chief of the journal from Alberto Montanari of the University of Bologna.

Clark is a senior scientist in the Hydrometeorological Applications Program at NCAR. He was also elected an AGU Fellow in 2016, when he was recognized for his work on process-based hydrologic modeling. Jamie Liu, AGU's marketing manager, asked Clark for his perspectives on this editorship.

AGU: *What does it mean to you to serve as editor in chief of* Water Resources Research?

Clark: My main motivation for accepting the *WRR* editor in chief position is to enhance the quality and impact of hydrologic science. I see several high-level opportunities: I want the journal to encourage cross-fertilization among different schools of thought, give more recognition and attention to grand challenges and emerging or hot topics, and attract more papers to *WRR* that are useful for professors in their teaching.

I also see several opportunities to accelerate science advances by improving the review process. I plan to foster constructive review comments, encourage authors to put adequate time into revising their paper to take full advantage of the constructive criticisms from the reviewers, and shorten the time between submission and decision. I recently published two *Editors' Vox* posts on this topic (http://bit.ly/Good-Reviews-1, http://bit.ly/Good-Reviews-2).

Over the past 8 years, I had several memorable experiences during my service as associate editor for *WRR.* In many cases, reviewers bent over backward to provide constructive advice, and authors devoted a considerable amount of time to act on the review comments and transform a mediocre submission into a landmark paper for the discipline. These experiences are very rewarding.

The role of editor in chief provides many opportunities to help the hydrologic science community enhance the quality and impact of published papers. I look forward to using the current *WRR* structure, which includes special sections, commentaries, editorials, highlights, and awards, to help foster discussion, encourage debate, synthesize research, and demonstrate the impact of our science to address societal problems. I also look forward to increasing the impact of *WRR* articles by selecting more articles for inclusion in *Eos* Research Spotlights, which provide plain-language summaries of the science advances published in *WRR,* and through increasing media attention for *WRR* papers that are of interest for the public. Increasing this enhanced content will help showcase the relevance of hydrologic science for society. I welcome ideas on ways that *WRR* can best serve the hydrologic research community and take advantage of new opportunities to have a positive impact on the evolution of hydrologic science.

AGU: *What research are you working on right now?*

Clark: My current research spans three broad areas: developing approaches to simulate hydrological processes, including understanding intermodel differences; developing methods to improve streamflow forecasts; and understanding space-time variability in climate and hydrology, including understanding the effects of climate change on regional water resources.

In the course of my career, I've published on many different research topics, including hillslope hydrology, snow hydrology, land-atmosphere interactions, and statistical hydrology. I'm leading the Computational Hydrology group within the Research Applications Laboratory at NCAR (http://bit.ly/NCAR-comput-hydrol). We have a set of interrelated projects on developing intermediate-complexity methods for downscaling climate models, developing probabilistic approaches to construct gridded meteorological fields, and advancing capabilities for continental-domain hydrologic modeling.

One recent contribution from our group is a unified approach to process-based hydrologic modeling, the Structure for Unifying Multiple Modeling Alternatives (SUMMA). This approach provides multiple options to simulate a wide range of biophysical and hydrologic processes, from the treetops to the stream. SUMMA is useful to characterize model and parameter uncertainty in hydrologic model simulations and to identify strengths and weaknesses in our existing hydrologic understanding.

We're now using the SUMMA concepts to unify land modeling activities across NCAR through the development of the Community Terrestrial Modeling System. In addition, through applications of information theory, we're improving our ability to quantify how effectively models use available information and to understand the information flow through models so that we can provide an estimate of system predictability and identify opportunities for model improvement.

AGU: *Where do you see growth or emerging research in hydrology? What do you think are some of the biggest problems that hydrologists need to solve?*

Clark: A key growth area for *WRR* is the integrated and interdisciplinary approach to hydrologic science, where many research groups actively share data and model source code to advance process understanding and improve modeling capabilities.

A key effort is to improve the theoretical underpinnings of hydrologic models. Many groups are now working together to compare results across basins, to forge closer linkages between model algorithms and general process explanations, and to identify and address model weaknesses. There is more focus on advancing integrated process understanding in research watersheds. A key example of this is the efforts of the Critical Zone Observatories, a U.S.-based network of research watersheds established by the National Science Foundation, to improve understanding of biophysical and hydrologic processes from the treetops to the stream.

Community-oriented endeavors are also emerging to develop more realistic representations of the interactions between human systems and hydrology systems and to advance hydrologic modeling for domains extending to the scale of continents and the globe. And there are emerging community efforts to advance process-oriented methods for parameter estimation, accomplished by improving the use of data collected on topography, vegetation, soils, and geology in characterizing the storage and transmission of water across the landscape.

Other disciplines also share this collaborative approach to science, which is necessary to address grand research challenges. Taking this integrated and interdisciplinary approach to hydrologic science will be a critical growth area for *WRR* in the foreseeable future.

The new WRR *editorial team includes (left to right) Ximing Cai, Xavier Sanchez-Vila, Ilja van Meerveld, Hari Rajaram, Martyn Clark, Scott Mackay, Jean Bahr, Peter Troch, Terri Hogue, Jessica Lundquist, and Charlie Luce. Credit: Erin Syring*

By **Jamie Liu** (email: jliu@agu.org), Marketing Manager, AGU

AGU Board Vacancy Filled, Council Leaders Chosen

AGU/Travis Frazier

Lisa J. Graumlich has officially joined the AGU Board of Directors. The Governance Committee would like to thank everyone who voted during the February special election to fill a vacancy on the Board. AGU president Eric Davidson and other Board members welcomed Lisa at the leadership orientation held in March. She will serve during the current 2017–2018 term.

At the time of the special election, there were 27,050 eligible voters. Of them, 5.8% cast votes, with 94.9% voting for Lisa, the candidate recommended by the committee to fill the vacancy. The committee received 954 comments from voters, with 92.2% of them stating that they were satisfied or very satisfied with the process.

Council Leadership Team Elected for 2017–2018

The Governance Committee announces the results of another recent election. At the beginning of every leadership term, AGU Council members elect their own leadership team. All Council members are given the opportunity for this leadership position, and anyone interested is placed on the ballot.

The committee worked with Robin Bell, AGU's president-elect and Council chair, to identify diversity needed on the leadership team. Criteria for this year included geography, career stage, Council experience, and gender.

Six new members were elected to the Council Leadership Team, joining three continuing members.

The committee determined that the following perspectives were needed on the 2017–2018 Council Leadership Team (CLT): someone with international perspective, at least one student or early-career member, and at least one Council member serving his or her first term. Voters were encouraged to keep diversity in mind while voting.

All but two Council members voted in the election, and the results were announced at the leadership orientation on 8 March. Six new members were elected to the Council Leadership Team, joining three continuing members. The 2017–2018 CLT members provide the diversity of perspectives needed:

- Robin Bell, AGU president-elect and Council chair
- Xavier Comas, first term on Council, Near-Surface Geophysics, U.S. and international perspectives
- Aisling Dolan, second term on Council, early career, international perspective
- Eileen Hofmann, second term on Council, Ocean Sciences, U.S. perspective
- Michael Manga, first term on Council, Volcanology, Geochemistry, and Petrology, U.S. perspective
- Chris McEntee, AGU CEO (nonvoting)
- Annie Tamalavage, second term on Council, student, U.S. perspective
- Scott Tyler, first term on Council, Hydrology, U.S. perspective
- Doug Wiens, second term on Council, Seismology, U.S. perspective

In the CLT election, Eileen Hofmann not only was elected to the Council Leadership Team but also was chosen as Council vice chair. In that role, she will serve also on the AGU Board. The AGU governance model includes four officers who hold seats on both the Council and the Board to ensure communication and continuity between those two bodies. Those overlapping positions are the president, president-elect, CEO, and Council vice chair.

