VOL. 99 • NO. 2 • FEB 2018

EOS

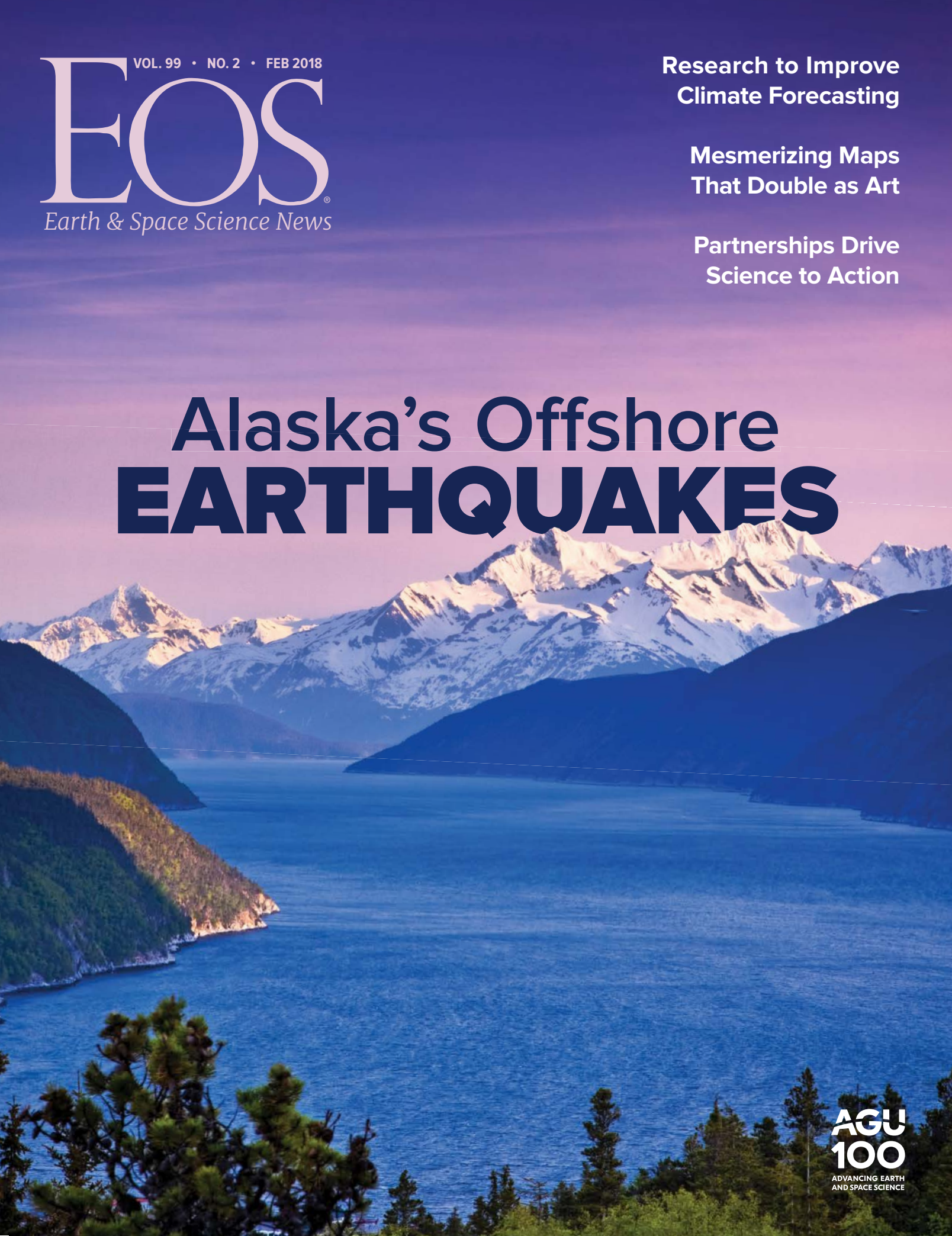
Earth & Space Science News

Research to Improve Climate Forecasting

Mesmerizing Maps That Double as Art

Partnerships Drive Science to Action

Alaska's Offshore EARTHQUAKES



AGU 100
ADVANCING EARTH AND SPACE SCIENCE


2018
HONORS
AGU100
ADVANCING
EARTH AND
SPACE SCIENCE
Recognize a colleague, mentor, peer, or student
for their achievements and contributions
to the Earth and space sciences.
• Union Medals • Union Fellowship • Union Prizes
• Union Awards • Sections Awards and Lectures
Union Honors Deadline: 15 March
Sections Deadline: 15 April
honors.agu.org

FEBRUARY 2018
VOLUME 99, ISSUE 2

COVER

A Closer Look at an Undersea Source of Alaskan Earthquakes

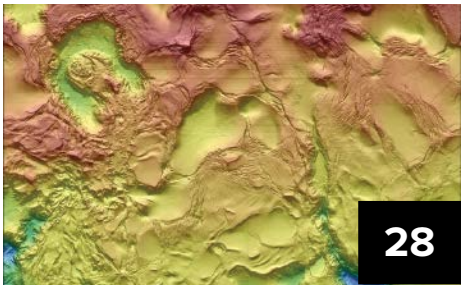
A systematic survey offers a striking portrait of movement along a 500-kilometer-long undersea section of the Queen Charlotte–Fairweather fault off the coast of southeastern Alaska.

PROJECT UPDATE

Advancing Climate Forecasting

Better forecasts, new products: The World Climate Research Programme coordinates research aimed at improving and extending global climate forecasting capabilities.

FEATURE



10 Mesmerizing Geophysical Maps That Double as Works of Art

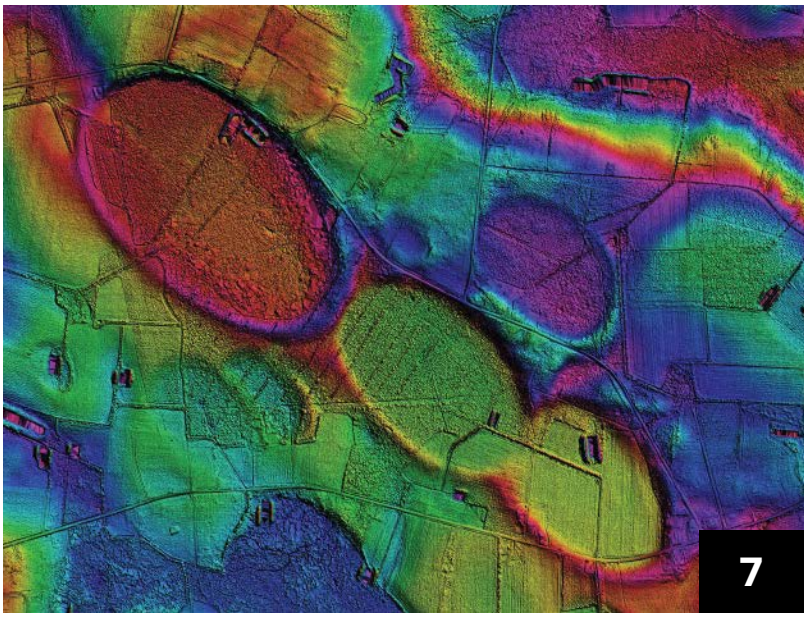
From tiny seafloor features in the Gulf of Mexico to craters pocking the surface of Mars, the details on these maps captivate and fascinate.

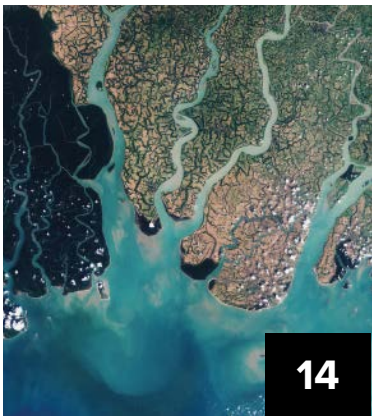
OPINION

10 Partnerships Drive Science to Action Across the AGU Community

Scientists and decision makers are working together to design, conduct, apply, and share research in ways that maximize value to society. How can AGU foster such partnerships?

DEPARTMENTS





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

Editorial Advisory Board

Mark G. Flanner, Atmospheric Sciences
Nicola J. Fox, Space Physics and Aeronomy
Peter Fox, Earth and Space Science Informatics
Steve Frolking, Biogeosciences
Edward J. Garnero, Study of the Earth's Deep Interior
Michael N. Gooseff, Hydrology
Brian C. Gunter, Geodesy
Kristine C. Harper, History of Geophysics
Sarah M. Hörst, Planetary Sciences
Susan E. Hough, Natural Hazards
Emily R. Johnson, Volcanology, Geochemistry, and Petrology
Keith D. Koper, Seismology
Robert E. Kopp, Geomagnetism and Paleomagnetism
John W. Lane, Near-Surface Geophysics
Jian Lin, Tectonophysics
Figen Mekik, Paleoceanography and Paleoclimatology
Jerry L. Miller, Ocean Sciences
Thomas H. Painter, Cryosphere Sciences
Philip J. Rasch, Global Environmental Change
Eric M. Riggs, Education
Adrian Tuck, Nonlinear Geophysics
Sergio Vinciguerra, Mineral and Rock Physics
Andrew C. Wilcox, Earth and Planetary Surface Processes
Earle Williams, Atmospheric and Space Electricity
Mary Lou Zoback, Societal Impacts and Policy Sciences

Staff

Production and Design: Faith A. Ishii, Production Manager; Melissa A. Tribur, Senior Production Specialist; Elizabeth Thompson, Production Assistant; Beth Bagley, Manager, Design and Branding; Travis Frazier and Valerie Friedman, Senior Graphic Designers

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; Kimberly M. S. Cartier, News Writing and Production Intern

Marketing: Jamie R. Liu, Manager, Marketing; Angelo Bouselli and Taryn Hudson, Marketing Program Managers; Ashwini Yelamanchili, Digital Marketing Coordinator

Advertising: Dan Nicholas, Display Advertising, Email: dnicholas@wiley.com; Heather Cain, Positions Available Advertising, Email: hcain@wiley.com

©2018. American Geophysical Union. All Rights Reserved. Material in this issue may be photocopied by individual scientists for research or classroom use. Permission is also granted to use short quotes, figures, and tables for publication in scientific books and journals. For permission for any other uses, contact the AGU Publications Office.

Eos (ISSN 0096-3941) is published monthly by the American Geophysical Union, 2000 Florida Ave., NW, Washington, DC 20009, USA. Periodical Class postage paid at Washington, D. C., and at additional mailing offices. POSTMASTER: Send address changes to Member Service Center, 2000 Florida Ave., NW, Washington, DC 20009, USA.

Member Service Center: 8:00 a.m.–6:00 p.m. Eastern time; Tel: +1-202-462-6900; Fax: +1-202-328-0566; Tel. orders in U.S.: 1-800-966-2481; Email: service@agu.org.

Use AGU's Geophysical Electronic Manuscript Submissions system to submit a manuscript: http://eos-submit.agu.org.

Views expressed in this publication do not necessarily reflect official positions of the American Geophysical Union unless expressly stated.

Christine W. McEntee, Executive Director/CEO

AGU 100 ADVANCING EARTH AND SPACE SCIENCE

Fossils Provide New Clues to Tibetan Plateau's Evolution

Called the "Roof of the World," the Tibetan Plateau perches high above the surrounding terrain, surpassed only by the Himalayan mountains that mark its southern border. But when and how the plateau reached its high elevation has remained unclear.

For one scientist and his team, tracing the evolution of the Tibetan Plateau now has a much needed clue: vertebrate fossils—woolly rhinos, shovel-tusked elephants, and climbing perch, to be precise.

"Most modern vertebrate fauna of the Tibetan Plateau have long histories living in this plateau," said Deng Tao, deputy director of the Chinese Academy of Sciences Institute of Vertebrate Paleontology and Paleoanthropology in Beijing and lead scientist on the study. What's more, "vertebrates are very sensitive to climatic and environmental changes," he said. Could the story of the plateau's evolution lie in their bones?

Deng's answer is yes. After examining fossils of animals that lived and died on the plateau over the past 34 million years, he and his team could trace when the plateau's elevation was low enough to allow animals to migrate across it.

"The uplift of the Tibetan Plateau was an important factor of global climate change during the late Cenozoic" (66 million years ago to the present), Deng said, "and it strongly influenced the development of the Asian monsoon system." Pinpointing the timing and speed of the plateau's uplift will help scientists better understand the geophysical processes that shaped southern Asia's landscape and the forces that influenced the paleoclimate in the region.

Their research, which Deng presented Thursday, 14 December, at the 2017 AGU Fall Meeting in New Orleans, La., suggests that the region hit its last growth spurt approximately 20 million years ago (http://bit.ly/Deng-2017). This early uplift time frame agrees well with most isotopic records.

Fossils as a Window into Uplift History

The Tibetan Plateau, the youngest and highest plateau in the world, rises approximately 5,000 meters above sea level, nearly one third of the way to the tropopause. Its height and location shape atmospheric flow and climate in the region. The Tibetan Plateau supports a diverse range of ecosystems, including deserts, forests, and tundra, all adapted to its high-altitude environment.

> "Vertebrates are very sensitive to climatic and environmental changes."

In the same way, past fauna would have reflected past environments, the researchers figured. To test this, Deng and his team examined newly excavated as well as archived fossils of ancient fish and mammals from the plateau that date to the late Oligocene (34–23 million years ago (Ma)) through the mid-Miocene (23–5.3 Ma) and Pliocene (5.3–2.6 Ma) epochs. They analyzed fossilized rodents, fish, Tibetan woolly rhinoceroses, shovel-tusked elephants, and ancestral relatives of arctic foxes, snow leopards, and bighorn sheep.

Although results published previously by the team parse analyses of separate species,

*A fossil skeleton of a woolly rhinoceros (*Coelodonta antiquitatis*), an extinct species that once roamed the Eurasian continent. Fossils of this species' Tibetan cousins (*Coelodonta thibetana*) are now helping scientists reconstruct the elevation history of the Tibetan Plateau. Credit: Didier Descouens, CC BY-SA 4.0 (http://bit.ly/ccbysa4-0)*

the results presented at the 2017 AGU Fall Meeting aggregate these studies, other research, and new fossil analyses into one comprehensive view. And what they found painted a clear picture.

During the late Oligocene, large mammals like the Tibetan woolly rhinoceros and shovel-tusked elephant roamed from northwestern China to the Indian subcontinent, Deng explained. The distribution of their fossils north and south of Tibet during the Oligocene indicates that the plateau's elevation was low enough to allow migration across the continent. In addition, the team found fossils suggesting that lowland species like the ancestors of climbing perch likewise made their homes in Tibet during the late Oligocene.

Late Oligocene fossil of Eoanabas thibetana, *an ancestor of the modern-day climbing perch, collected in central Tibet and used to constrain the latest period of a low-elevation Tibet. Credit: Wu et al., 2017, https://doi.org/10.1038/s41598-017-00928-9, CC BY 4.0 (http://bit.ly/ccby4-0)*

Adapt or Perish in High-Altitude Tibet

By the early Miocene, however, fossil records suggest that the plateau was elevated enough that large mammals who lived just north of Tibet had to curtail their southward migration, Deng explained. For example, although paleontologists have found shovel-tusked elephant fossils from the mid-Miocene north of the plateau, none exist within or south of the plateau during that epoch.

Vertebrates that were trapped on the now elevated Tibetan Plateau either evolved to survive in a high-altitude cryosphere or died out. Lowland-adapted species of fish and rodents perished, and their fossils disappeared.

For vertebrates that survived, including the ancestral forms of the woolly rhinoceros, snow leopard, arctic fox, and bighorn sheep, their Pliocene fossils show that the animals had long since adapted to freezing temperatures at high elevations, Deng said. The plateau must have uplifted a few million years prior to the most recent ice age at the end of the Pliocene, the researchers argue, for the animals to have been well adapted to the cold by then.

That uplift timing supports the theory that the Tibetan Plateau's rise to the top resulted from the collision of the Indian and Eurasian continental plates that occurred 40–50 Ma. The evolutionary history suggested by this timing also agrees with the past environmental conditions suggested by isotope ratios of oxygen, hydrogen, and calcium found in carbonate rocks that surround the fossils.

Lingering Questions

For Deng and his team, the geographic locations of the fossil deposits and their stratigraphic origins tell a single story: a low-elevation Tibet in the late Oligocene, a constant uplift in the early Miocene, and a modern-elevation Tibetan Plateau by the middle to late Miocene.

"Fossils are really valuable and probably an underused source of insights," Katherine Freeman said about resolving the controversy surrounding the timing of the Tibetan Plateau uplift. Freeman is an isotope biogeochemist and a professor of geosciences at Pennsylvania State University in University Park. "Although their record can be discontinuous, they would be excellent for marking changes on broad time and spatial scales." She added that she "certainly welcome[s] this additional perspective on a tricky problem."

However, not all paleoelevation proxies agree with the early Miocene rise suggested by fossils and stable isotope measurements. For example, isotope studies of tooth enamel found in fossils from the high Himalayas dating to the late Miocene show signatures consistent with the animals chewing C4 grasses, plants species that thrive in warmer conditions. Those results indicate that Tibetan climate in the late Miocene might have been much warmer, suggesting that elevations were likely much lower than they are today and contradicting the recent fossil-based analysis.

How do you resolve this discrepancy? "We want to find more fossil records from Cenozoic basins in the Tibetan Plateau," Deng said. More fossils, the team thinks, will clear up the fuzzier details of the plateau's past.

By **Kimberly M. S. Cartier** (@AstroKimCartier), News Writing and Production Intern

2018 CIDER SUMMER PROGRAM
July 9 – AUGUST 3, 2018
"Relating geochemical and geophysical heterogeneity in the Deep Earth"

CIDER
Cooperative Institute for Dynamic Earth Research

CIDER announces their annual summer program on behalf of the geosciences community *(http://www.deep-earth.org/). Organizers*: Ved Lekic, Kanani Li, Carolina Lithgow Bertelloni, Sujoy Mukhopadhyay and Bruce Buffett.

Significant advances and discoveries since 2004 motivate a return to this long-standing question. Improvements in the quality and quantity of observations have combined with computational advances in modeling seismic-wave propagation to turn blurry images into sharply focused snapshots of the present-day structure. Advances in experimental and theoretical mineral physics have brought new insights into the crystal structure and transport properties of materials at high pressure and temperature. Advances in geochemical analysis reveal growing evidence for short-lived isotopes in the early Earth. The purpose of CIDER 2018 is to bring together junior and senior scientists from different disciplines to cross-educate each other and help advance this inherently multi-disciplinary question.

The program features a 4 week tutorial and research program for about 40 advanced graduate students and post-docs), while scientists at the assistant professor/researcher level are welcome at any point in the program, with a minimum commitment of 2 weeks.

This summer program will be held at the Kavli Institute of Theoretical Physics, University of California, Santa Barbara. It is supported by the NSF/FESD program. Applications are invited for both senior and junior participants at:

http://www.deep-earth.org/summer18.shtml
Application deadline: February 16, 2018

NOAA Reports Arctic Experiencing a Warmer "New Normal"

Recent observations of declining sea ice, persistently elevated temperatures, and other factors confirm that a new climate era endures in the Arctic, according to the annual, major assessment of the region by the National Oceanic and Atmospheric Administration (NOAA) that was just released.

Observations during 2017 "confirm that the Arctic shows no signs of returning to the reliably frozen state that it was in just a decade ago," Jeremy Mathis, director of NOAA's Arctic Research Program, said 12 December as the agency unveiled its 2017 Arctic Report Card (http://bit.ly/Arctic-2017).

"Arctic temperatures continue to increase at double the rate of global averages," he told reporters at a news briefing at the 2017 AGU Fall Meeting in New Orleans, La. The mean Arctic air temperature over land in 2017 exceeded the 1981–2010 average by 1.6°C, making it the second-highest average in the observational record after 2016, according to the NOAA report.

The report also found that the thickness of sea ice cover has continued to decline. Ice more than 1 year old composed just 21% of ice cover in 2017, whereas in 1985 it was 45%. Arctic ocean plankton blooms increased, as did overall land vegetation. Record permafrost warming has also occurred at many sites around the Arctic according to 2016 data, the most recent complete set of permafrost observations.

In March 2017, maximum winter sea ice shrank to its smallest extent ever observed in the Arctic, the report also noted. In August 2017 in the Barents and Chukchi Seas, surface temperatures reached 4°C above average. Amid all the warming, however, melting of the Greenland ice sheet fell below average when compared with the previous 9 years, NOAA found.

The Arctic Report Card "is a valuable annual reminder of the rapid, ongoing evolution of the Arctic region," John Farrell, executive director of the U.S. Arctic Research Commission, an independent federal agency, told *Eos.* The report card's results "should alarm us all, but the environmental intelligence section also shows us what we can do to respond," he added.

Paul Berkman, professor and director of the Science Diplomacy Center at Tufts University's Fletcher School of Law and Diplomacy, told *Eos* that the concept of a "new normal" is constructive to prepare the world for the opportunities as well as the challenges that will accelerate with diminished ice in the Arctic.

Arctic Changes and Administration Priorities

At the mid-December briefing, Mathis said that Americans should realize that the impact of climate shifts in the Arctic will not stay in the Arctic. "These changes will impact all of our lives. They will mean living with more extreme weather events, paying higher food prices, and dealing with the impacts of climate refugees," he said.

Retired Navy Rear Adm. Timothy Gallaudet, acting NOAA administrator, also underscored in his remarks that the Arctic's transformation, including its opening to ship passage, deeply affects the region as well as the rest of the planet. He added that the impacts on national and economic security are White House and NOAA priorities.

Despite the Trump administration's stance on climate change, including proposed budget cuts and plans to withdraw from the Paris climate agreement, Gallaudet insisted that the administration, as well as NOAA, acknowledges the gravity of the report.

"I can tell you that NOAA, speaking as the NOAA deputy, is taking action already in terms of advancing our Earth system prediction and [modeling] and observation capability," Gallaudet said. "That is going to allow us to better inform the public and the administration on the changing Arctic."

Gallaudet also said that, a few weeks prior to the report's release, the White House Office of Science and Technology Policy convened a meeting of the federal Interagency Arctic Research Policy Committee about this report and other actions. "So the White House is addressing [the report] and acknowledging it and factoring it into their agenda," he said.

Environmental Intelligence

The NOAA report also calls for expanding and improving sustained information gathering "to provide actionable intelligence and forecasting needed by people of the Arctic and other stakeholders," among other measures.

"As a society, we ignore the Arctic at our peril, and a failure to act on what we know is inexcusable," Henry Huntington, an independent Arctic researcher and the Arctic science director for the Ocean Conservancy, told *Eos,* referring to the report's section on the need for improved Arctic observation.

A series of resiliency and adaptation workshops in Alaska's coastal communities in 2017 have highlighted the need to adopt the environmental intelligence framework described in the report card, Molly McCammon, executive director of the Alaska Ocean Observing System, told *Eos.*

But Berkman said that something is missing from the environmental intelligence approach of the report. "Environmental intelligence as a concept has particular value to integrate natural science data into evidence, especially with system-level models," he said. "However, evidence requires the integration of natural sciences and social sciences as well as indigenous knowledge, with the latter two arenas of investigation missing entirely from the 2017 Arctic Report Card."

A collapsed block of ice-rich permafrost sits in shoreline waters in Drew Point, Alaska. Climate changes in the Arctic include record permafrost warming, according to NOAA's latest annual "report card" on the region, which was released 12 December 2017. Credit: Benjamin Jones, USGS

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

Dan Rather's Vision for Scientists in an Era of "Fake News"

Veteran journalist Dan Rather speaks to AGU Fall Meeting attendees. Credit: Jules Clifford/EPNAC

"The fate of our very planet is at stake," renowned journalist Dan Rather told a packed auditorium of scientists on 11 December at the 2017 AGU Fall Meeting in New Orleans, La. "Earth is warming; human activity plays a major role. We can, if we act with speed and purpose, likely mitigate some of the harm. But will we?" he asked.

The urgency of the task in today's charged political environment, the pushback from the Trump administration about fake news as well as its inaction on climate change, and the need for scientists to better communicate their work were among Rather's themes in his Presidential Forum speech. Rather, 86, was a CBS news anchor from 1981 to 2005 and has covered every U.S. president since Dwight Eisenhower. He is a veteran reporter of wars, civil rights, science, and other major news spanning the past 50 years.

From his vantage, Rather sees society at large at a crossroads. "We find ourselves in a moment of reckoning," he said in his address. "Are we going to guide our future by science, reason, and knowledge, or are we going to succumb to superstition, ignorance, and propaganda?"

Science Under Siege

The United States faces a unique threat, Rather said, with a president who has told an unprecedented number of easily debunked lies since the very beginning of his term—all the while attacking the press and media and accusing them of publishing "fake news."

"Journalists and scientists are both under siege," Rather said, "beset by accusations of fake news, self-interest, and bias. Much of this comes from coordinated attacks from powerful actors who have a vested interest in the truth remaining hidden."

During a news briefing that followed his talk, Rather said that "many of the attacks on the whole business of climate change [are] very cynical" because what President Trump is trying to accomplish "is financed by very wealthy special interests whose businesses and products, by their calculation, might suffer" if climate change became even more widely accepted.

"We can dance around it," Rather said, but in many instances, public officials "are bought and paid for, and they deliver."

Rather said at the briefing that Trump "is really preaching the gospel of division" and that his dismissal of climate change as coming from the intellectual elite resonates with Trump's political base.

> "Journalists and scientists are both under siege… beset by accusations of fake news, self-interest, and bias."

Despite the administration's stance on climate change, Rather said that he is optimistic by nature and by experience and "without apology."

"That's not Pollyannaish optimism with me. We are in a very perilous time in this country. This is not normal," he said. "But there is a fundamental decency and an empathetic core to the people of the United States that when the big chips are on the table—which is to say, when you are absolutely positive we have to do it—then the country responds."

However, Rather told *Eos* that there is a sense of urgency to fix these problems. "If [the country] keeps going in the direction that it's going, I hate to contemplate what would happen. I don't think that will happen," he explained. "The country really needs to pull out of this."

Rediscovering Nuance

So how do we combat anti-intellectual forces? "I want to see a revolution in how we communicate science," Rather said.

A cynicism toward science and scientists has been brewing for years, he said, because the nuances and individual stories have largely been ignored in the name of splashy results. "I believe this breeds much of the dangers and distrust that we're witnessing and experiencing today," Rather said.

Scientists are often criticized for not explaining themselves well enough or for not taking science communication seriously, he noted. But although he hopes the science community embraces communication "with more urgency," ultimately, scientists' job is "to be great researchers, to understand data, to dream up ingenious experiments."

Rather then spoke to the science communicators in the auditorium: "What if we confront our biases about what the public might find interesting?" He also asked the scientists in the audience how often they're told to frame their science in a way they'll think the public will find interesting. Many in the audience raised their hand, and some scattered laughter could be heard.

"I think you're getting the wrong advice," he said. As a result, "much of the story of science is being lost in popular culture."

What Rather hopes is that scientists and communicators will form a partnership to tell "compelling but also truthful" stories and celebrate the slow, nuanced, roiling debate that encapsulates the scientific process.

"Those of us in the press and media, we're always looking for easy answers, simple narratives," Rather said. Instead, he imagines a future in which storytellers can highlight what scientists themselves are passionate about to capture the "joy and awe of discovery" of the scientific process. "We can focus on the journey of discovery as well as the results," Rather said. And by telling stories about diverse scientists around the world who might not be tenured at prestigious universities, "we can democratize the pursuit of science," he continued.

Through partnerships in storytelling, we can slowly build a culture that values science, Rather explained. And as the founder and CEO of News and Guts, an independent news production company, he wants to do his part to help shape that culture. "I may have only a little bit to offer, but whatever I have to offer, why, I want to try," he later told *Eos*.

Fear Not

Getting the public engaged in science is not an onerous task, Rather noted in his address. He pointed out that millions observed the 2017 solar eclipse and that many people visit science museums across the country every year. The public, he said, is knowledge hungry.

When AGU president Eric Davidson asked Rather his advice for scientists who are reluctant to speak to the media for fear of being misrepresented, Rather's response was simple: "Fear not."

"This is not worthy of some of the best minds in the country to talk about risk to say, 'I'm afraid to do something,'" he continued. "No. The best of science is not afraid to do anything."

When speaking with the media, "Is there a risk sometimes? Are you going to get burned sometimes?" Rather asked. "Yeah, probably, unless you're very lucky and very careful."

But the pursuit of science—and for that matter, life itself—is about taking risks, he explained. "So don't come into science and science storytelling thinking, 'What might happen?' Have some courage; take the risk."

Shifting the Culture

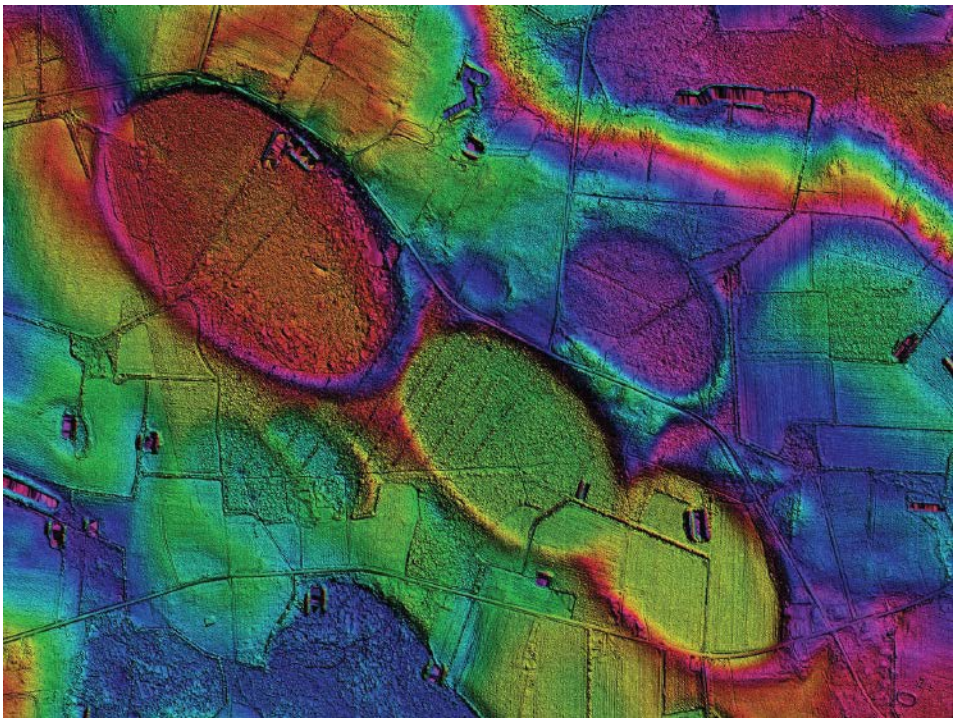
To change the paradigm around science communication, Rather urges small, individual acts from scientists—engage with local schools, or even just talk to a relative about your research, he said. Scientific "leaders can't lead if they don't have those who can amplify their calls," he explained.