Please join us in congratulating these members on their new leadership positions.

By **Margaret Leinen** (email: agu_governance@agu.org), Chair, Governance Committee, AGU; **Robin Bell,** President-elect and Council Chair, AGU; and **Carol Finn,** U.S. Geological Survey, Denver, Colo.

Fostering International Collaboration Amid Policy Challenges

Despite recent, restrictive travel policies, Earth and space scientists from many nations are expected to convene at the AGU Fall Meeting in New Orleans this December. To reduce travel risks and support global science, AGU will update travelers regarding visas and entry rules and increase opportunities for virtual participation in the meeting. Credit: iStock.com/Anna Bryukhanova

Changes in immigration and visa policies instituted by U.S. president Donald Trump have caused confusion and concern across many sectors and have begun to have a negative impact on international science collaborations. Many non-American scientists are rightfully concerned that they may be challenged when seeking entry into the United States. They could face barriers even if they have appropriate passports and visas because of their nationality, religion, ethnicity, name, or recent travels.

Others who are not concerned about their own situations may still wish to show solidarity with their colleagues and may consider a boycott of U.S.-based scientific meetings as a statement of protest. The Trump administration's proposals and statements disregarding the value of science-based evidence to inform policy, including international policies on climate change, human health, and international security, add to the frustration and concern of many scientists throughout the world.

In the face of this shifting landscape of governmental support for and recognition of scientific contributions to society, AGU is more committed than ever to fostering collaboration and engagement in the global scientific community. We respect the diversity of opinions as well as the legitimate concerns of many travelers. At the same time, we sincerely hope that many of you will choose to join us at the upcoming AGU Fall Meeting in New Orleans from 11 to 15 December to advocate for and celebrate the importance of continued international scientific collaboration.

> We will make every effort to ensure that AGU meetings continue to bring the community together, in person and virtually, to advance Earth and space science.

Commitment to Advancing Earth and Space Science

Toward those ends, we will make every effort to ensure that AGU meetings continue to bring the community together, in person and virtually, to advance Earth and space science. We are taking the following actions to maximize meeting opportunities and minimize travel risks.

We will provide prospective travelers with regular updates from our communications with officials at the U.S. Transportation Security Administration (TSA) and other agencies and organizations regarding entry into the United States for the Fall Meeting and other AGU-sponsored meetings.

For those who feel unsafe traveling, we will increase virtual participation opportunities during and after Fall Meeting.

For all who can join us for Fall Meeting, we will add programming focused on the importance of international collaborations in science.

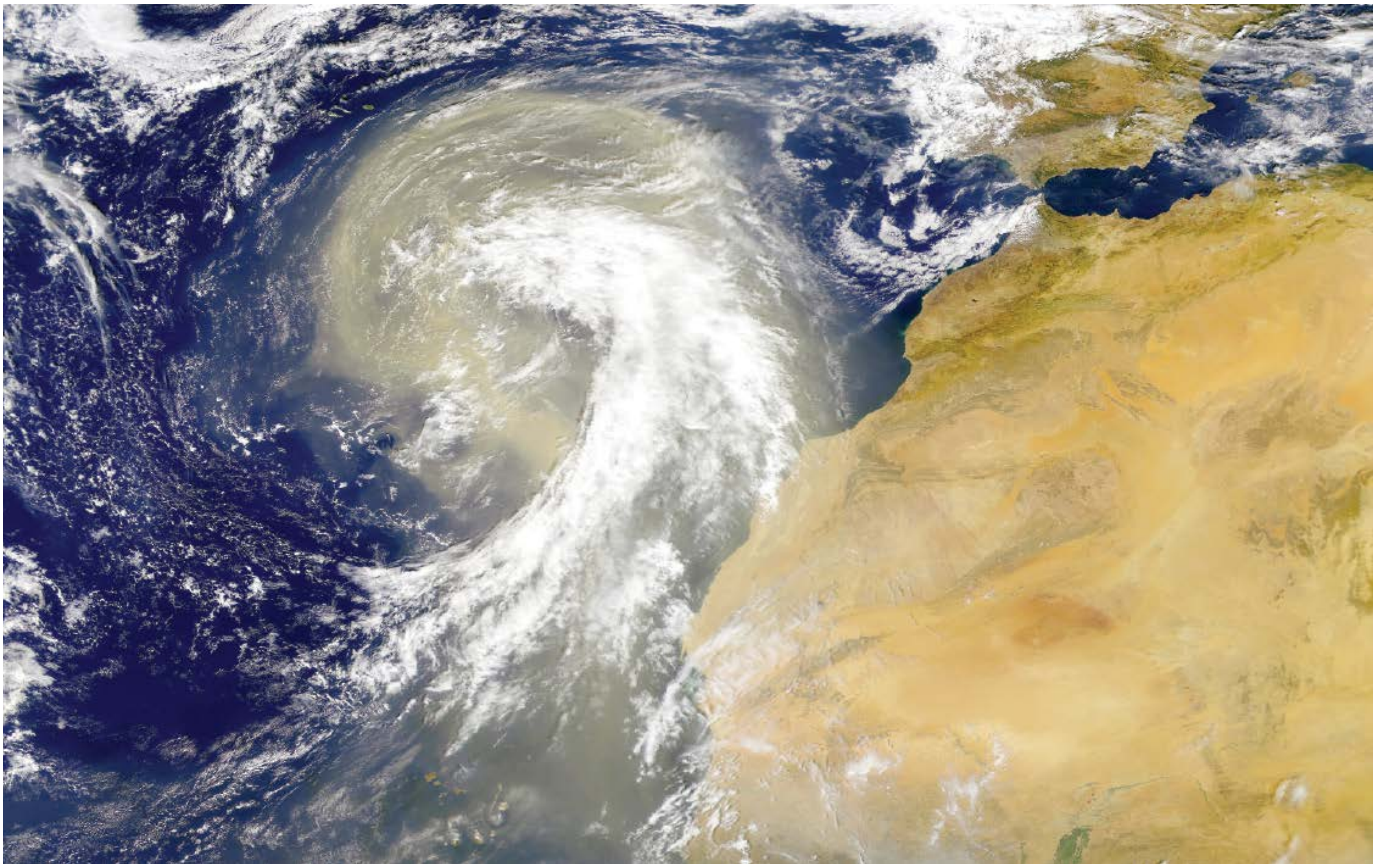
We invite you to help us make a strong statement at Fall Meeting through your presence, participation, and voice, either in events that we are planning or in sessions that you might also propose. These sessions will cover topics such as data security and access, scientific integrity and freedom for government-employed scientists, the emerging global field of geohealth, and scientific input regarding implementation of the Paris accord on climate change. It is essential that we have broad geographic and multidisciplinary representation in these sessions. We will report session outcomes beyond the meeting as part of our strategy.

Several other exciting innovations will be introduced at the New Orleans venue this December. Look for updates soon from Denis-Didier Rousseau, the Fall Meeting chair, and Rick Murnane, chair of the AGU Meetings Committee.

Should you have specific travel or meeting concerns, please contact AGU director of meetings Lauren Parr at meetingsdirector@agu.org. We also welcome your recommendations about how to ensure that Fall Meeting and other AGU-sponsored meetings can best continue to convene the world's Earth and space science community.

By **Eric Davidson** (email: president@agu.org), President, AGU; and **Lauren Parr,** Meetings Director, AGU

Satellite Data Reveal Effects of Aerosols in Earth's Atmosphere



A dust plume from the Sahara Desert streams out over the northeastern Atlantic Ocean. Researchers are using satellite imagery to better predict how tiny aerosol particles like these might influence global climate. Credit: NASA Visible Earth

Earth's atmosphere is dusted with tiny particles known as aerosols, which include windblown ash, sea salt, pollution, and other natural and human-produced materials. Aerosols can absorb or scatter sunlight, affecting how much light reflects back into space or stays trapped in the atmosphere.