These actions may seem small and insignificant, but thousands and thousands compounding on each other will have a large effect. "I've covered enough social movements to know that big change begins with small commitments and engagement," Rather said.

The full video of Dan Rather's 2017 Presidential Forum lecture can be viewed at http://bit.ly/drather-video.

By **JoAnna Wendel** (@JoAnnaScience) and **Randy Showstack** (@RandyShowstack), Staff Writers; and **Mohi Kumar,** Scientific Content Editor

Four Planetary Landscapes That Scientists Can't Explain



A lidar image of mysterious features on Earth called Carolina bays. These depressions dot much of the East Coast of the United States, they're all oriented in the same direction, and scientists still don't know how they formed. This image was taken in South Carolina, showing four Carolina bays, each between half a kilometer and 1 kilometer long. The image uses hue-saturation-value mapping to highlight elevation changes in the bays, from the ridges to the shallow depressions, revealing features that often can get overlooked from a ground-level view. The technique creates a continuum of colors across the rainbow, repeating the rainbow several times, to capture extremely fine details as elevation changes. Credit: Michael Davias

Take a tour of the solar system, and you'll find myriad mysteries. How old are Saturn's rings? What carved out Mercury's hollows? What created Iapetus's weird ridge?

At the 2017 AGU Fall Meeting in New Orleans, La., several scientists dedicated a poster session to just a pinch of solar system puzzles—including strange landscapes on our own planet.

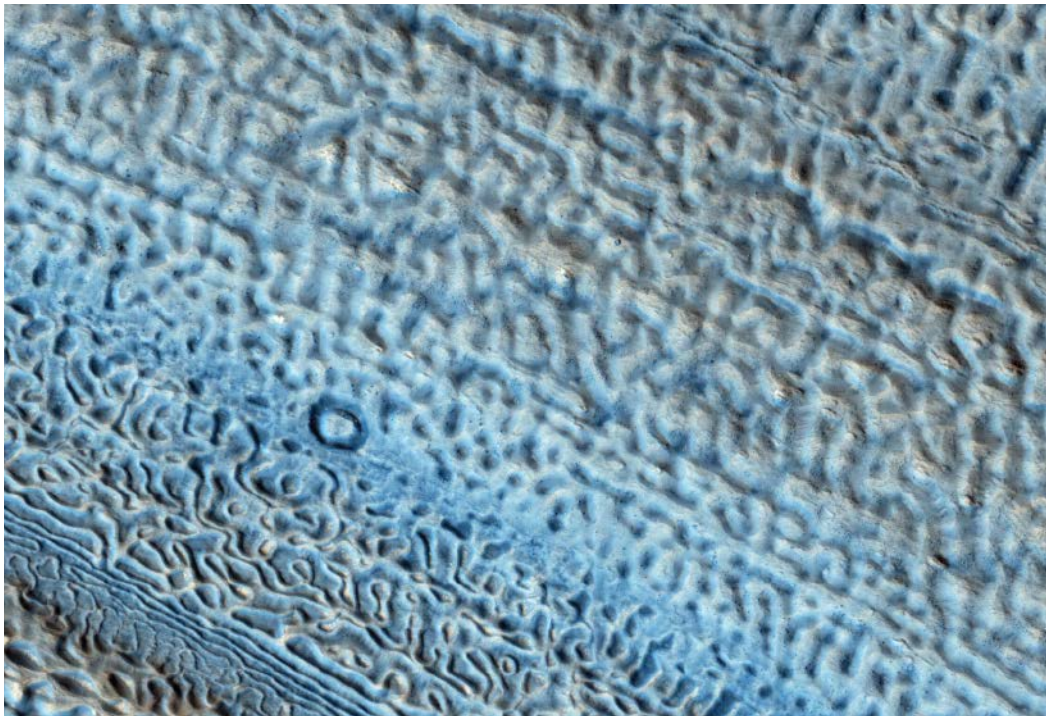
"We thought it would be interesting to create a risk-free session" where scientists could "come with a totally off-the-wall idea and everyone [would] want to chat about it," said Angela Stickle, a planetary scientist at the Johns Hopkins University Applied Physics Laboratory in Laurel, Md., and coconvener of the session.

Perhaps some new collaborations will come out of the discussion, Stickle added. Maybe an Earth scientist has seen an image of a strange feature on Mars and thought, "Wait, I've seen something like that on Earth!" and a new partnership will flourish.

Here are four of these mysterious terrains, along with possible explanations for them. For more of the solar system's wacky, unexplained morphology, browse abstracts from the meeting's poster session "If You See Something, Say Something: Exploring the Weird and Wonderful Features of the Solar System Posters" (P11A, http://bit.ly/Mystery-Terrains).

Brainy Mars?

One curious landscape spotted on Mars is a vast expanse known as the "brain terrain." Scientists spotted the landscape in 2013 as they began to study Arcadia Planitia, a vast, smooth plain in Mars's northern midlatitudes. Some scientists posit that the roughly 10-meter-wide dark troughs are places



NASA's Mars Reconnaissance Orbiter snapped this image of Mars's so-called brain terrain from several hundred kilometers away. Scientists estimate that the dark troughs are about 10 meters wide. Credit: NASA/JPL-Caltech/University of Arizona

where ice has been lost to sublimation—the process by which solid ice skips the liquid stage and just evaporates—while the bright spots still contain ice, said Nathan Williams, a planetary scientist at NASA's Jet Propulsion Laboratory in Pasadena, Calif., and a poster presenter.

If this explanation is true, more questions abound. "How old is the ice?" Williams wondered. "What implications does that have on the climate history of Mars?"

Most important of all, "in the future, could ice from the brain terrain be used as an in situ resource for drinking, fuel, and/or agriculture?" Williams asked.

Willy Wonka and the Taffy Factory

Meanwhile, half a planet away in the southern midlatitudes lies Mars's taffy pull terrain, or simply "taffy terrain," which looks like a swirling mass of the gooey candy trapped in time. Scientists found the terrain in the basin of a 2,300-kilometer-wide impact crater called Hellas Planitia and nowhere else.

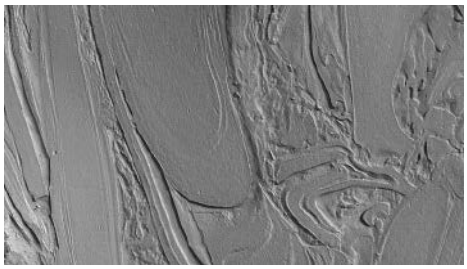


Image of the mysterious taffy pull terrain taken by the Mars Global Surveyor orbiter. The image covers an area 3 kilometers across. Credit: NASA/JPL

"The taffy terrain bears some resemblance to submarine salt domes in the Gulf of Mexico, glacial deposits with mixed ash in Iceland, or chalk formations in Egypt's White desert," Laura Kerber, a planetary scientist at the Jet Propulsion Laboratory, wrote in her poster abstract.

However, scientists have "never seen anything like it, and it's only on one place on Mars, so something weird is going on there," said Tanya Harrison, a planetary scientist at Arizona State University at Tempe who was not involved in this particular poster.

The leading theory behind the taffy terrain's origins involves landscapes containing different types of rock—some easy to erode, some harder to erode. As time passes, more easily eroded rock moves away, leaving behind the weird, flowlike pattern on the harder rocks, Harrison explained.

Carolina Bays

Our own blue planet isn't lacking mysterious terrains. On the United States' East Coast, for example, stretching from New Jersey to Florida, hundreds of unexplained depressions pock the landscape. These depressions, which range in length from 180 meters to around 20 kilometers, are the Carolina bays—so named because a large cluster is found in the Carolinas. All of them are aligned northwest to southeast, and no one has a solid explanation for how they formed.

"Tens of thousands of these landforms [exist] around and amongst millions of people, and yet no serious geological undertakings have been made in the past 40 years to investigate them," said Michael Davias, a researcher at Cintos Research, an independent group of citizen scientists, and a presenter of a poster.

Theories of formation range from swarms of meteorites to wind, Davias said. Scientists seem to be divided into two camps: those who think some external force like impacts created the depressions and those who think the depressions formed from wind- or water-related erosion.

Bright Streaks

One face of Saturn's icy moon Dione is criss-crossed with unexplainable bright streaks. The Cassini spacecraft first showed scientists these streaks on Dione, as well as on the larger moon Rhea. Scientists have yet to figure out their origins.

When a mystery like these bright streaks pops up, "it makes you rise to the challenge" to get to the bottom of it, said Emily Martin, a planetary scientist at the National Air and Space Museum in Washington, D. C., and a presenter of a poster on the topic.

The leading theory behind the bright streaks involves tectonics, but not the kind of tectonics we're familiar with on Earth, Martin pointed out. No other plate tectonics like Earth's exists in the solar system, so the cracks and faults on Dione and Rhea result from the pushing and pulling of gravity as the moons orbit Saturn.

However, Martin is currently exploring an alternative theory involving impacts: Maybe an impact's scour created the bright streaks, or perhaps a cloud of orbiting debris rained down on the moons.

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

O. Walter Lennartsson (1943–2017)

Nancy Lennartsson

Olof Walter Lennartsson

Olof Walter Lennartsson, an internationally recognized space plasma physicist, died suddenly on 2 February 2017 at his home in Los Altos, Calif. Walter's research combined theory, analysis of data from instrumentation on the ground and aboard spacecraft, and his own insight into physical processes to enhance our understanding of Earth's magnetosphere and its dynamics.

Early Career

Walter studied theoretical space physics from 1966 to 1973 at the Swedish Royal Institute of Technology (KTH) with first-generation space pioneers Lars Block, C.-G. Fälthammar, and Rolf Boström in the laboratory founded and directed by Hannes Alfvén. His thesis work addressed electric field and current distributions in the ionosphere. That study was one of the earliest to suggest an electric potential drop along auroral magnetic field lines.

> Walter applied his keen analytical skills and insights to improve the designs of several very successful space plasma instruments.

He published subsequent work on the subject in several papers throughout his career. His theoretical work contributed significantly to the identification of possible mechanisms that could permit the formation and maintenance of large electric fields parallel to the magnetic fields in and above Earth's ionosphere in the auroral zones.

Walter's work, along with that of many others, provided the motivation to develop new and improved techniques specifically designed to test the proposed mechanisms. In particular, he helped to develop very high time resolution plasma instrumentation that was deployed on NASA's Fast Auroral Snapshot Explorer mission and the Magnetospheric Multiscale mission.

After leaving KTH, Walter spent 3 years at NASA's Marshall Space Flight Center in Huntsville, Ala., where he applied himself to the interpretation of complex data from early spacecraft in Earth's magnetosphere.

Morphology and Dynamics of the Magnetosphere

In 1978, Walter joined the Space Physics Group at the Lockheed Palo Alto Research Laboratory (LPARL) in Palo Alto, Calif. The LPARL group pioneered the use of ion composition measurements of hot plasmas in Earth's magnetosphere. The group had recently discovered that at times, oxygen ions (O^+) could be a significant component of the hot plasma, implying that magnetospheric plasma could also come from Earth's ionosphere rather than solely from the solar wind, as had previously been assumed. Walter used this, as well as other aspects of ion composition, to better understand the complex transport and heating processes that form Earth's plasma sheet.

Walter, working with members of the group, soon became the driving force behind the analysis and interpretation of data from the LPARL mass spectrometer on board NASA's International Sun-Earth Explorer 1 (ISEE-1) spacecraft. He and his collaborators used data from ISEE-1 as well as several other Earth-orbiting spacecraft over the following years to address the role of ion composition in magnetic storms, substorms, geomagnetic pulsations, and, most important, the formation and dynamics of Earth's plasma sheet.

The earlier work was done to establish the morphology and dynamics of O^+ and other heavy ions in all regions of Earth's magnetosphere. Walter's papers on morphology and dynamics of the plasma sheet are fundamental reading for anyone studying Earth's magnetosphere.

Physical Mechanisms and Processes

After magnetospheric morphology and dynamics were reasonably well established, the focus of Walter's work shifted to elucidating the physical mechanisms and processes acting on the magnetosphere. Magnetospheric researchers now use large-scale models to explore magnetospheric dynamics, guided in their work by the careful interpretation of magnetospheric composition data in Walter's papers.

In addition to his interpretation and theoretical work, Walter applied his keen analytical skills and insights to improving the designs of several very successful space plasma instruments built by the LPARL group. Notable among these were the High-Energy Range Spectrometer instrument on the European Space Agency's Giotto mission to Comet Halley and the Toroidal Imaging Mass-Angle Spectrograph instrument on NASA's Polar spacecraft.

Walter published 91 papers, including 30 single-author papers. He was a frequent speaker at international conferences, where his advice and counsel were often sought and freely given. He was an outstanding scientist and a good friend to the many people with whom he worked.

Walter retired from Lockheed Martin in 2013. He is survived by his wife of 38 years, Nancy Lennartsson, and their son, Nils.

By **W. K. Peterson** (email: bill.peterson@lasp.colorado.edu), Laboratory for Atmospheric and Space Physics, University of Colorado Boulder; and **Edward G. Shelley,** Lockheed Martin, Ashland, Ore. (retired)

Visit Eos.org every day for the latest news and perspectives.

Partnerships Drive Science to Action Across the AGU Community

A growing movement in the geosciences offers a novel and promising approach to leveraging our science to advance societal priorities. Rather than in two unconnected groups—scientists who perform research and publish it in professional journals and decision makers who try to understand and apply this research after the fact—scientists are increasingly working in partnerships with people making decisions to design, conduct, apply, and share research in ways that optimize its value to society.

This "coproduction" process requires a commitment by scientists and decision makers to listen to each other and recognize the value of the other's expertise. Through these partnerships, scientists can ask novel research questions while simultaneously generating knowledge for making more robust decisions.

Heightened interest in coproduction is motivated by increased demand from decision makers, who could benefit from knowledge contained in current research but generally cannot directly apply off-the-shelf peer-reviewed literature. The Water Utility Climate Alliance (see https://www.wucaonline.org), a collaboration among 12 of the largest water providers in the United States, has initiated several such successful coproduction efforts. This alliance coordinated pilot projects with utilities in New York City; Portland, Ore.; Seattle, Wash.; and Tampa Bay, Fla., that demonstrate the value of iterative, collaborative processes between decision makers and scientists to address climate adaptation challenges (see *Vogel et al.* [2016] for details and *Advisory Committee on Climate Change and Natural Resource Science* (*ACCCNRS*) [2015] for additional examples).

We are longtime members of AGU, and we see growing evidence of coproduction within AGU, in many sections and focus groups and in AGU leadership. We have also noticed an expansion of resources, within and affiliated with AGU, that could support this work. Here we demonstrate trends, report on responses to surveys about community engagement that we conducted at past Fall Meetings, offer ideas for how to help the movement toward scientist–decision maker partnerships expand, and describe ongoing activities and existing resources that could be leveraged in these partnership efforts.

Scientists and decision makers can be thought of as two very different species coexisting in the same ecosystem. Over time, they can develop a symbiotic relationship. Credit: Natphotos/Photodisc/Getty Images

Some geoscientists are already familiar with coproduction. We emphasize, however, that this approach is growing in breadth and depth. We consider it complementary to other research approaches, and we recognize its potential to enhance support for all ways of doing science.

Terms at the Foundation of the Coproduction Movement

Decision makers increasingly welcome partnerships with scientists as they tackle such issues as global change, natural hazards, and environmental justice. Scientists from many fields and career stages embrace these partnerships to help inform their work.

To help provide clarity across the many disciplines involved, we define terms as follows:

- **Science** refers to the entire enterprise, including basic and applied research, citizen science, science education, science-related capacity building, and science policy.
- **Decision-making** refers to choosing a course of action, including managing public and private resources, policy making, and decisions made by citizens and officials that affect their communities.
- **Decision makers** are people who do the work to recommend actions, as well as those who make the final decision.
- **Coproduction** is any partnership between researchers and decision makers that leverages the expertise of both groups to design, conduct, apply, and share the research.

Coproduction has other names and connotations (Figure 1), but we use it to mean a genuine partnership where knowledge is exchanged in both directions through much of the life of a project according to both partners' needs. We contrast this with a one-way approach, where scientists design and conduct research but leave application, and sometimes sharing, to others and always after the research is completed [*Beier et al.*, 2016; *ACCCNRS*, 2015].

Activities and Trends

Several AGU activities connect science with society (Table 1). Most span disciplines and began or reinvented themselves recently. For example, the Societal Impacts and Policy Sciences (SIPS; Table 1) focus group promotes activities to facilitate connections between society and

Earth and space science. Their activities and affiliations continue to grow, crossing all geoscience disciplines; SIPS liaisons connect with other sections and focus groups. In another example, the Thriving Earth Exchange (TEX; Table 1), more than 100 scientists have contributed their time, pro bono, to support coproduction in communities.

AGU Fall Meeting abstracts reflect a growing interest in coproduction. To document this trend, we used the Astrophysics Data System search engine to sift Fall Meeting abstracts from 2001 to 2015 for words that denote these partnerships (Figure 1). We checked the abstracts to confirm that the terms were used in a way that coincided with engagement as defined above.

Terms more frequently used to denote scientist-to-scientist partnerships were excluded from our search. Abstracts containing multiple keywords were counted only once, and they were counted in the category that is lower in the bar graph in Figure 1. In every year, abstracts were normalized by an annual factor to make the total number (all submitted abstracts) match the total for 2015.

Abstracts indicating partnerships between scientists and decision makers are found in most of AGU's sections and focus groups, as well as in Education and Union sessions. Hydrology, Global Environmental Change, Public Affairs, Earth and Space Science Informatics, and Natural Hazards had the largest overall percentages. These remained the top five when values were adjusted according to the section and focus group size as specified by current AGU member primary designations.

Tellingly, over this time period, we found a considerable increase in abstracts overall that refer to these partnerships that are distributed across sections and focus groups (Figure 2), suggesting a growing community that crosses disciplines with the potential to provide an opportunity to learn from diverse experiences.

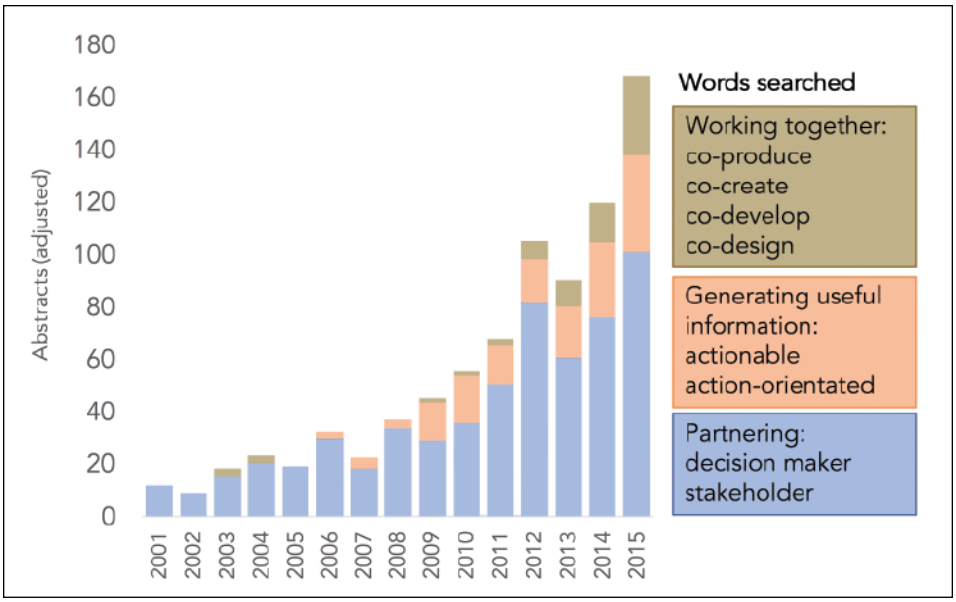


Fig. 1. We surveyed AGU Fall Meeting abstracts from 2001 through 2015 for terms that indicated partnerships between scientists and decision makers and found a growing interest in coproduction.

Fall Meeting abstracts after 2015 were not yet available when we did this survey, but preliminary searches of the 2016 Fall Meeting schedule suggested a continued increase.

These activities and trends suggest that increasing AGU's capacity to support coproduction will benefit all disciplines. It will generate greater societal involvement in, understanding of, and use of Earth and space science in decision-making, which could increase public support for that discipline and for science as a whole.

How AGU Can Contribute

At the 2016 AGU Fall Meeting, several sessions featured examples of coproduction:

- "Toward More Effective Decision Maker–Scientist Engagement" (see http://bit.ly/FM2016-PA33D)
- "Making an Impact: Stories, Tips, and Lessons Learned from Collaborating with Communities" (see http://bit.ly/FM2016-PA24B)
- "Improving the Usability of Climate, Extreme Event, and Hazard Data and Information Products for Community Decision Makers" (see http://bit.ly/FM2016-PA22A)

These sessions included 42 oral and 95 poster presentations, three panel discussions, and two lightning poster sessions (links above go to part 1 of each session series). We, as part of an informal coalition of scientists and decision makers interested in coproduction, linked these together and connected them to a TEX workshop, two evening networking events (one sponsored by TEX and another organized by session conveners), and a press event.

Table 1. AGU-Affiliated Activities at the Science-Society Interface That Support Coproduction

ACTIVITY	START DATE	GOALS	ACTIVITIES
Societal Impacts and Policy Sciences (SIPS; https://sfg.agu.org/sips)	2008, 2014 (relaunch)	inform about relevant issues, promote outreach, provide resources, and implement innovative education and interactions that better connect science and society	luncheons, media trainings, science policy primers, one-on-one meetings with an attorney, sessions at the Fall Meeting (e.g., most Science to Action sessions in 2017)
Water and Society Technical Committee (W&S; https://hydrology.agu.org/committees)	2011	increase activities related to water and society within the Hydrology section	committee meeting, Water and Society sessions at the Fall Meeting
Thriving Earth Exchange (TEX; https://thrivingearthexchange.org)	2013	help scientists, community leaders, and sponsors work together to solve local challenges related to natural resources, climate change, and natural hazards	managing about 50 ongoing projects, launching new projects, networking events, coproduction workshop and sessions at meetings
Resilience Dialogues (http://resiliencedialogues.org)	2016	online consultation service for community leaders to engage in dialogues with scientists, resilience practitioners, subject matter experts, and other leaders	10 communities participating in the collaboration's beta phase
GeoPolicy Connect (https://geopolicyconnect.agu.org)	2016	bridge the science and policy divide by gathering experts across sectors to discuss challenging science policy issues	first issue addressed: hydraulic fracturing, at the inaugural meeting, 20–21 October 2016 in Fort Collins, Colo.

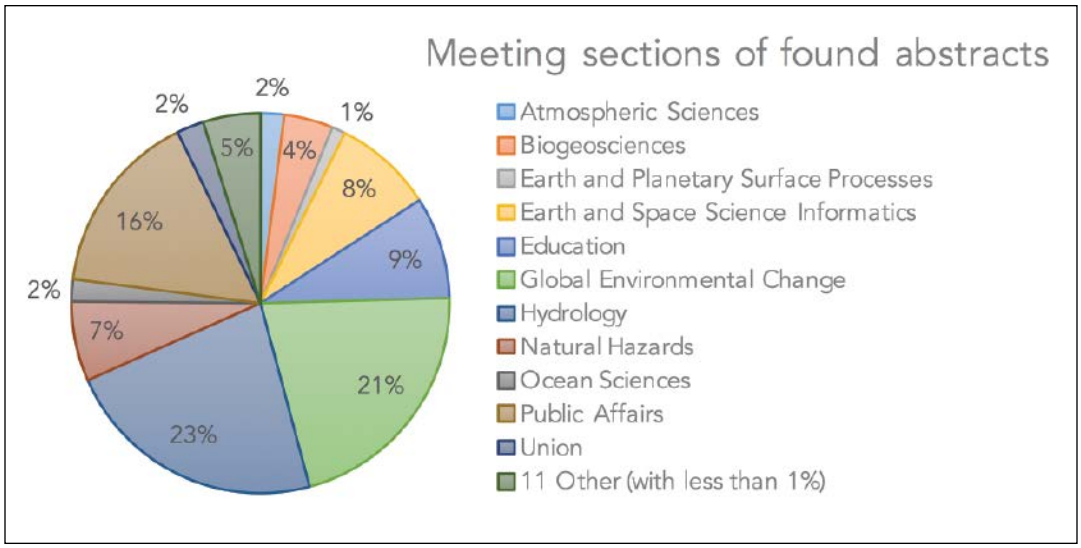


Fig. 2. Abstracts indicating partnerships between scientists and decision makers are found in most of AGU's sections and focus groups, as well as in Education and Union sessions.

As session organizers, we asked participants to identify the most important tasks AGU should undertake to improve decision maker–scientist engagement. We also collected responses to a premeeting survey, which included ideas from 26 session presenters. These responses and informal discussions at the meeting produced suggestions for nine activities. The activities range from individual to institutional and from current activities to long-term goals. References to items in Tables 1 and 2 connect ideas to examples of existing activities and resources.

- **Educate:** offer education in communications, media relations (Table 1, SIPS), and coproduction (Table 1, TEX); develop an engagement tool kit (Table 1, TEX); and encourage geoscience curricula to include engagement-related content
- **Make publications accessible to a broader audience:** include plain-language summaries alongside research articles (similar to abstracts at the 2017 Fall Meeting), support open-access journals (Table 2) or reduced publication-related fees for select groups, encourage graphical abstracts, publicize coproduction (e.g., in *Eos*), and solicit case studies that highlight localized or contextualized applications (Table 2)
- **Assist with funding:** develop ways to measure and illustrate to funders the value of partnerships, help navigate funding opportunities, and promote funding practices that advance coproduction
- **Create rewards:** develop descriptions for how scientists and nonscientists alike could make coproduction count toward career advancement and tenure that institutions can use and create a coproduction award
- **Foster more interactions among scientists and decision makers:** continue to grow TEX (Table 1), seek novel ways to connect scientists and decision makers (Table 1, TEX and Resilience Dialogues), and host a regular coproduction forum (e.g., Science to Action activities at the 2017 Fall Meeting; see http://bit.ly/FM2017-S2A)
- **Encourage more social science interactions:** promote better understanding of what social science brings to research in the geosciences and involve sociologists and science and technology studies scholars in geoscience research
- **Make AGU Fall Meeting more attractive to decision makers:** provide reduced registration fees, new session formats, outreach, and relevant welcoming sessions (Table 1, SIPS and TEX) and include more social scientists
- **Grow community focused on building partnerships:** increase sessions (Table 1, SIPS and W&S) and publications (Table 2, *Earth's Future*) focused on engagement processes and methods, not just results, and connect with other organizations exploring coproduction (e.g., American Association for the Advancement of Science, American Meteorological Society)
- **Promote an AGU-wide conversation about the role of a scientist in society:** encourage all scientists to consider societal consequences of their research and identify potential real-world effects (Table 2, *The Bridge*, Sharing Science, and 2017 Special Collection) and convey coproduction ideas to the larger AGU community (Table 1, SIPS and TEX; and this work)

We offer this list to highlight recent activities and promote conversations that we hope you will join. We can learn much from one another's efforts, and this sharing can inspire new ideas that lead to more actionable science. The growth of these activities could prepare the next generation for careers beyond traditional research that can help integrate science and decision-making. Finally, partnering offers a means to diversify the types of people who participate in, benefit from, contribute to, and, ultimately, support the geosciences.

Table 2. Resources Affiliated with AGU That Could Support or Promote Coproduction Activities

RESOURCE	DESCRIPTION
The Bridge (https://thebridge.agu.org)	blog platform to provide scientists, policy makers, and experts with means to communicate ideas about the science–policy interface
Sharing Science (https://sharingscience.agu.org)	network to foster the sharing of science with the public, media, K–12 audiences, and/or policy makers
GeoHealth (http://bit.ly/AGU-GeoHealth)	new open-access journal, outlet for research that relates Earth and environmental sciences to human, agricultural, and environmental health
Earth's Future (http://bit.ly/AGU-Earths-Future)	transdisciplinary open-access science journal exploring global change, sustainability, and resiliency
2017 Special Collection (http://bit.ly/AGU-ESS-special)	a series of commentaries from across AGU's journals illustrating and explaining the relevance of research across the Earth and space sciences for the benefit of humanity

Building Bridges

Bridges between science and society do not build themselves. They require careful planning to align incentives, find and share resources, balance priorities, navigate cultural and practical differences, and make sure that information shared fits the context of the problem (*Jacobs* [2002], *Ferguson et al.* [2014], *Beier et al.* [2016], and many others). Yet, through these efforts, both science and society are elevated, and more science is brought to the places where people live, work, and play. Ultimately, better partnerships ensure that our science serves society and better fulfills our motivations, and our responsibilities, individually and as a community.

We believe that AGU has the opportunity to become a scientific society that excels at supporting these partnership efforts. We have shared what we have seen, but we recognize that our searches for trends in coproduction could be refined and broadened, our list of ideas could be expanded, and the collection of ongoing activities is likely greater than we know. We hope this article promotes further conversations and investigations that can help us learn from each other and leverage each other's work.

At the 2017 Fall Meeting, the grassroots organizing continued to expand. Working as an informal coalition, a group of more than 20 AGU members planned many Science to Action activities, including 14 sessions with 113 posters and 69 oral presentations, two panel discussions, two evening networking events, and two workshops (see http://bit.ly/Science-to-Action). These activities addressed important aspects of the growing movement toward strong scientist–decision maker partnerships.

We aim to continue conversations that will strengthen this community of practice in coming months, years, and the next 100 years of AGU and beyond. We welcome your participation.

Acknowledgments

We thank three anonymous reviewers for helping sharpen our message and participants in this growing Science to Action community for their enthusiasm, engagement, and inspiration.

References

Advisory Committee on Climate Change and Natural Resource Science (ACCCNRS) (2015), Report to the Secretary of the Interior, 30 March, Reston, Va., https://nccwsc.usgs.gov/acccnrs.