Despite aerosols' known impact on Earth's temperature, major uncertainties plague current estimates of their overall effects, which in turn limit the certainty of climate change models. In an effort to reduce this uncertainty, *Lacagnina et al.* have combined new satellite data, providing, through model simulations and for the first time, data on aerosols' ability to absorb or reflect light globally.

In this new study, the team focused on the direct effects of aerosols on shortwave radiation in 2006. These effects depended on the particles' vertical location with respect to clouds, the reflective properties of the underlying land or water, and the optical properties of the aerosol particles themselves, including how much light they are prone to scatter or absorb.

The researchers used instruments aboard the French Polarization and Anisotropy of Reflectances for Atmospheric Science coupled with Observations from a Lidar (PARASOL) satellite and NASA's Aura spacecraft to measure aerosol optical properties around the world. Data from NASA's Moderate Resolution Imaging Spectroradiometer (MODIS) satellite instrument provided measurements of cloud characteristics and land reflectance, and an aerosol climate model known as ECHAM5-HAM2 helped fill in any gaps in the observations.

Using these data, the researchers calculated the global average radiative effect for 2006, revealing an overall cooling effect due to aerosols. At regional scales, however, different mixtures of aerosols led to widely varying effects. For example, the cooling effects of aerosols were larger in the Northern Hemisphere because of higher pollution emissions and infiltration by desert dust.

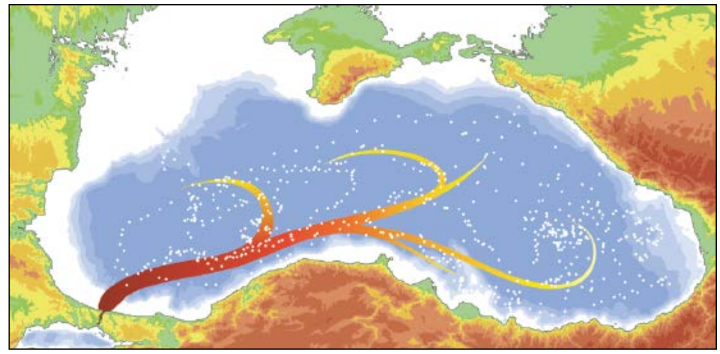
Overall, the heat transfer measurements in this study were consistent with past measurements using other methods. The authors call for additional studies that also integrate data from multiple sources and for improved global measurements of aerosol absorption to better understand and predict the future effects of aerosols on climate change. (*Journal of Geophysical Research: Atmospheres,* https://doi.org/10.1002/2016JD025706, 2017) **—Sarah Stanley, Freelance Writer**

Big Storms Pump Mediterranean Water Far into the Black Sea

Below a depth of about 150 meters, the Black Sea is devoid of oxygen. Only certain microbes can survive in this "dead zone," which reaches depths of more than 2000 meters. Warm, salty water flowing from the Mediterranean Sea into the Black Sea ventilates the middepth water column of the sea, trapping anoxic water below and maintaining the sea's distinctive structure. However, the precise fate of inflowing Mediterranean waters has remained something of a mystery to scientists.

In a new study, *Falina et al.* present the first sea-wide overview of the behavior of Mediterranean waters in the Black Sea. They track the path of the newly arrived water and investigate what happens when strong winds affect incoming flow.

Mediterranean water flows into the Black Sea through its single connection: Bosphorus Strait. Previous research has shown that more water exits the Black Sea at the strait than enters. The Mediterranean water that does flow in mixes with fresher Black Sea water, and as its salinity and density decrease, the Mediterranean water forms plume-shaped features. These plumes flow away from the mouth of the strait and descend until their density matches that of surrounding waters, usually at depths of 100 to 600 meters.



Pathways of Mediterranean plumes in the middepth layer of the Black Sea as inferred from ship and float data (white dots). While being carried by the currents from the Bosphorus, warm plumes gradually cool because of mixing and become indistinguishable from the Black Sea's waters within a year. Credit: Anastasia Falina, Artem Sarafano

To track the size and location of these Mediterranean plumes throughout the Black Sea, the authors relied on the tendency of the plumes to stay warmer than surrounding waters. The researchers compiled temperature, depth, and salinity data collected from aboard three ships as well as by a network of autonomous instruments known as Argo floats. The entire data set covered 657 locations from 2005 to 2009.

The data revealed that after strong storms over Bosphorus Strait, Mediterranean plumes propagate throughout the main part of the sea, covering much more area than previously thought. The Rim Current, which transports upper and middepth waters counterclockwise around the entire Black Sea, carries the plumes along, delivering them after several months to interior gyres in the eastern and western parts of the sea.

During these strong storms, powerful winds are known to thrust water in the strait northward, dramatically increasing the amount of Mediterranean water entering the Black Sea. The scientists hypothesize that this results in the formation of abnormally large, warm plumes that propagate throughout the sea. Mixing makes the plumes undetectable in less than a year.

These findings could help improve understanding of the Black Sea's dead zone. They could also contribute to the study of other water systems that feature oxygen-free layers, including fjords, the Baltic Sea, and Cariaco Basin. (*Journal of Geophysical Research: Oceans*, https://doi.org/10.1002/2017JC012729, 2017) **—Sarah Stanley, Freelance Writer**

Why Do Great Earthquakes Follow Each Other at Subduction Zones?

People walk through the streets of Talca, Chile, past major damage from the earthquake of 12 March 2010. Credit: Joe Raedle/Getty Images

Seismologists have recently recognized that great subduction zone earthquakes, also known as megathrust earthquakes, tend to recur in "supercycles." These cycles are characterized by the release of strain in a cluster of earthquakes within a few years of each other, followed by a lengthy period of quiescence ranging from several decades to several centuries, during which time strain once again accumulates. Megathrust earthquakes have the potential to cause widespread damage and devastating tsunamis, yet the mechanisms that trigger two or more of these events within a few years to a decade are still not well understood, primarily because of a lack of long-term geodetic data.

Now *Melnick et al.* have analyzed a decade's worth of continuously measured GPS data spanning two great earthquakes, the 2010 Maule (*M* 8.8) and 2015 Illapel (*M* 8.3) events. Both earthquakes occurred along the central Chilean margin where the Nazca plate is diving beneath the South American plate at a rate of 66 millimeters per year. The team used these data to estimate changes in surface deformation rates throughout the Andes Mountains and then compared the results with numerical simulations.

The researchers' findings indicate that surface velocities increased following the Maule earthquake, a change they attribute to the large-scale, elastic response of both the continental and oceanic plates to fault slip during and immediately after the earthquake. This response, the team argues, accelerated the rate of shortening across the megathrust and heightened the stress on adjacent fault segments. According to the researchers, the resulting period of stress accumulation constitutes a "superinterseismic" phase of the earthquake cycle that may have brought nearby fault segments closer to failure and ultimately triggered the 2015 event.

This study demonstrates that cycles of megathrust earthquakes can be strongly influenced by the behavior of nearby seismic events. The results may help clarify the occurrence of clusters of other great earthquakes, including those that have occurred in Alaska, Cascadia, Sumatra, and Japan, as well as provide insight into the processes controlling the lag time between those events. (*Geophysical Research Letters*, https://doi.org/10.1002/2016GL071845, 2017) **—Terri Cook, Freelance Writer**

For Magnetic Reconnection Energy, O—Not X—Might Mark the Spot

Magnetic reconnection is one of the most important—and least understood—processes in all of space physics. This reconnection happens at the boundaries of Earth's magnetic field, where it meets the Sun's, causing magnetic field lines to break and realign in an explosive manner that can generate hazardous radiation, especially during solar storms. A new study by *Fu et al.* adds weight to suggestions that scientists have been looking for this energy in the wrong type of reconnection.