Beier, P., et al. (2016), A how-to guide for coproduction of actionable science, *Conserv. Lett., 10*(3), 288–296, https://doi.org/10.1111/conl.12300.

Ferguson, D. B., J. Rice, and C. Woodhouse (2014), Linking environmental research and practice: Lessons from the integration of climate science and water management in the western United States, Clim. Assess. for the Southwest, Tucson, Ariz., https://doi.org/10.13140/RG.2.2.12774.63042.

Jacobs, K. (2002), *Connecting Science, Policy, and Decision-Making: A Handbook for Researchers and Science Agencies,* Natl. Oceanic and Atmos. Admin., Silver Spring, Md., https://leopoldleadership.stanford.edu/sites/default/files/Jacobs_2001-02_Connecting.Science.Decisionmaking.pdf.

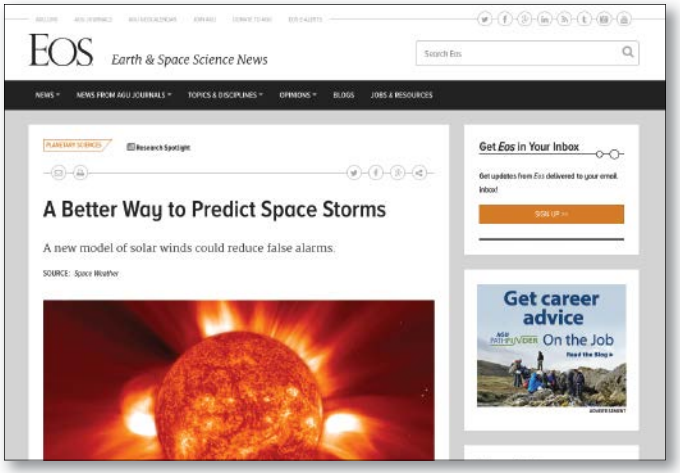
Vogel, J., E. McNie, and D. Behar (2016), Co-producing actionable science for water utilities, *Clim. Serv., 2,* 30–40, https://doi.org/10.1016/j.cliser.2016.06.003.

By **Julie A. Vano** (email: jvano@ucar.edu), Research Applications Laboratory, National Center for Atmospheric Research, Boulder, Colo.; **David Behar,** San Francisco Public Utilities Commission, San Francisco, Calif.; **Philip W. Mote**, Oregon Climate Change Research Institute, Corvallis; **Daniel B. Ferguson,** University of Arizona, Tucson; and **Raj Pandya,** AGU, Washington, D. C.

Read it first on EOS.org

Articles are published on Eos.org before they appear in the magazine.

Visit **https://eos.org** daily for the latest news and perspectives.



Exploring the Restless Floor of Yellowstone Lake
http://bit.ly/EOS_yellowstone

Enabling FAIR Data Across the Earth and Space Sciences
http://bit.ly/EOS_data-ess

A Better Way to Predict Space Storms
http://bit.ly/EOS_predit-storm

Humans to Blame for Higher Drought Risk in Some Regions
http://bit.ly/EOS_risk-regions

Probing the Grain-Scale Processes That Drive Plate Tectonics
http://bit.ly/EOS_plate-tectonics

Vetting New Models of Climate Responses to Geoengineering
http://bit.ly/EOS_model-climate

Monitoring Coastal Zone Changes from Space

Sentinel-2A natural-color satellite image of the Sundarbans area in the Ganges–Brahmaputra delta, captured on 18 March 2016. The erosional forces from the sea and the wind along the coast, together with the huge amount of silt and other sediments deposited in the countless estuaries (visible in the water), continually change the landscape. Satellite images are a key component of coastal monitoring efforts, especially in rapidly changing areas such as this. Credit: ESA

The world's coastal zones, currently home to a large fraction of the world's population, are under serious threat from coastal erosion, cyclones, storms, and saltwater incursion into estuaries and coastal aquifers. In the future, scientists expect these hazards to increase because of the combined effects of sea level rise, climate change, human activities, and population increase.

How coastal environments respond to natural and anthropogenic factors depends on the characteristics of the forcing agents and on the properties of the coastal systems that remain poorly known and mostly unsurveyed on a global scale. To better understand changes affecting coastal zones and to provide useful information to decision makers, we need to collect and analyze various types of observations with global coverage.

In this context, observations from space represent an important complement to existing in situ observing systems (e.g., regional tide gauge networks). Here we highlight the benefit of systematic coastal monitoring from space. Such data combined with in situ observations and databases will be extremely useful to constraining models of coastal change.

Issues with Coastal Monitoring

Regional sea level change, winds, waves, currents, extreme events, vertical ground motions, river runoff, sediment supply, land use change and urbanization, policies, and regulations all act as forcing agents on coastal zones. Satellites have a tremendous potential to observe and characterize these forcing agents, but their instruments often are not adapted to the special conditions of coastal zones.

For example, coastal residents are particularly concerned about rising sea levels in response to anthropogenic global warming. High-precision satellite altimetry has considerably improved our understanding of sea level variations at global and regional scales, but that is not the case for coastal areas. In terms of impacts, what counts at the coast is the sum of global mean rise, superimposed regional variability, small-scale ocean processes, and local vertical land motions.

Satellite altimetry, optimized for the open ocean, performs poorly within 10 kilometers of the coast because landmasses contaminate the data. Recent progress in reprocessing radar waveforms in coastal areas and use of new altimetry techniques (e.g., K_a band altimetry and synthetic aperture radar (SAR) mode) have enabled the satellite community to develop new coastal altimetry data sets. However, coverage from these products remains uneven in space and time, and efforts are needed to construct a consistent gridded coastal altimetry database with global coverage.

Keeping an Eye on Forcing Agents

To be effective, satellite data must be coupled with in situ measurements; the strengths and limitations of each data source complement each other. For example, extreme sea levels that result from a variety of oceanic, atmospheric, and terrestrial processes acting on a broad range of timescales are highly correlated with the global mean sea level rise: The higher the global mean rise is, the higher the water elevation is during extreme events [*Menéndez and Woodworth,* 2010]. Data banks of tide gauge records are valuable sources of information on mean and extreme sea levels, supplementing satellite data. Version 2 of the Global Extreme Sea Level Analysis (GESLA-2) is the most complete extreme sea level data set assembled to date [*Woodworth et al.,* 2017]. The satellite community has made it a priority to ensure that this activity is maintained and extended in the future.

Although wave models are available at global, regional, and local scales, wave and wind measurements in the coastal zones are still limited. Altimetry and SAR images can provide such information; however, we need to undertake investigations using existing and upcoming altimeter data sets (in particular, using the new SAR mode). A multisensor approach (altimetry, SAR, and scatterometry)

to measuring winds and waves in selected coastal regions could provide much-needed constraints on coastal hydrodynamic and flooding models.

Other forcing agents acting on coastal zones include river runoff, sediment supply, and changes in land use. Over previous decades, human activities have strongly modified river runoff and sediment delivery to the coastal zone, with great influence on coastal erosion. Accurate estimates of such quantities are thus crucial. Satellite altimetry, particularly in ungauged or poorly gauged hydrological basins, now routinely measures the water level on land, from which river discharge can be derived. We can also indirectly estimate river discharge for medium-sized basins (<10,000 square kilometers) from satellite images in the visible and near-infrared spectra.

The Surface Water and Ocean Topography (SWOT) satellite mission planned for launch in 2021 will improve the characterization of global runoff processes with a 50-meter-resolution threshold (see https://swot.jpl.nasa.gov). Although the capability of remote sensing systems to retrieve land use change is now well established, what's still missing is an easy-to-use database collecting relevant information with global coverage and long records.

Net subsidence and the resilience of many of the world's significant deltas (home to millions of people, infrastructure, and significant food supply) are the summed response to sediment supply, land subsidence in response to water and hydrocarbon extraction, and land use change. Techniques like Global Navigation Satellite Systems (GNSS) and interferometric synthetic aperture radar (InSAR) provide invaluable information on land motions at local scales [*Allison et al.*, 2016], but many coastal zones are not equipped with GNSS receivers, and systematic monitoring of land motions by InSAR is still missing in many vulnerable areas such as the low-lying coasts of Pacific islands and subsiding cities of southeastern Asia. Thus, we need to equip the most vulnerable coastal sites with precise positioning equipment to measure long-term vertical land motions.

Keeping an Eye on Coastal Evolution

Sediment supply and transport processes drive changes occurring along shorelines and in nearshore coastal zones as well as in river estuaries. These changes are still poorly quantified in most coastal areas, and coastal observatories developed to track them using in situ and airborne data remain limited.

Here again, space data offer an opportunity to gather additional observations with a global perspective. Currently, most space-based initiatives are based on a visual processing of high-resolution optical data (0.5- to 1-meter resolution) from imaging satellites. Errors in georectification (aligning satellite images with maps) and on shoreline indicators lead to an effective precision of 1–5 meters in the shoreline position.

However, because we currently lack automatic techniques for processing these data, no global satellite-based database of shoreline position changes exists. Automatic analysis of optical images, the use of high-resolution synthetic aperture radar images in cloudy tropical areas, and accurate estimates of shoreline indicators thus represent high-priority objectives for science fields related to coasts.

> Although wave models are available at global, regional, and local scales, wave and wind measurements in the coastal zones are still limited.

Global to regional data sets based on ocean color sensors allow us to quantify the dynamics of suspended sediment, which has been related to shoreline changes with some success close to such dynamic estuaries as the Amazon and the Mekong [e.g., *Loisel et al.*, 2014]. However, we need further methodological developments that allow repeated data acquisitions in highly dynamic areas (e.g., estuaries, sandy inlets, and sandy beaches) to improve our understanding of coastal evolution in other types of coastal environments. For example, suspended sediments are visible in the satellite image of the Ganges-Brahmaputra Delta on page 14.

High-resolution digital elevation models and coastal bathymetric data are other examples of critical data sets needed for a number of applications in coastal zones, including accurate modeling of flooding during storm surges and quantification of coastal morphological changes due to sedimentary processes or human interventions. A high-precision (~20-centimeter) and high-resolution (~1- to 10-meter) database of continuous marine–land topography and bathymetry would be particularly useful to represent detailed submersion patterns while being consistent with uncertainties of extreme sea level values.

Lidar techniques have enabled important progress, but they still require postprocessing to remove features like trees or vehicles from the raw data. Repeated bathymetric surveys with wide coverage would be useful to understanding nearshore coastal processes. We expect progress from new techniques such as satellite and drone-acquired high-resolution imagery. Nearshore bathymetry, shoreline changes, and high-resolution topography are definitely observational priorities, especially along densely populated coastlines.

Putting It All Together

If we are to make progress on understanding the magnitude and causes of changes in the coastal zone on a global basis, we must make considerable investments in space-based and in situ observation systems. Modeling and synthesis activities must accompany the measurements, so that the research can provide insight into the future change of coastal areas.

Finally, access to global coastal data sets is still too limited. International efforts such as the World Climate Research Programme (see https://www.wcrp-climate.org) should consider establishing a data repository gathering all needed coastal observations, whether collected locally or through satellite remote sensing.

Acknowledgments

This paper is an outcome of the forum organized in October 2016 at the International Space Science Institute (Bern, Switzerland) on the use of space data to monitor coastal zones (see http://bit.ly/coastal-zone-white-paper).

References

Allison, M., et al. (2016), Global risks and research priorities for coastal subsidence, *Eos, 97,* https://doi.org/10.1029/2016EO055013.

Loisel, H., et al. (2014), Variability of suspended particulate matter concentration in coastal waters under the Mekong's influence from ocean color (MERIS) remote sensing over the last decade, *Remote Sens. Environ., 150,* 218–230, doi:10.1016/j.rse.2014.05.006.

Menéndez, M., and P. L. Woodworth (2010), Changes in extreme high water levels based on a quasi-global tide-gauge data set, *J. Geophys. Res., 115,* C10011, https://doi.org/10.1029/2009JC005997.

Woodworth, P. L., et al. (2017), Why we must tie satellite positioning to tide gauge data, *Eos, 98,* https://doi.org/10.1029/2017EO064037.

By **A. Cazenave** (email: anny.cazenave@legos.obs-mip.fr), Laboratoire d'Études en Géophysique et Océanographie Spatiales, Toulouse, France; also at International Space Science Institute, Bern, Switzerland; **G. Le Cozannet,** Bureau de Recherches Géologiques et Minières, Orléans, France; **Jérôme Benveniste,** Centre for Earth Observation, European Space Agency, Frascati, Italy; **P. L. Woodworth,** National Oceanography Centre, Liverpool, U.K.; and **N. Champollion**, University of Bremen, Bremen, Germany

Government workers check storm sewers for blockage during a 2015 flood in Jakarta, Indonesia. Climate forecasters use tropical climate patterns to help model less-predictable patterns at higher latitudes. Credit: Reynold Sumayku/Alamy Stock Photo

ADVANCING CLIMATE FORECASTING

Better forecasts, new products: The World Climate Research Programme coordinates research aimed at improving and extending global climate forecasting capabilities.

By William J. Merryfield, Francisco J. Doblas-Reyes, Laura Ferranti, Jee-Hoon Jeong, Yvan J. Orsolini, Ramiro I. Saurral, Adam A. Scaife, Mikhail A. Tolstykh, and Michel Rixen

Climate forecasts predict weather averages and other climatic properties from a few weeks to a few years in advance. Increasingly, forecasters are using comprehensive models of Earth's climate system to make such predictions.

Researchers also use climate models to project forced changes many decades into the future under assumed scenarios for human influence. Those simulations typically start in preindustrial times, so far in the past that details of their initial states have little influence in the present era. By contrast, climate forecasts begin from more

recent observed climate system states, much like weather forecasts. For this reason, they are sometimes referred to as initialized climate predictions.

Climate forecasts are produced at numerous operational [*Graham et al.*, 2011] and research centers worldwide. Models and approaches vary, and by coordinating research efforts, the modeling community can make even greater progress. The Working Group on Subseasonal to Interdecadal Prediction (WGSIP; http://bit.ly/WGSIP-climate) of the World Climate Research Programme (WCRP) facilitates such coordination through a program of numerical experimentation—evaluating model responses to different inputs—aimed at assessing and improving climate forecasts.

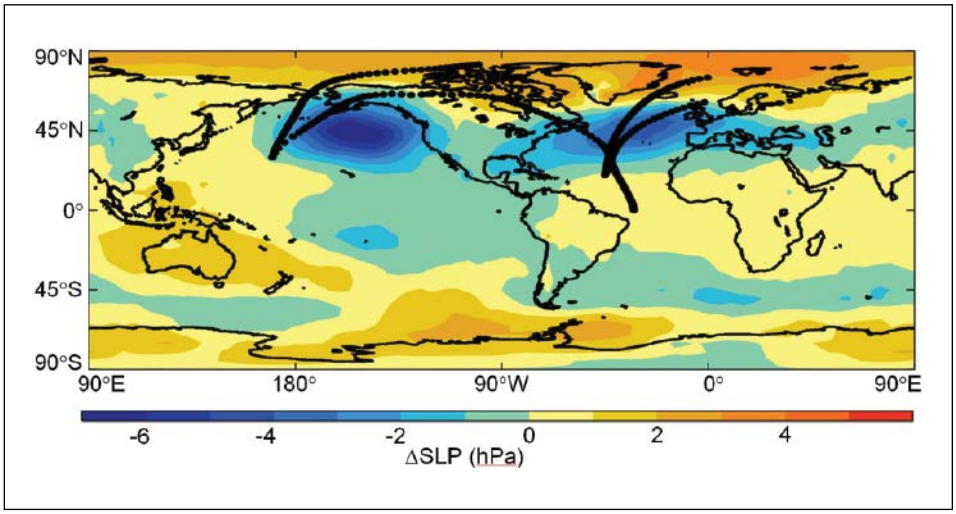


Fig. 1. Averaged atmospheric response during winter in the Northern Hemisphere to recent El Niño events, connecting atmospheric changes in the tropics with those at latitudes farther north and south. Dots represent approximate pathways of planetary waves [after Scaife et al., *2017]. Colors show associated changes in sea level pressure (SLP) in hectopascals (hPa), indicative of atmospheric circulation changes. In the Northern Hemisphere, changes are clockwise for positive contours, represented by warm colors, and counterclockwise for negative contours, represented by cool colors; these directions are opposite in the Southern Hemisphere. Credit: Adam Scaife*

WGSIP currently supports a project that archives hindcasts; this is a major community resource for climate forecasting research. It also supports three additional targeted research projects aimed at advancing specific aspects of climate forecasting. These projects examine how well climate forecast models represent global influences of tropical rainfall, assess how snow predictably influences climate, and study how model drifts and biases develop and affect climate forecasts.

Multiple Model Archive of Hindcasts

Climate varies naturally over a wide range of timescales, driven by processes within and interactions between the atmosphere, ocean, and such other components of the climate system as land, sea ice, and the biosphere. These factors combine with long-term changes forced largely by human influences on the concentrations of greenhouse gases and other atmospheric constituents. Together, these natural variations and forced long-term trends affect society in countless ways.

Because of the innate complexity of these interacting natural systems, analysis of multiple models from different forecasting systems is a key to better understanding climate variability and its prediction. To support such studies, WGSIP initiated the Climate-system Historical Forecast Project (CHFP; http://bit.ly/CHFP-hindcast), under which historical forecasts, or hindcasts, from many prediction models are permanently archived [*Tompkins et al.*, 2017].

Hindcasts test models by seeing how well they can replicate events or trends that have already happened. All models require these hindcasts to make useful climate forecasts because they enable correction of model biases and estimation of historical skill. In addition, they provide an invaluable resource for analyzing and comparing the properties of climate forecast models, assessing the quality of the forecasts themselves, and exploring multimodel forecasting methodologies.

Climate forecast models show encouraging levels of skill at predicting seasonal rainfall in all tropical ocean basins during the Northern Hemisphere's winter months.

Tropical Influences

The heaviest rainfall on Earth occurs over tropical oceans. As water vapor condenses to form droplets in the moist tropical air, the water releases substantial amounts of latent heat. This heat produces deep convection currents that propel the resulting clouds to great heights. The accompanying uplift turns into divergent horizontal winds near the tops of these clouds, high in the troposphere.

Variations in climate alter the patterns of tropical rainfall from year to year. Shifts in upper level divergent winds drive disturbances in atmospheric circulation. These disturbances, known as Rossby or planetary waves, propagate eastward and poleward away from the equator in the winter hemisphere and affect atmospheric circulation in the extratropical regions, outside

of the tropics. Such tropical influences on extratropical climate are known as teleconnections (Figure 1).

In some regions of the tropics, climate variations are relatively predictable because strong couplings between the tropical ocean and atmosphere modulate climate on relatively slow oceanic timescales. The most prominent such modulation is the El Niño–Southern Oscillation.

Because the predictable tropical climate influences the less predictable extratropical climate through teleconnections, tropical predictability could enable skillful predictions of the extratropical climate.

These interconnections raise several important and related questions:

- How much do tropical teleconnections contribute to extratropical climate variability?
- How well are extratropical circulation responses to tropical climate variability represented in current climate models?
- To what extent can improvements in the modeling of teleconnections improve the skill of extratropical climate forecasts?

To address these questions, the WGSIP teleconnection initiative (see http://bit.ly/teleconnections) is examining how well climate forecast models represent the chain of causation connecting variations in tropical rainfall to planetary wave forcing and propagation and hence to modulation of extratropical climate. A pilot analysis of one model [*Scaife et al.*, 2017] is being extended to many models, drawing on the CHFP archive and other hindcast data sources.

Recent results [*Molteni et al.*, 2015] indicate that teleconnections are more directly connected to tropical rainfall than sea surface temperature, which has often been used to infer teleconnection driving. In addition, climate forecast models show encouraging levels of skill at predicting seasonal rainfall in all tropical ocean basins during the Northern Hemisphere's winter months, especially in the eastern and western Pacific.

Ongoing efforts will determine how well different models represent the sources and propagation of planetary waves driven by tropical rainfall. We will then relate those model attributes to skill in forecasting winter climate variations in the northern extratropics, including the Arctic and North Atlantic oscillations.

Snow Effects

Seasonal snow cover strongly influences surface reflectivity and exchanges of heat and moisture between the land and the atmosphere across vast Northern Hemisphere regions. These land–atmosphere couplings can influence large-scale atmospheric circulation following horizontal and upward propagation of planetary waves into the stratosphere. Hence, year-to-year variations in snow could potentially serve as a source of predictability for cold-season climate. In addition, the springtime snow cover over the Himalayan–Tibetan Plateau region could influence the onset of the Indian summer monsoon [*Senan et al.*, 2016].

Whether such predictability can substantially benefit climate forecasts depends on the robustness of snow–climate influences and whether current models can adequately capture them. Many investigations have exam-

International Ocean Discovery Program

IODP

CALL FOR APPLICATIONS

Apply to participate in *JOIDES Resolution* Expeditions

Application deadline: 15 April 2018

Guaymas Basin Tectonics and Biosphere Expedition (385)

September to November 2019

IODP Expedition 385 (based on Proposals 833-Full2 and 833-Add) will core and log a series of sites in the Guaymas Basin to investigate the relationship of tectonics, magmatism, sedimentation, carbon cycling, and microbial activity. The Guaymas Basin in the Gulf of California is a young, marginal rift basin characterized by active seafloor spreading and rapid deposition of organic-rich sediments from highly productive overlying waters. The active formation of oceanic crust combined with a thick sedimentary overburden has given rise to a dynamic environment, where strongly connected physical, chemical, and biological processes govern the cycling of sedimentary carbon. Its fate upon deposition depends on the relative efficiencies of interrelating microbial and chemical processes, leading either to sequestration or release of carbon. Expedition 385 aims to illuminate the interaction between these processes and its ultimate consequences for carbon cycling, which will help understand similar settings in marginal seas throughout the world.

Drilling toward and through seismically imaged sills of varying age and temperature into the intercalated sill-sediment package will provide core and log data to constrain the links between sediment accumulation, sill emplacement, sediment alteration, fluid expulsion, as well as microbial utilization and sequestration of carbon along subseafloor fluid pathways. The primary objectives are to

(1) Explore the physical and chemical gradients along active and extinct fluid pathways associated with sill emplacement;

(2) Investigate subsurface microbial communities that are sustained by alteration products, in order to determine how efficiently they capture carbon-bearing alteration products; and

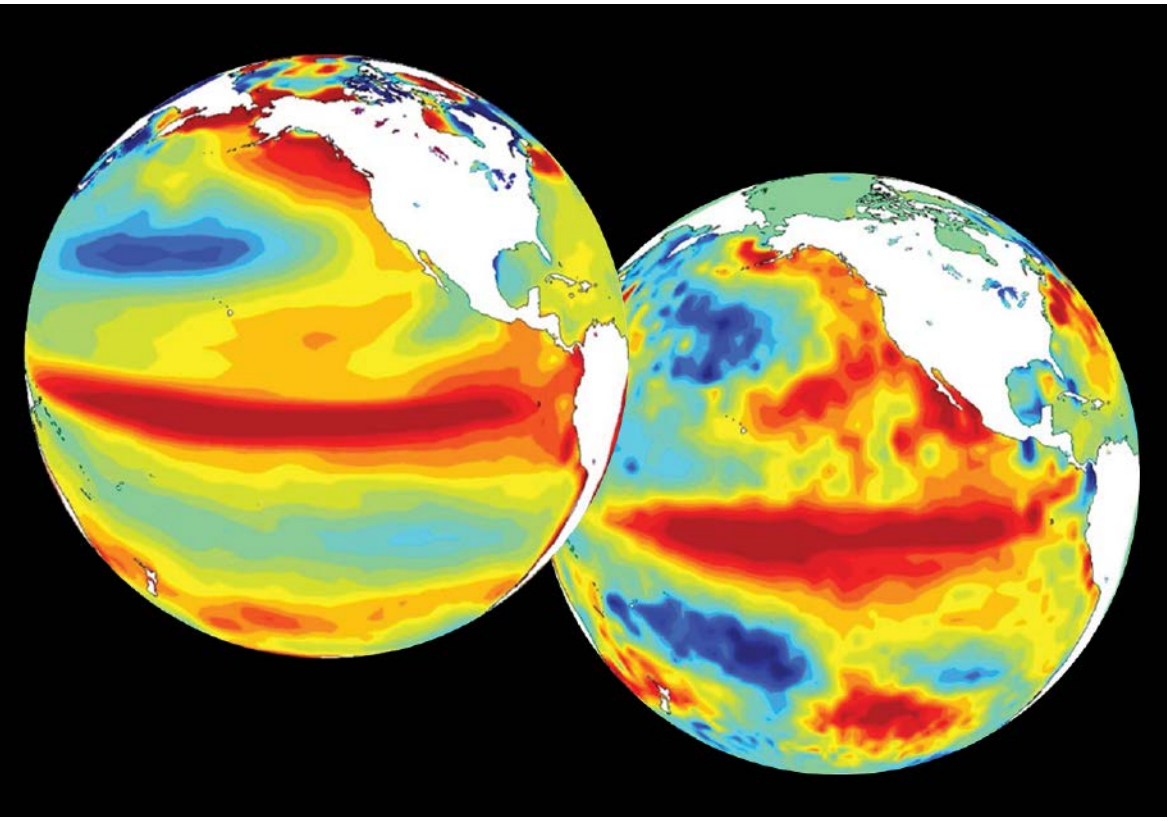
(3) Advance our understanding of the conditions that limit life in the deep biosphere.

Coring sill-sediment successions will provide an integrated record of igneous accretion as well as baseline data of carbon flux, including unaltered subsurface sediments and those that have experienced multiple generations of sill intrusion at depth. Petrophysical data (e.g., porosity/permeability) will also constrain crustal fluid flow and heat exchange that exert fundamental controls on this system. All findings will deepen our understanding of mechanisms of carbon remobilization implicated in global-scale rapid climate change.

For more information about the expedition science objectives and the *JOIDES Resolution* Expedition Schedule see http://iodp.tamu.edu/scienceops/ - this includes links to the individual expedition web pages with the original IODP proposal and expedition planning information.

WHO SHOULD APPLY: Opportunities exist for researchers (including graduate students) in all shipboard specialties – including but not limited to sedimentologists, micropaleontologists, paleomagnetists, inorganic/organic geochemists, microbiologists, petrologists, petrophysicists, and borehole geophysicists.

WHERE TO APPLY: Applications for participation must be submitted to the appropriate IODP Program Member Office – see http://iodp.tamu.edu/participants/applytosail.html



As the science underlying climate forecasts continues to develop, the accuracy of the forecasts can be expected to increase. One group of researchers contributes to this process through a program of numerical experimentation. Shown here is a comparison of departure from normal sea surface temperatures in February 2016. On the right are observed anomalies, whereas on the left are anomalies as forecast by Environment and Climate Change Canada's CanCM4 climate model 12 months earlier, averaging over an ensemble of 10 forecasts. Warm colors indicate higher than normal temperatures; cool colors represent lower than normal temperatures. Credit: Jean-Philippe Gauthier and Juan Sebastian Fontecilla, ECCC/CCMEP

ined these issues but have come to differing conclusions depending on the methodology and specific observations or the model used [see, e.g., *Jeong et al.,* 2013; *Orsolini et al.,* 2013, and references therein].

The WGSIP SNOWGLACE initiative (see http://bit.ly/SNOWGLACE) is addressing these issues through coordinated multimodel experiments comparing forecasts that use either realistic or average snow states. Through this initiative, we hope to learn more about the effects of snow on surface air temperature and circulation over subseasonal timescales and to assess and improve our capabilities for predicting subseasonal to seasonal snow cover.

SNOWGLACE currently involves seven participating institutions and welcomes additional participants. A data center being established at the Korea Polar Research Institute will help to facilitate these investigations.

Characterizing Imperfect Models

Although climate models are increasingly realistic, finite spatial resolution, approximations and uncertainties in representing small-scale processes, and other factors limit their accuracy. Each model thus simulates a climate that differs to some extent from that of the real world. When models are initialized from observed climate states, they inevitably drift toward their own biased climate [*Sanchez-Gomez et al.,* 2016].

In addition, when models incorporate physically inconsistent initial atmospheric and ocean states, the resulting computational "shocks" can accelerate the development of errors [*Mulholland et al.,* 2015]. These influences can be difficult to separate from the drift signal. These drifts, shocks, and biases can be estimated and removed from climate forecasts through various postprocessing methods informed by the hindcasts for that model.

Model drifts and biases are important in their own right because they contain information about the nature and causes of model imperfections. Even though drifts can be approximately removed, the correction procedures themselves may introduce errors, and drifts and biases still may degrade forecasts by distorting the model representation of the observed climate system.

To provide a multimodel framework for the study of model drifts and biases and their impacts on climate forecasts, WGSIP initiated the Long-Range Forecast Transient Intercomparison Project (LRFTIP; http://bit.ly/LRFTIP). The project has developed a data archive describing drifts in many climate forecast models and seeks to establish a standard set of model diagnostics for characterizing drift behavior on timescales from days to months to years.

The project has so far exploited hindcast data sets that include the Subseasonal to Seasonal Prediction Project (S2S; http://www.s2sprediction.net) for subseasonal forecasts, WGSIP's CHFP for seasonal forecasts, and the Coupled Model Intercomparison Project Phase 5 (CMIP5; http://bit.ly/CMIP-5) for decadal forecasts. We plan to add data from other climate prediction models

and their hindcasts and particularly welcome experiments in which the same model has been initialized using different methods or different observational data sets. We invite institutions interested in contributing to consult the LRFTIP data guide (see http://bit.ly/LRFTIP-guide) and to contact project organizers (email: ec.pitple-lrftip.ec@canada.ca).

Toward Improved Climate Services for Society

As the science underlying climate forecasts continues to develop, forecast accuracy can be expected to draw closer to natural limits of predictability. Realizing the potential utility of climate forecasts will require tailoring products for decision-making by different sectors and effectively characterizing and communicating forecast uncertainty. By advancing the science of climate forecasting, WGSIP projects are contributing to this process.

References

Graham, R., et al. (2011), Long-range forecasting and the Global Framework for Climate Services, *Clim. Res., 47,* 47–55, https://doi.org/10.3354/cr00963.

Jeong, J. H., et al. (2013), Impact of snow initialization on subseasonal forecasts of surface air temperature for the cold season, *J. Clim., 26,* 1956–1972, https://doi.org/10.1175/JCLI-D-12-00159.1.