For decades, the classic introductory textbook picture of magnetic reconnection has depicted two parallel lines that pull themselves together into an X shape, as if pinched together, until they finally touch at the center of the X line. Then the field lines snap and realign. Like a rebounding rubber band, they fling plasma out from the center of the X, generating currents that can surge down into the Earth's magnetic field. During high solar activity, this process generates the dangerous radiation that threatens power grids, satellite communications, and the health of astronauts.

At least, that is the conventional wisdom. But that's not what the authors' analysis shows. Instead, the intense blasts of energy may come from a different kind of magnetic reconnection, one not as often shown in textbooks: so-called O lines, where the approaching field lines spiral and swirl together, as if caught in a whirlpool.

The team analyzed data from the European Space Agency's Cluster satellites, a quartet of spacecraft launched in 2000 that fly in formation—sometimes less than 10 kilometers apart—which allows them to make detailed measurements from within magnetic reconnection events. In particular, the authors examined a pass through a magnetic storm on 9 October 2003, high over Earth's nightside.

During their pass through this storm, the craft flew within a few hundred kilometers of several potential sites of reconnection. The team used computer models to re-create the topology of the field lines, finding that two of them were X lines and the rest were O lines. But instead of seeing the highest current levels at X lines, as expected, the team found most of the greatest current spikes to be near O lines. At the X lines, the current was almost nonexistent.

The team writes that their results clearly show that O lines, not X lines, are responsible for energy dissipation in reconnection, a result that is likely to spark a great deal of discussion. (*Geophysical Research Letters,* https://doi.org/10.1002/2016GL071787, 2017) **—Mark Zastrow, Freelance Writer**

Mushrooms Could Provide a Record of Grassland History

Since the Industrial Revolution, concentrations of carbon dioxide (CO_2) in the atmosphere have rapidly increased. How does this influx of atmospheric carbon affect ecosystems, such as forests, croplands, and the 40 million acres of American lawns? The answer to this question may lie in an unexpected source: mushrooms.

Trees and grasses pull carbon out of the atmosphere during photosynthesis and thus play a key role in the global carbon cycle. Theoretically, researchers can study how vegetation changes over time to assess the effects of increasing concentrations of CO_2. Unfortunately, studying historical changes in grass communities is difficult. Unlike trees, which build tree rings from year to year, grasses leave little behind when they die and decompose, so scientists must use creative methods to look at grassland ecosystems from years past.

One method involves using the two stable isotopes of carbon, ^{13}C and ^{12}C, as natural tracers. But where can records of these isotopes be found?

Perhaps in mushrooms, *Hobbie et al.* hypothesized. The authors tracked the ^{13}C to ^{12}C ratios in mushrooms from lawns in America's Midwest to study the historical shift in grass varieties in the region. The fungi feed on dead plant matter, so changes in carbon isotopes within mushrooms from samples collected over time can allow researchers to look at what kinds of grasses the fungi had consumed from season to season and year to year.

To see how changes in temperature, precipitation, and CO_2 in the atmosphere can affect vegetation, the researchers looked at competition between two kinds of plants: C_3 and C_4 grasses, which use different metabolic pathways for photosynthesis. These different pathways produce different ^{13}C to ^{12}C ratios in plant tissues.

C_3 grasses—such as wheat, oats, and ryegrass—are called cool-season plants and thrive in a temperature range of 65°F–75°F. These grasses are highly productive in the spring and fall, but high summer temperatures reduce growth. C_4 plants, on the other hand, flourish in warmer and drier environments. These warm-season plants include corn, crabgrass, and bluestem grasses and are more efficient than C_3 plants at photosynthesis under low concentrations of CO_2.

Amanita thiersii mushrooms. *Scientists are measuring carbon isotopes in fungal tissues to learn more about the types of plants that decomposed and fed the mushrooms. How mushrooms change over time may directly reflect how rising carbon dioxide levels are affecting plant competition in forests, croplands, and lawns, researchers hypothesize. Credit: Michael Kuo*

The researchers used isotopic data from samples of the fungus *Amanita thiersii* collected between 1982 and 2009 from 26 locations in the southeastern and south central United States. The scientists combined these data with information on temperature, precipitation, and CO_2 concentrations over the same period to study changes in the balance between C_3 and C_4 plants.

They found that high temperatures were good predictors of a higher percentage of C_4 grasses, whereas higher precipitation favored C_3 productivity. Over the 1982–2009 period, C_3 grass productivity increased 18.5%, which the scientists attributed to a 13% increase in atmospheric CO_2 during that time.

The researchers point out that shifting lawn management practices also could have played a role in the changing grass landscape. Despite this, the novel method of using mushrooms to study the vegetation landscape and plant competition over time could be used in the future to assess how grasslands are adapting to climate change and to increasing CO_2 concentrations. (*Journal of Geophysical Research: Biogeosciences*, https://doi.org/10.1002/2016JG003579, 2017) **—Alexandra Branscombe, Freelance Writer**

Exploring Ancient Ocean Acidification in the Rock Record

Earth's history is dotted with major mass extinction events from various natural disasters, including climate change. Fossil evidence shows a mass extinction at the end of the Triassic, more than 200 million years ago, which killed off much of the planet's marine life.

In the Lombardy Basin of northern Italy, for example, abundant marine fossils are embedded in the sediment layer that marks the end of the Triassic, but above this, the same fossils are notably absent. Scientists theorize that the die-off was most likely caused by climate change that acidified the ocean.

In a new study, *Jost et al.* establish a new method for studying ancient geological oceans using carbon and calcium isotope measurements with numerical modeling to measure the consequences of ocean acidification in the geologic past.

The researchers collected samples from a 100-meter-thick limestone section in the Lombardy Basin spanning the Triassic and Jurassic boundary and measured the ratios of stable carbon ($^{13}C/^{12}C$) and calcium ($^{44}Ca/^{40}Ca$) isotopes in each layer. They found large negative carbon and calcium isotopic excursions—in other words, a shift toward greater relative abundance of the lighter isotope of each element—after the extinction event. This finding is consistent with an ocean acidification scenario, which could have caused the mass extinction.

Next, the authors simulated the ocean's carbon and calcium cycles, injecting different carbon volumes into the model. The simulation scenarios were compared with the actual carbon data measured in the sediment layers. The coupled model revealed that ocean acidification was responsible for only 20% of the calcium isotopic changes. The remaining 80% were from local mechanisms, likely caused by an increase in aragonite, a form of calcium carbonate that was potentially favored in the wake of ocean acidification.

This novel method is relevant to geoscientists studying the global impacts of climate change, particularly, to what extent ocean acidification has played a role in extinction events. (*Geochemistry, Geophysics, Geosystems*, https://doi.org/10.1002/2016GC006724, 2017) **—Alexandra Branscombe, Freelance Writer**

A Two-Way Relationship Between the Atlantic and Pacific Oceans

Tropical cyclones such as Hurricane Patricia, seen here in the eastern Pacific approaching Mexico in 2015, can be influenced by varying sea surface temperatures both within their own ocean basin and from afar. Credit: Scott Kelly/NASA

Scientists have long known of an apparent one-way relationship between the Atlantic and Pacific oceans: Unusually warm sea surface temperatures in the eastern and central tropical Pacific during El Niño can curb tropical cyclones in the Atlantic. However, in a new study, *Patricola et al.* sought to find out whether varying sea surface temperatures in the Atlantic Ocean remotely influence tropical cyclones in the eastern and central North Pacific.

Using cyclone records from 1950 to 2015 and simulated idealized climate cycles, the authors found that when the Atlantic's surface warms, subsequent tropical cyclones in the eastern Pacific are less frequent and weaker. Likewise, when the Atlantic's surface cools, the eastern Pacific experiences more frequent and stronger cyclones instead. The authors found that this relationship can be driven by a climatic pattern called the Atlantic Meridional Mode.

The Atlantic Meridional Mode describes the waxing and waning of the Atlantic Ocean's surface temperatures. During its positive phase, this mode brings unusually warm sea surface temperatures to the northern tropics. In its negative phase, sea surface temperatures cool.

Scientists are well aware that the mode's positive phase strengthens cyclones within the Atlantic basin, whereas the negative phase suppresses them. However, the new study suggests that the Atlantic Meridional Mode can strengthen and suppress cyclones in the eastern Pacific basin too, weakening tropical cyclone seasons there during its positive phase and intensifying them during its negative phase.

The authors propose one driving factor behind this inverse relationship: vertical wind shear. In both simulations and observations from the cyclone database, vertical wind shear in the eastern Pacific reliably increased during the mode's positive phase, which suppressed cyclones in the eastern Pacific.

An analogous connection moves in the other direction, where unusually warm sea surface temperatures in the tropical Pacific increase wind shear over the Atlantic, ultimately suppressing tropical cyclones there. The authors suggest that further study on these connections and their underlying mechanisms could improve the accuracy of future cyclone forecasts. (*Geophysical Research Letters,* https://doi.org/10.1002/2016GL071965, 2017) **—Brendan Bane, Freelance Writer**

Which Regions Are Most at Risk for Ice Loss in East Antarctica?

The environment of Antarctica is unique in many ways, one being that the continent is covered almost entirely by a vast sheet of ice, stretching from the towering plateau of East Antarctica to the chain of mountainous islands (interconnected by ice) that form West Antarctica. This ice sheet comprises about 90% of the ice on Earth, not to mention the massive shelves of ice and icebergs that float just offshore.

If Earth's oceans and atmosphere continue to warm at the rates projected by most climate models, over the next few hundred years the Antarctic ice sheets could melt enough to cause a sea level rise of several meters. Most likely, the severity of ice loss will vary geographically because of physical differences across the continent, such as ice thickness and bedrock topography. Previous simulations have shown that most of the ice melt will occur in the West Antarctic ice sheet, yet less is known about how the East Antarctic ice sheet would respond to environmental warming.

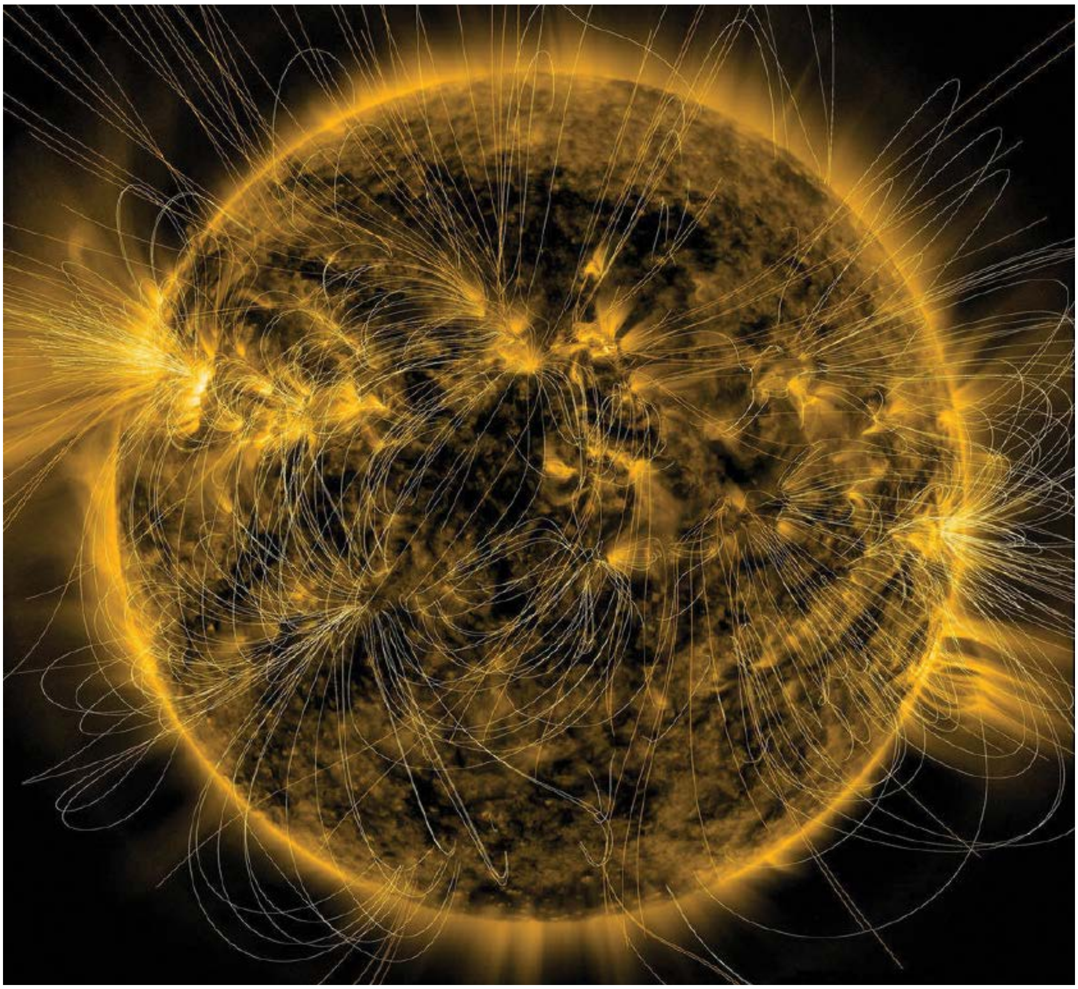
The eastern side of the East Antarctic ice sheet is much larger and has slow flowing glaciers, and its bedrock is a rocky terrain of deep basins and high mountain ranges buried beneath the ice. Recent studies have already shown warm ocean water flowing southward from areas of the ice sheet, suggesting that the region could be affected by further warming.

To find out more, *Golledge et al.* used an ice sheet model to simulate the flow of water from melting ice sheets, ice shelves, and ice streams over thousands of years. They also examined data on the average long-term rates of ice loss for each ice drainage basin, or catchment, to determine which catchments are most sensitive to various conditions associated with climate change.

Comparing the results of their models with other simulations and observations and assuming a projected ocean temperature rise of about 36°F, the researchers found that the majority of East Antarctica's future ice loss will most likely occur in a catchment near the eastern Weddell Sea called Recovery.

The researchers predict that how soon and how much the ice sheet in this region melts will determine the degree to which East Antarctica will contribute to future sea level rise. In turn, this could amplify surface temperatures, producing an even greater global impact. (*Geophysical Research Letters,* https://doi.org/10.1002/2016GL072422, 2017) **—Sarah Witman, Freelance Writer**

Explaining Unexpected Twists in the Sun's Magnetic Field



The Sun's magnetic field lines, shown here using a model, can further twist and loop after they encounter near-Earth space. This leads to errors in space weather forecasts. But is there a way to monitor these late twists? Credit: NASA/SDO/AIA/LMSAL

Space weather forecasting requires understanding what happens when the Earth's magnetic field meets the Sun's. When their field lines touch, they can suddenly link up with each other and explosively realign. Like a snapping rubber band, the field lines rebound, sparking geomagnetic storms and sending dangerous radiation toward Earth that can damage satellites and threaten power grids.