Molteni, F., T. N. Stockdale, and F. Vitart (2015), Understanding and modelling extratropical teleconnections with the Indo-Pacific region during the northern winter, *Clim. Dyn., 45,* 3119–3140, https://doi.org/10.1007/s00382-015-2528-y.

Mulholland, D. P., et al. (2015), Origin and impact of initialization shocks in coupled atmosphere-ocean forecasts, *Mon. Weather Rev., 143,* 4631–4644, https://doi.org/10.1175/MWR-D-15-0076.1.

Orsolini, Y. J., et al. (2013), Impact of snow initialization on sub-seasonal forecasts, *Clim. Dyn., 41,* 1969–1982, https://doi.org/10.1007/s00382-013-1782-0.

Sanchez-Gomez, E., et al. (2016), Drift dynamics in a coupled model initialized for decadal forecasts, *Clim. Dyn., 46,* 1819–1840, https://doi.org/10.1007/s00382-015-2678-y.

Scaife, A. A., et al. (2017), Tropical rainfall, Rossby waves and regional winter climate predictions, *Q. J. R. Meteorol. Soc., 143,* 1–11, https://doi.org/10.1002/qj.2910.

Senan, R., et al. (2016), Impact of springtime Himalayan–Tibetan Plateau snowpack on the onset of the Indian summer monsoon in coupled seasonal forecasts, *Clim. Dyn., 47,* 2709–2725, https://doi.org/10.1007/s00382-016-2993-y.

Tompkins, A. M., et al. (2017), The Climate-system Historical Forecast Project: Providing open access to seasonal forecast ensembles from centers around the globe, *Bull. Am. Meteorol. Soc.,* https://doi.org/10.1175/BAMS-D-16-0209.1.

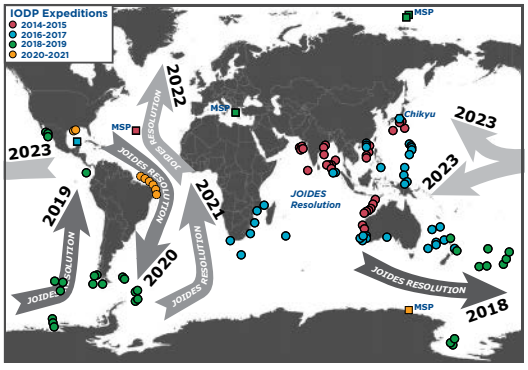
Author Information

William J. Merryfield (email: bill.merryfield@canada.ca), Canadian Centre for Climate Modelling and Analysis, Environment and Climate Change Canada, Victoria, B.C.; **Francisco J. Doblas-Reyes,** Barcelona Supercomputing Center, Barcelona, Spain; **Laura Ferranti,** European Centre for Medium-Range Weather Forecasts, Reading, U.K.; **Jee-Hoon Jeong,** Department of Oceanography, Chonnam National University, Gwangju, South Korea; **Yvan J. Orsolini,** Norwegian Institute for Air Research, Kjeller, Norway; **Ramiro I. Saurral,** Centro de Investigaciones del Mar y la Atmósfera, Buenos Aires, Argentina; **Adam A. Scaife,** Met Office Hadley Centre, Exeter, U.K.; **Mikhail A. Tolstykh,** Institute of Numerical Mathematics, Russian Academy of Sciences, Moscow, Russia; and **Michel Rixen,** World Meteorological Organization, Geneva, Switzerland

CALL FOR PROPOSALS
Scientific Ocean Drilling

IODP
INTERNATIONAL OCEAN DISCOVERY PROGRAM

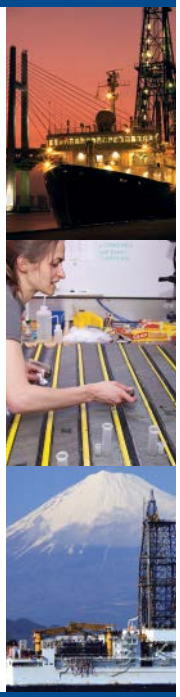
The International Ocean Discovery Program (IODP) explores Earth's climate history, structure, mantle/crust dynamics, natural hazards, and deep biosphere as described at www.iodp.org/science-plan. IODP facilitates international and interdisciplinary research on transformative and societally relevant topics using the ocean drilling, coring, and downhole measurement facilities *JOIDES Resolution* (JR), *Chikyu*, and Mission-*Specific Platforms* (MSP). **All three IODP facilities are now encouraging new proposals.**



The JR is currently scheduled into early 2020 (iodp.tamu.edu/scienceops). The JR is expected to operate in the Equatorial and North Atlantic, Gulf of Mexico, Mediterranean, Caribbean, and the Arctic in 2021 and 2022, and to complete its circumnavigation with a return to the Indo-Pacific region by 2023. Proposals for these future operational areas are strongly encouraged.

MSP expeditions are planned to operate once per year on average to recover core from targets that are generally inaccessible by JR and Chikyu. MSP proposals for any ocean are welcomed. To encourage exciting Chikyu expeditions in the future, new pre-proposals for both riser and non-riser Chikyu operations will be considered.

Investigators are reminded that the interval from the first proposal submission to expedition scheduling is on the order of 4-5 years due to the science and safety review process and required lead time for scheduling. Submission information can be found at www.iodp.org/submitting-proposals. We also invite proposals that involve drilling on land and at sea through coordination with the International Continental Drilling Program (ICDP).



Submission Deadline: April 2, 2018 • More information: www.iodp.org • Contact: science@iodp.org

A CLOSER LOOK AT AN UNDERSEA SOURCE OF ALASKAN EARTHQUAKES

A systematic survey offers a striking portrait of movement along a 500-kilometer-long undersea section of the Queen Charlotte–Fairweather fault off the coast of southeastern Alaska.

By Daniel S. Brothers, Peter Haeussler, Amy East, Uri ten Brink, Brian Andrews, Peter Dartnell, Nathan Miller, and Jared Kluesner

Sunny K. Awazahura-Reed/Design Pics Inc/Alamy Stock Photo

During the past century, movement along the Queen Charlotte–Fairweather fault, which lies for most of its length beneath the waters off southeastern Alaska and British Columbia, has generated at least seven earthquakes of magnitude 7 or greater. These include a magnitude 8.1 earthquake in 1949, the largest ever recorded in Canada.

Other events include a magnitude 7.8 earthquake in 1958 that dislodged a massive landslide above Lituya Bay in Alaska. The earthquake generated a tsunami that sent water 525 meters up the mountainside, a world record run-up [*Miller*, 1960]. The 2012 magnitude 7.8 Haida Gwaii earthquake, centered on Moresby Island, British Columbia, and the 2013 magnitude 7.5 earthquake near Craig, Alaska [*Walton et al.*, 2015], increased awareness of the potential geologic hazards posed to residents of southeastern Alaska and western British Columbia.

Together, these events highlight the need for a greater understanding of the Queen Charlotte–Fairweather fault and its history.

Yet despite the dramatic effects of this fault's activity, a near absence of high-resolution marine geophysical and geological data limits scientific understanding of its slip rate, earthquake recurrence interval, paleoseismic history, and rupture dynamics.

The U.S. Geological Survey (USGS) has now completed a systematic examination of the tectonic geomorphology along a 500-kilometer-long undersea section of the

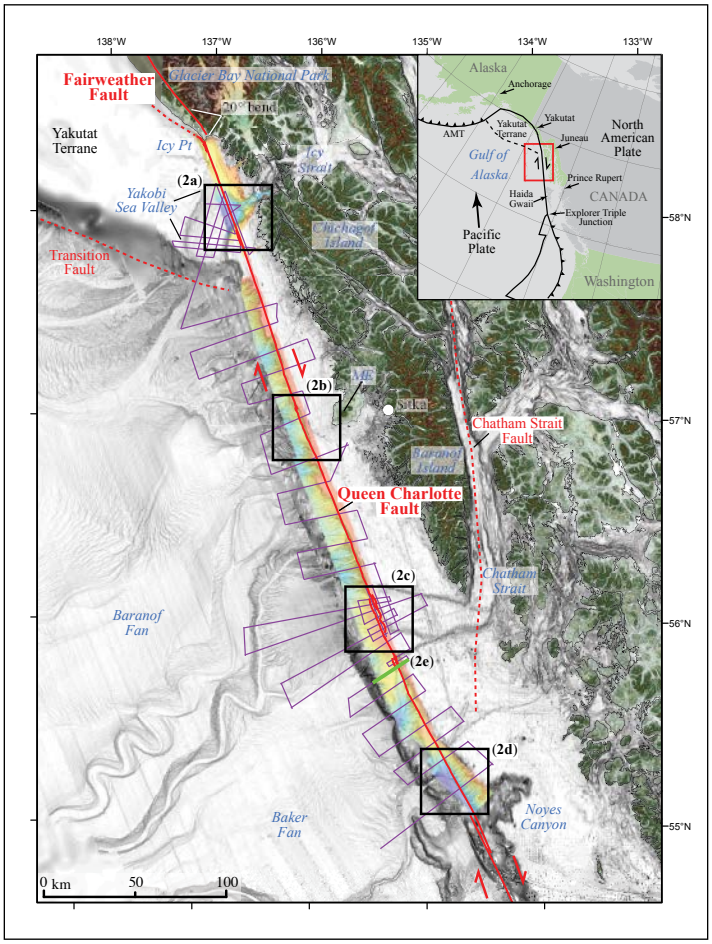


Fig. 1. Recent geophysical surveys provided high-resolution seafloor depth data for the northernmost undersea portion of the Queen Charlotte–Fairweather fault (area outlined in red). The colored seafloor relief represents multibeam echo sounder data acquired along the continental shelf and slope in 2015 and 2016; the gray seafloor relief in deeper water west of the fault was acquired by the University of New Hampshire in 2005. Black boxes are locations of depth imagery shown in Figures 2a–2d. Purple lines represent high-resolution seismic reflection profiles that were acquired in 2016 aboard the R/V Norseman*. One such profile (green line) is shown in Figure 3. AMT represents the Alaska–Aleutian megathrust, and ME indicates Mount Edgecumbe.*

Queen Charlotte–Fairweather fault that offers new insights into activity at this strike-slip boundary, where the North American and Pacific plates slide horizontally past each other.

A Complicated Boundary

The Queen Charlotte–Fairweather fault system and its better known counterpart, the San Andreas Fault (which is highly visible on land in California), form the boundary between the North American and Pacific tectonic plates. The Queen Charlotte–Fairweather fault system defines this plate boundary for a distance of more than 1,200 kilometers, from Yakutat, Alaska, to the Queen Charlotte Triple Junction, a confluence of three faults west of British Columbia (Figure 1). Within this system, the Queen Charlotte fault represents the underwater section and is widely recognized as one of the world's most seismically active continent-ocean transform faults [*Plafker et al.*, 1978; *Bruns and Carlson*, 1987; *Nishenko and Jacob*, 1990; *Walton et al.*, 2015].

The northern part of the boundary between the North American and Pacific plates is complicated by the collision of the Yakutat terrane, a block of crustal material surrounded by faults, with southern Alaska. In this region, the Pacific plate begins to subduct, or plunge beneath, the North American plate along a boundary known as the Alaska-Aleutian megathrust.

The Fairweather fault is the only stretch of the fault system accessible by land. To the south of Icy Point, the Fairweather fault runs offshore, becoming the Queen Charlotte fault, which extends about 900 kilometers southward along the continental slope.

Earlier studies estimated the Fairweather fault's slip rate to be 41–58 millimeters per year [*Plafker et al.*, 1978; *Bruns and Carlson*, 1987; *Elliot et al.*, 2010], but few direct observations of horizontal seafloor displacement existed [*Bruns and Carlson*, 1987] because of the absence of high-resolution seabed data.

Geophysical Surveys

In 2015, our team conducted two marine geophysical surveys, one aboard R/V *Solstice* and a second on R/V *Alaskan Gyre* (see https://on.doi.gov/2ynQo7h). We collected high-resolution seafloor depth data using multibeam sonar along the northernmost section of the fault. We also used a chirp subbottom profiler, which returns detailed images down to 50 meters beneath the seafloor.

In 2016, two additional cruises (aboard R/V *Medeia* and R/V *Norseman*) extended data coverage of the Queen Charlotte–Fairweather fault an additional 325 kilometers southward (see https://on.doi.gov/2ABWXt4). We again used multibeam sonar to map the ocean floor and multichannel seismic reflection to image deeper layers of sediment. Most recently, seismic reflection and chirp surveys were completed in July 2017 aboard the R/V *Ocean Starr*.

In total, during 95 days of seagoing operations, we collected more than 5,000 square kilometers of high-resolution depth data, 9,400 kilometers of high-resolution multichannel seismic reflection profiles, and 500 kilometers of subbottom chirp data.

A Clearer View of the Fault System

Imagery from the surveys shows the fault in pristine detail, cutting straight across the seafloor, with offsetting seabed channels and submerged glacial valleys (Figure 2). The continuous knife-edge character of the fault is evident over the entire 500-kilometer-long survey area. At the same time, we can see several previously unknown features, including a series of subtle bends and steps in the fault that appear to form basins within the fault zone.

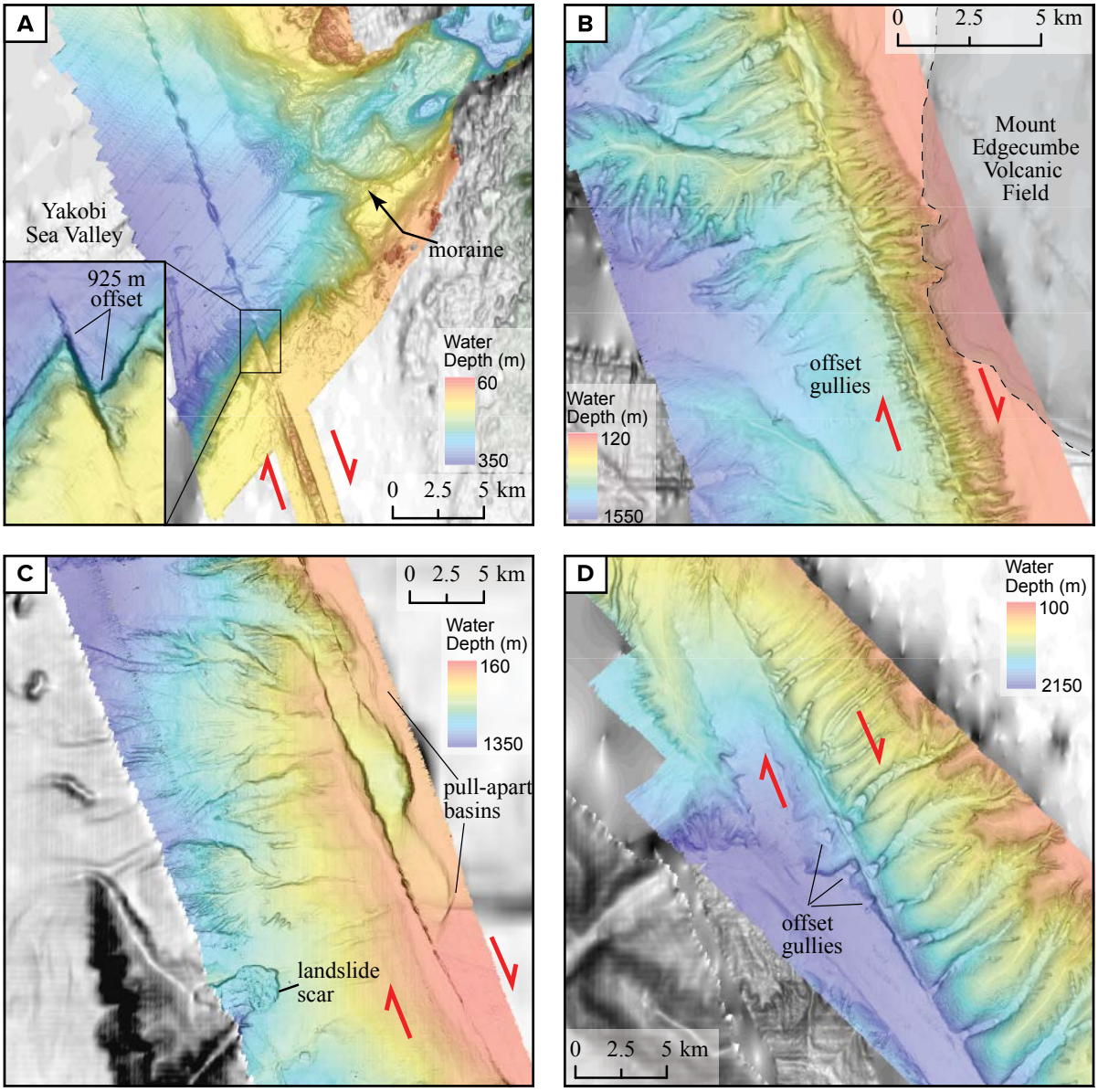


Fig. 2. High-resolution depth images at four locations along the Queen Charlotte fault show the morphological features of the fault and the continental slope. Red arrows indicate the relative sense of motion (see Figure 1 for locations).