However, some conditions are more conducive to this process, called magnetic reconnection. Particularly important is the orientation of the Sun's magnetic field. Although Earth's magnetic field is fixed about its North and South poles, the Sun's magnetic field is warped throughout space, and Earth may find itself in a part of the field pointing in a different direction at any given time. The best conditions for magnetic reconnection are when the Sun's magnetic field is aligned southward, antiparallel to Earth's.

Scientists measure the direction of the Sun's field with satellites stationed between the Sun and Earth, like NASA's Advanced Composition Explorer (ACE) and Deep Space Climate Observatory (DSCOVR). They warn us of approaching storms by monitoring the solar wind, the stream of charged particles thrown off by the Sun.

However, recent studies have shown that the direction of the Sun's field can shift by the time it reaches Earth's magnetic field, apparently twisting after passing those satellites. This could lead to inaccurate space weather forecasts.

To determine why this happens, *Turc et al.* analyzed archival data for 82 solar storms caused by approaching magnetic clouds ejected by the Sun. The team compared solar wind measurements with data from closer satellites orbiting in and around Earth's magnetic field and used a model to reconstruct the conditions in between. Their work zeroed in on two factors.

The first is the bow shock that the Earth creates in the solar wind. Like a ship plowing through water, the Earth creates a shock wave in the solar wind as it flows past, which the Sun's field lines must traverse. The team's analysis showed that depending on their relative orientations, the shock could alter the direction of the field.

Second, after crossing the bow shock, the field lines encounter the influence of Earth's magnetic field. They don't simply meet it head-on, but instead drape themselves over the Earth's bulbous field and warp in the process.

The authors report that these two factors combine to shift the direction of the field, which could alter the probability of magnetic reconnection. In some cases, it even reversed a benign northward field into a reconnection-prone southward field and vice versa. These reversals spanned roughly 20% of the Earth-Sun magnetic field boundary and lasted more than half an hour, making them significant enough to potentially throw off forecasts of geomagnetic storms.

The authors report that their models successfully reproduced the observations roughly 80% of the time. But more work must be done to improve their performance and incorporate them into real-time forecasts. (*Journal of Geophysical Research: Space Physics,* https://doi.org/10.1002/2016JA023654, 2017) **—Mark Zastrow, Freelance Writer**

Atmospheric Sciences

Postdoctoral Researcher, University of Minnesota

The atmospheric chemistry and biometeorology group (www.atmoschem.umn.edu; www.biometeorology.umn.edu) at the University of Minnesota has immediate openings for two postdoctoral researchers. The successful candidates will work as part of an interdisciplinary team to advance scientific understanding and predictability of methane emissions from the US Upper Midwest, a key region for the global methane budget. The work will include analysis of ongoing, long-term measurements from the UMN tall tower and other flux datasets, as well as new in-situ eddy-covariance measurements in the field for wetlands, rivers, and agricultural systems.

Candidates should have a PhD in a related science or engineering field. Analytical experience with advanced instrumentation is required. Expertise in one or more of the following areas would be a significant asset: eddy covariance measurements, methane measurements, agricultural emissions, wetland dynamics, trace gas emissions, and numerical modeling.

The University of Minnesota offers a number of high-quality career development resources for postdocs, for example through the Postdoctoral Association for Advocacy, Career Development, and Networking (http://www.pda.umn.edu) and the "Preparing Future Faculty" program (https://cei.umn.edu/support-services/preparing-future-faculty/). In addition, the research project itself will be multi-institutional and collaborative, providing a strong opportunity for disciplinary and cross-disciplinary development and networking.

Please email a CV, a cover letter describing research experience, career goals, your fit for the position, 2–3 representative publications, and contact information for three references to Tim Griffis, timgriffis@umn.edu and to Dylan Millet, dbm@umn.edu, ATTN: Postdoctoral Search.

Biogeosciences

Assistant Professor in Earth-Life Interactions, University of California, Davis

The Department of Earth and Planetary Sciences at the University of California, Davis seeks applications for a tenure-track faculty position in the broad area of Earth-Life Interactions. We seek creative scientists who study the interactions between life and surface environments on any spatial and temporal scale using novel laboratory, field, and/or computational approaches. We encourage applications from a diverse range of disciplines including, but not restricted to, biogeochemistry, geobiology, and paleoclimatology. We are particularly interested in applicants who will expand our current research programs and have the potential to build new connections both within the department and across campus, such as with other departments in the Division of Mathematical and Physical Sciences, the College of Agriculture and Environmental Sciences, College of Biological Sciences, or the UC Davis Genomics Center.

Appointment will be at the Assistant Professor rank. Candidates must possess a Ph.D. or equivalent in geoscience or a related field by the time of appointment. The appointee is expected to develop and maintain a vigorous externally funded research program and to teach at the undergraduate and graduate levels. Supervision of graduate students and departmental, university, and service to the discipline are expected.

Candidates should submit a cover letter, CV, publication list, statements of research plans, teaching interests, and contributions to diversity, and

The Marine Physical Laboratory at the Scripps Institution of Oceanography at the UC San Diego is seeking a **Postdoctoral Scholar Employee** in the research group led by Professor Ken Melville.

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Qualifications:
- Recent PhD in Physical Oceanography or related field including engineering
- Strong background in fluid mechanics

Applications must be submitted to Ken Melville at **kmelville@ucsd.edu** with the following:
1. Curriculum vitae;
2. Personal statement of experience and career goals;
3. Three professional references (name and email)

All materials must be submitted by June 30th, 2017 for consideration.
http://airsea.ucsd.edu/

*The University of California San Diego is an Equal Opportunity/ Affirmative Action Employer contact information of four references by June 15, 2017. Applications should be submitted online via the job listing #JPF01496 at https://recruit.ucdavis.edu/apply/JPF01496. Inquiries may be addressed to the Search Committee Chair at eps-search@ucdavis.edu.

Hydrology

Assistant, Associate or Full Professor in Water Resources and Environmental Engineering, Virginia Tech

The Charles E. Via, Jr., Department of Civil and Environmental Engineering (CEE) at Virginia Tech invites applications for a tenure-track faculty position in Water Resources Engineering. The successful candidate will join the Environmental and Water Resources Engineering faculty at the Occoquan Watershed Monitoring Laboratory (OWML) in the National Capital Region (NCR) of Virginia and at the main campus in Blacksburg, Virginia. The position is located at the OWML in Manassas,Virginia. The OWML is a fully-staffed lab and a locally-supported monitoring program with a well-instrumented network of automated gaging and sampling stations for the acquisition of hydrologic and water quality data in the 570-square-mile Occoquan watershed. The 1,700-acre Occoquan Reservoir is a component of the drinking water supply for 1.7 million people in the NCR and is recognized as a model for sustainable indirect potable reuse.

Areas of expertise sought include stormwater management, urban hydrology and related resiliency, and water supply and system management. Applicants with research expertise and experience focusing on integrated field experiments, reservoir management, sensor networks, and watershed modeling in the built environment are particularly encouraged to apply. The successful candidate will possess project management skills, an ability and desire to work in collaborative teams, a willingness to engage in a range of research areas related to the OWML mission, and integrate with and build upon the already-existing portfolio of research at the OWML, much of which is applied research devoted to a sustainable urban water cycle.

The position will be filled at either the Assistant, Associate or Full Professor rank. A Ph.D. degree in Civil Engineering or a closely-related discipline is required. Applicants from a range of engineering and science backgrounds will be considered depending on their areas of expertise. Preference will be given to candidates with proven leadership capabilities and an established record of teaching, research, outreach and scholarship. The successful candidate will be expected to teach undergraduate and graduate courses in water resources engineering, supervise students, develop a sponsored research program, collaborate with other Virginia Tech faculty in the NCR and in Blacksburg, and contribute in service opportunities to the university and profession.

Virginia Tech is a recipient of the National Science Foundation ADVANCE Institutional Transformation Award to increase the participation of women in academic science and engineering careers. Virginia Tech is an Equal Opportunity/Affirmative Action employer. The CEE Department strongly supports the Virginia Tech Principles of Community. Information about the CEE Department is available at www.cee.vt.edu.

Applicants are required to apply online at www.jobs.vt.edu and should use posting number TR0170047. Applicants must provide a cover letter, contact information for three professional references, a candidate statement discussing teaching, research, and professional goals, and a current CV. Those wishing further information about the search process may contact Faculty Search Committee Co-Chairs, Dr. Mark Widdowson (mwiddows@vt.edu) or Dr. Adil Godrej, Director, Occoquan Watershed Monitoring Laboratory (agodrej@vt.edu). Review of applications will begin June 23, 2017 and continue until the position is filled.

Interdisciplinary

Assistant/Associate/Full Professors-Physical and biological Oceanography, marine geophysics/geology, The Southern University of Science and Technology

The department of oceanography at the Southern University of Science and Technology of China (SUSTech) invites applications for tenure-track (or tenured) faculty positions at the ranks of Assistant, Associate, and Full Professors. Applicants must have earned doctoral degrees in marine geophysics/geology, physical oceanography, biological oceanography and ocean engineering or closely related fields. Successful applicants will be expected to establish a robust, externally funded research program and demonstrate strong commitment to undergraduate and graduate teaching, student mentoring, and professional services. These positions will remain open until filled.

SUSTech is a young university at Shenzhen, China (next to Hong Kong) since 2010 which is set to become a world-leading research university, to lead the higher education reform in China, to serve the needs of innovation-oriented national development and the needs of building Shenzhen into a modern, international and innovative metropolitan. These positions are created with a significant development to establish a vigorous research program in oceanography at SUSTech to serve the national call for China's important role in deep sea research and resource-oriented exploration in the world oceans.

To apply send a cover letter, complete vitae with list of publications, and three names of references to hiring@sustc.edu.cn, or to Dr. Y. John Chen, Chair Professor at Department of Oceanography, Southern University of Science and Technology, No 1088, Xueyuan Rd., Xili, Nanshan District, Shenzhen, Guangdong, China 518055.

Associate Professor in Climate Science, Stockholm University

The Department of Meteorology at Stockholm University (MISU) conducts research and education in an international environment, addressing fundamental questions about the ocean and the atmosphere, with a focus on weather and climate. Our education programs cover modern weather forecasting, the climate system and climate processes. Our current research programs include the dynamics, physics, chemistry and biogeochemistry of the ocean and the atmosphere. We work from the deep ocean to the mesosphere and from the tropics to the poles. We use theory and statistical methods, numerical modeling and reanalysis, and observations from the land surface and ships, from balloons and aircraft, and from rockets and satellites.

At www.misu.su.se/research you will find an overview of ongoing research. The department has about 70 employees and is embedded in a larger research environment at Stockholm University that includes the Bolin Centre for Climate Research, The Swedish e-Science Research Centre and the Baltic Sea Centre.

Subject

Climate science

Subject description

By climate science is here meant atmospheric sciences and oceanography on time scales relevant for weather and climate.

Main responsibilities

Research, teaching and supervision.

Qualification requirements

In order to qualify for employment as associate professor, the applicant must have demonstrated good teaching skills and have a doctoral degree, or equivalent research expertise, of relevance to the subject area and the main responsibilities of the position.

All teaching positions at Stockholm University require the ability to collaborate and the general ability and suitability to perform one's duties.

Assessment criteria

In the appointment process, special attention will be given to research and teaching skills. The assessment of research skills will focus primarily on merits within the subject area of the position.

In the case of otherwise similar qualifications, a demonstrated ability to work within or connecting different sub-disciplines within the atmospheric sciences and oceanography will be used to distinguish the candidates.

Teaching and learning in higher education

Completed training in teaching and learning in higher education, or equivalent knowledge, is an advantage. An applicant who has not completed at least 15 credits of teaching and learning in higher education and is not considered to have otherwise acquired equivalent knowledge should undergo such training within the first two years of employment.

Additional information

The candidate should be able to teach a broad range of the departmental curriculum.

The language of instruction in first-cycle courses and programmes is Swedish. If the successful candidate does not speak Swedish at the time of appointment, he/she is expected to acquire the necessary language skills during the first two years of employment.

Female applicants are particularly welcome, as most associate professors and professors at the department are men. Stockholm University strives to

Project Leader, Program for Climate Model Diagnosis and Intercomparison (PCMDI)

We have an opening for the Project Leader and Principal Investigator of the Program for Climate Model Diagnosis and Intercomparison (PCMDI), a major research activity funded by the DOE Office of Science. You will direct an internationally-recognized research effort in climate science, including climate model diagnostics, model performance metrics, and climate change detection and attribution research, and you will provide leadership and community support for international climate modeling activities. This position is in the Atmospheric, Earth and Energy Division.

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Contact

Further information about the position can be obtained from the Head of the Department, Professor Jonas Nycander, telephone: +46 8 16 43 36, jonas@misu.su.se and Professor Annica Ekman, telephone: +46 8 16 23 97, annica@misu.su.se.

For questions regarding the application process, please contact administrator Katarina Gustafsson, telephone: +46 8 16 22 92, katarina.gustafsson@su.se.

Union representatives

Anqi Lindblom-Ahlm (Saco-S) and Lisbeth Häggberg (Fackförbundet ST and Lärarförbundet), telephone: +46 8 16 20 00 (operator), and seko@seko.su.se (SEKO).

Application

Apply for the position at Stockholm University's recruitment system by clicking the "Apply" button. It is the responsibility of the applicant to ensure that the application is complete in accordance with the instructions in the job advertisement, and that it is submitted before the deadline June 20, 2017.

We would appreciate it if your application is written in English. Since it will be examined by international experts, English is the working language. We plan to start interviewing in November, 2017.

The University's rules of employment and instructions for applicants are available at: Instructions – Applicants. The criteria for employment within the Faculty of Science are available at: Guidelines – Employment

You are welcome to apply!

Stockholm University – our education and research produce results.

Faculty Positions available in the School of Environmental Science and Engineering, The Southern University of Science and Technology

The Southern University of Science and Technology (known as SUSTech or SUSTC) (http://www.sustc.edu.cn/en) was founded in 2011 with public funding from Shenzhen City. A thriving metropolis of 20 million people bordering Hong Kong, Shenzhen has often been referred to as the "Silicon Valley of China" with strong telecommunication, biotechnology and pharmaceutical sectors. The goal of SUSTech is to become a top-tier international university that excels in interdisciplinary research, talent development and knowledge discovery. English is the language of instruction.

The School of Environmental Science and Engineering at SUSTech was established in May 2015 to provide a new platform for performing cutting-edge research and for training a new generation of environmental scientists, engineers and managers who are interdisciplinary, innovative and global-thinking. Currently the school has 18 full time faculty members (http://ese.sustc.edu.cn/en/) with 30 or more tenure-track/tenured positions to be filled. In addition to a generous startup package to each tenured or tenure track faculty position, the school was recently awarded a 3-year grant of 50 million RMB (~7 million USD) to strengthen its 5 core areas of research. Moreover, the school is in line to receive 120 million RMB (~18 million USD) for research instrument capability development.

Applications are invited for faculty positions at all ranks. Areas of interest include, but are not limited to, water pollution and treatment, environmental (soil, groundwater, ecosystem) remediation and restoration, hydrology and water resources engineering, biogeochemistry, environmental microbiology, atmospheric chemistry, air pollution control, air quality engineering, solid waste treatment and utilization, environmental health risk assessment, environmental health interventions, remote sensing of the environment, global change, and environmental management. Highly competitive salaries and benefit packages will be provided to tenure-track/tenured faculty. New hires may be eligible for additional government support such as the Shenzhen City's Peacock Program and the Chinese Government's One Thousand Talents Program (http://www.sustc.edu.cn/en/faculty_en).

Applicants are required to have a Ph.D. degree in environmental science and engineering, earth and atmospheric sciences, or related disciplines. Post-doctoral experiences are preferred but not required. Candidates must have a proven and consistent track record of high-quality scientific publications and good communication skills. Chinese language skill is a plus but not required. To apply, submit the following materials electronically to iese@sustc.edu.cn: 1) Cover Letter; 2) Curriculum Vitae (with a complete list of publications); 3) Statement of research and teaching interest; 4) Selected reprints of three recent papers; and 5) Names and contact information for five references. All positions remain open until filled. For additional information, contact Xiaoli Wang, Email: wangxl@sustc.edu.cn, phone: +86-755-8801-0821.

Postdoctoral Position in Presolar Grains at the Carnegie Institution for Science

The Department of Terrestrial Magnetism invites applications for a two-year postdoctoral research position to conduct studies on the origin of presolar stardust grains in meteorites. The primary focus will be on isotopic measurements by secondary ion mass spectrometry (Cameca NanoSIMS 50L) and resonance ionization mass spectrometry (Univ. of Chicago CHILI) and the interpretation of isotopic data in the context of astrophysical models. Additional work will involve Raman and infrared spectroscopy, and focused ion beam preparation of samples for transmission electron microscopy

NEON Observatory Director/Chief Scientist

Boulder, CO

Summary

Battelle operates the National Ecological Observatory Network (NEON), which is solely funded by the National Science Foundation. NEON is a 30+ year project designed to provide data for scientists to better understand and forecast the impacts of climate change, land use change and invasive species on continental scale ecology. NEON collects data and samples using a combination of field sampling, sensors, and airborne remote sensing measurements across the US.

The NEON Observatory Director/Chief Scientist will serve as the scientific lead of the Observatory and is responsible for facilitating community-led transformative research using the Observatory platform. This position will lead the Observatory science program through close coordination with the ecological science community and ensure that the Observatory fulfills its scientific and educational mission. In addition, this position will build impactful external activities with collaborators nationally and internationally.

Candidates must have a Ph.D. with at least 15 years of experience and an established record of outstanding scholarly achievement in ecology, advancing ecological thought and managing complex research programs.

Submit your resume/CV and cover letter to: battelle.org/careers

Battelle provides employment and opportunities for advancement, compensation, training, and growth according to individual merit, without regard to race, color, religion, sex, national origin, sexual orientation, gender identity, marital status, age, genetic information, or disability.

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and synchrotron transmission X-ray microscopy. Required qualifications for the position include a Ph.D. in a relevant discipline and experience in one or more of these techniques. Applications should be submitted online at https://jobs.carnegiescience.edu/jobs/dtm and should include a curriculum vitae and list of publications, description of thesis research, and contact information for three professional references. Submission details are available when you click on "Apply Now." Review of the applications will begin immediately and continue until position is filled. Please address any questions you have to Dr. Larry Nittler (lnittler@carnegiescience.edu). The Carnegie Institution is an equal opportunity employer. All qualified applicants will receive consideration for employment and will not be discriminated against on the basis of gender, race/ethnicity, protected veteran status, disability, or other protected group.

Ocean Science

Applied Physics Laboratory – Research Associate, University of Washington

The Applied Physics Laboratory at the University of Washington (APL-UW) is seeking Post-doctoral Research Associates with research interests in Oceanography, Polar Science, Remote Sensing, Environmental Acoustics and Ocean Engineering. This is a full-time appointment, with expected terms of two years subject to satisfactory performance and availability of funding.

Positions are not project-specific; a specific applicant is expected to define his/her research goals within the broad program areas of the participating APL departments: Air-Sea Interaction & Remote Sensing (AIRS), Acoustics Department (AD), Ocean Engineering (OE), Ocean Physics Department (OPD), Polar Science Center (PSC). Successful applicants must hold a recent (no more than 4-years) PhD or foreign equivalent in order to assume a post-doctoral position.

More information can be found http://ap.washington.edu/ahr/academic-jobs/position/nn23792/

Applicants are asked to submit electronically:

(1) A curriculum vitae,
(2) A publication list,
(3) A brief research proposal (no more than 5 pages, double-spaced, excluding bibliography and figures) describing research to be pursued during a two-year tenure at the University of Washington, and
(4) The names of four individuals who can provide a letter of reference.

In addition, a letter of support from a mentor in one of the participating departments (AIRS, AD, OE, OPD, PSC) is strongly encouraged. Further information on current research at APL, by department and principal investigator, can be found at: http://www.apl.washington.edu/departments/departments.php

Applications should be submitted via email:

Dr. Kevin Williams
Sr. Principal Physicist, Acoustics Department Chair, Liaison of Science and Engineering Group
williams@apl.washington.edu

Applying downscaled global climate models to improve marine resource management on the U.S. Northeast Shelf, Atmospheric and Oceanic Sciences Program at Princeton University

The Atmospheric and Oceanic Sciences Program at Princeton University in cooperation with NOAA's Geophysical Fluid Dynamics Laboratory (GFDL), National Ocean Service (NOS) National Centers for Coastal Ocean Science (NCCOS) and the Northeast Fisheries Science Center (NEFSC), seeks a postdoctoral or more senior research associate to develop predictions and projections of the response of coastal habitats and living marine resources (i.e. fish, corals, submerged aquatic vegetation, sea turtles, seabirds, mammals) to climate variability and change using downscaled global climate models for the U.S. Northeast Shelf Large Marine Ecosystem (U.S. NES LME). Projects would leverage recent advances in statistical downscaling for estuarine environments, dynamical downscaling for the Northeast US Shelf and estuaries, and could consider seasonal to century scales. The overarching objective is the development of innovative management-relevant applications that advance ecosystem-based marine resource management in the region.

PhD is required. Candidates with quantitative, interdisciplinary knowledge from subsets of fields including marine ecology/fisheries ecology, oceanography, geospatial modeling, and climate science are encouraged to apply. Experience conducting statistically rigorous uncertainty assessments, conducting spatio-temporal analyses of large data sets and/or model output, and developing habitat and/or population models for marine resources is highly desirable.

This is a one-year position (subject to renewal after the first year) based at NOAA GFDL in Princeton, New Jersey. Complete applications, including a CV, publication list, 3 references in order to solicit letters of recommendation, and a one-to-two page statement of research interests must be submitted to https://www.princeton.edu/acad-positions/position/1561 no later than June 15, 2017, for full consideration. This position is subject to the University's background check policy.

Princeton University is an Equal Opportunity/Affirmative Action Employer and all qualified applicants will receive consideration for employment without regard to age, race, color, religion, sex, sexual orientation, gender identity or expression, national origin, disability status, protected veteran status, or any other characteristic protected by law.

Postcards from the Field

Dear everyone,

As the Sun rises, it's clear why this is an exciting time in the Willamette Basin in Oregon. For a brief period, Fall Creek Reservoir is temporarily drained to its original streambed, which is below conventional winter lake levels. This 49-meter-tall dam normally impedes the downstream migration of juvenile salmon, but the draining of the reservoir helps them continue their migration. We're working to learn more about the other short- and long-term implications of this novel management strategy.

Going with the flow,
—**Christina Murphy,** Ph.D. candidate, Oregon State University, Corvallis

View more postcards at *http://americangeophysicalunion.tumblr.com/tagged/postcards-from-the-field.*