Because the surveys spanned four sections of the fault that ruptured in significant historical earthquakes, the results provide a unique catalog of geomorphic features commonly associated with active strike-slip faults.

The Fairweather fault bends 20° as it extends southward across the shoreline near Icy Point (Figures 1 and 2a) and then continues southward at a 340° strike along the shelf edge as a single fault trace for another 150 kilometers.

Numerous submarine canyons, gullies, and ridges have been displaced or warped along the fault. Fault valleys parallel to the margin locally separate geomorphically distinct upper and lower sections of the continental slope (Figures 2b and 3). A Pleistocene basaltic–andesitic volcanic edifice exposed at the seabed extends from Mount Edgecumbe to the shelf edge (Figure 2b).

West of southern Baranof Island, the fault takes a series of subtle 3°–5° right steps and bends that form en echelon pull-apart basins along the shelf edge (Figure 2c). The fault continues southward as a single lineament but exhibits a subtle warp and series of westward steps displacing submarine canyon valleys (Figure 2d) before crossing Noyes Canyon and extending southward into Canadian waters [see, e.g., *Barrie et al.*, 2013].

Fault Slip Rates

The offset features along the seabed provide important information for reconstructing past fault motion. From the ages of these features we can calculate the average rate of motion along the fault, then estimate the typical recurrence interval for large earthquakes.

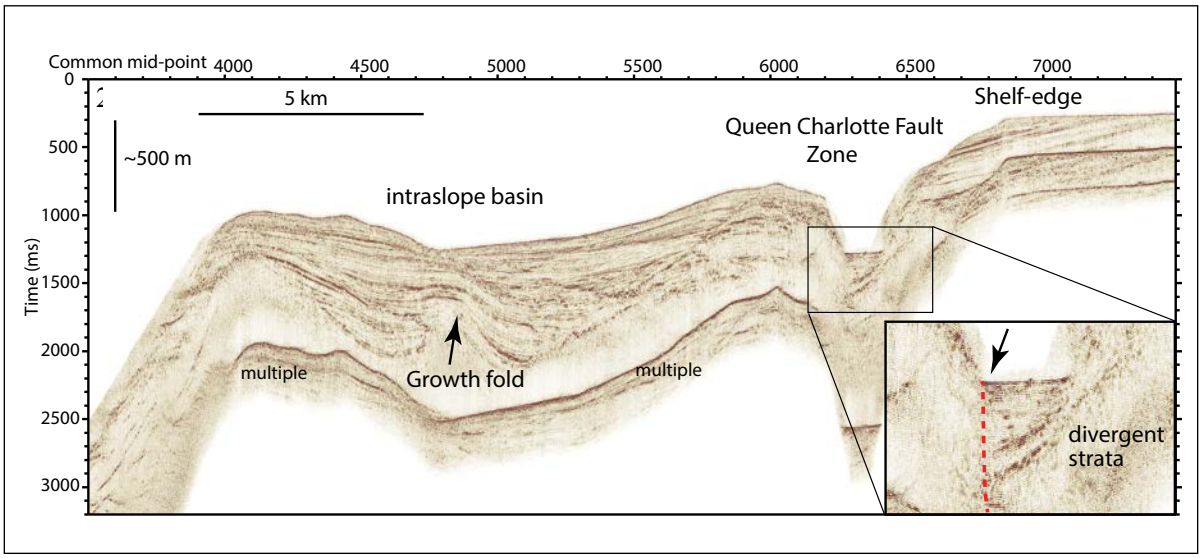


Fig. 3. A seismic reflection profile acquired in August 2016 highlights the structure and stratigraphy of the continental slope.

For example, the southern margin of the Yakobi Sea Valley has been sliced and translated about 925 meters by the linear, knife-edge fault trace (Figure 2a). Ice likely retreated from the valley about 17,000 years ago. Thus, the slip rate of the Queen Charlotte–Fairweather fault across the Yakobi Sea Valley exceeds 50 millimeters per year. It is one of the fastest slipping continent-ocean transform faults in the world [*Brothers et al.*, 2015].

Furthermore, we observe coincidence between the pull-apart basins shown in Figure 2c and the northernmost extent of the 2013 Craig earthquake, implying that changes in fault geometry likely influenced the length of rupture propagation [e.g., *Walton et al.*, 2015].

A Real-World Laboratory

The USGS, the Geological Survey of Canada, the Sitka Sound Science Center, and the University of Calgary jointly led a research cruise in September 2017 to collect sediment cores along the Queen Charlotte–Fairweather fault in Canadian and U.S. territories to constrain the sedimentation history along the margin and date features offset by fault motion (see https://on.doi.gov/2pesZGp).

Overall, this project has shown that the Queen Charlotte–Fairweather fault is an ideal laboratory for examining the tectonic geomorphology of a major strike-slip fault and the associated processes responsible for generating offshore hazards.

Acknowledgments

We thank J. Currie, G. Hatcher, R. Wyland, A. Balster-Gee, P. Hart, J. Conrad, T. O'Brien, A. Nichols, M. Walton, R. Marcuson, and E. Moore of the USGS; K. Green of the Alaska Department of Fish and Game; G. Greene of Moss Landing Marine Laboratories; V. Barrie and K. Conway of the Geological Survey of Canada; and the crews of the R/V *Solstice*, R/V *Medeia*, R/V *Norseman*, R/V *Ocean Starr*, and R/V *Alaskan Gyre*. We also thank J. Warrick, R. von Huene, J. Watt, and an anonymous reader for helpful reviews. The USGS Coastal and Marine Geology Program funded this study. Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. government.

References

Barrie, J. V., K. W. Conway, and P. T. Harris (2013), The Queen Charlotte fault, British Columbia: Seafloor anatomy of a transform fault and its influence on sediment processes, *Geo Mar. Lett., 33,* 311–318, https://doi.org/10.1007/s00367-013-0333-3.

Brothers, D. S., et al. (2015), High-resolution geophysical constraints on late Pleistocene–Present deformation history, seabed morphology, and slip-rate along the Queen Charlotte-Fairweather fault, offshore southeastern Alaska, Abstract NH23B-1882 presented at 2015 Fall Meeting, AGU, San Francisco, Calif., 14–18 Dec.

Bruns, T. R., and P. R. Carlson (1987), Geology and petroleum potential of the southeast Alaska continental margin, in *Geology and Petroleum Potential of the Continental Margin of Western North America and Adjacent Ocean Basins, Beaufort Sea to Baja California, Earth Sci. Ser.*, vol. 9, edited by D. W. Scholl, A. Grantz, and J. G. Vedder, pp. 269–282, Circum-Pac. Counc. for Energy and Miner. Resour., Houston, Texas.

Elliot, J. L., et al. (2010), Tectonic block motion and glacial isostatic adjustment in southeast Alaska and adjacent Canada constrained by GPS measurements, *J. Geophys. Res., 115,* B09407, https://doi.org/10.1029/2009JB007139.

Miller, D. J. (1960), Giant waves in Lituya Bay, Alaska, *U.S. Geol. Surv. Prof. Pap., 354-C*, 51–86, scale 1:50,000.

Nishenko, S. P., and K. H. Jacob (1990), Seismic potential of the Queen Charlotte-Alaska-Aleutian seismic zone, *J. Geophys. Res., 95*(B3), 2511–2532, https://doi.org/10.1029/JB095iB03p02511.

Plafker, G., et al. (1978), Late Quaternary offsets along the Fairweather fault and crustal plate interactions in southern Alaska, *Can. J. Earth Sci., 15*(5), 805–816, https://doi.org/10.1139/e78-085.

Walton, M. A. L., et al. (2015), Basement and regional structure along strike of the Queen Charlotte fault in the context of modern and historical earthquake ruptures, *Bull. Seismol. Soc. Am., 105,* 1090–1105, https://doi.org/10.1785/0120140174.

Author Information

Daniel S. Brothers (email: dbrothers@usgs.gov; @DBrothersSC), Pacific Coastal and Marine Science Center, USGS, Santa Cruz, Calif.; **Peter Haeussler,** Alaska Science Center, USGS, Anchorage; **Amy East,** Pacific Coastal and Marine Science Center, USGS, Santa Cruz, Calif.; **Uri ten Brink** and **Brian Andrews,** Woods Hole Science Center, USGS, Woods Hole, Mass.; **Peter Dartnell,** Pacific Coastal and Marine Science Center, USGS, Santa Cruz, Calif.; **Nathan Miller,** Woods Hole Science Center, USGS, Woods Hole, Mass.; and **Jared Kluesner,** Pacific Coastal and Marine Science Center, USGS, Santa Cruz, Calif.

AGU PATHFINDER

ADVANCE YOURSELF

Abstracts Now Open for Spring 2018 Showcases

Submission Deadline: 31 March 2018

Students need to take only these three simple steps to gain valuable experience presenting their research.

1. **Submit an abstract**
2. **Upload a poster and accompanying video presentation**
3. **Evaluate the posters of peers and receive feedback on their own poster**

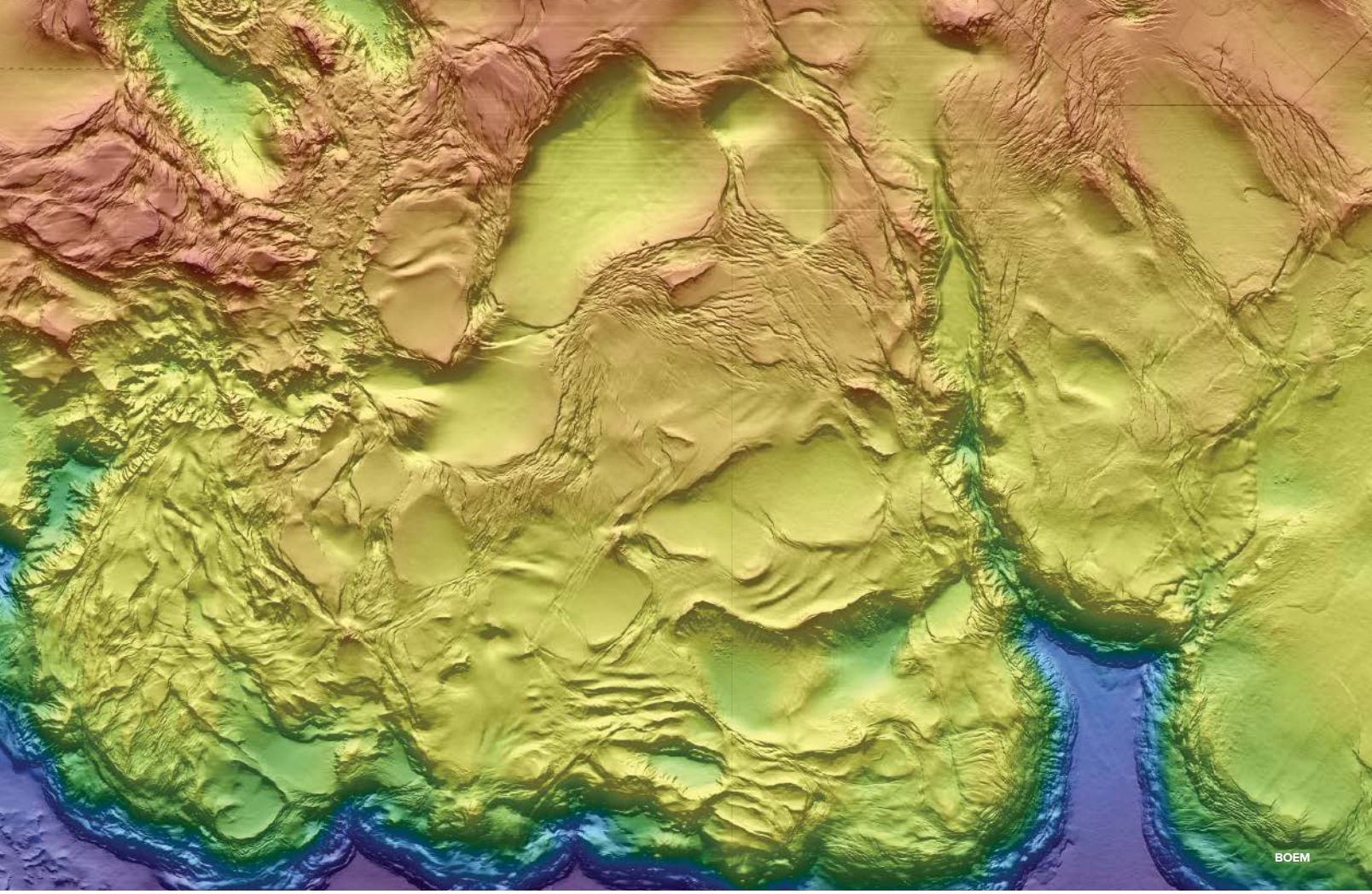
What students say about Virtual Poster Showcase:

"I especially liked that fellow students reviewed posters, as that gave me experience in critically thinking about the research other students were doing as well as my own."

"It was a really valuable experience for me, and I know I am much more ready to participate in a bigger, in-person conference."

Learn more about the biannual showcases:

virtualposter.agu.org



10 MESMERIZING GEOPHYSICAL MAPS THAT DOUBLE AS WORKS OF ART

From tiny seafloor features in the Gulf of Mexico to craters pocking the surface of Mars, the details on these maps captivate and fascinate.

By JoAnna Wendel and Mohi Kumar

They say a picture is worth a thousand words. For Earth and space scientists, a certain class of images is worth much more.

These images are maps. They can slice across time and space, overlaying information on never-before-seen features or changing landscapes. They can even highlight how humans change those same landscapes. Maps are central to our sciences; without them, we're just playing in the dirt.

Here we take a look back at the many breathtaking maps highlighted in *Eos* and in AGU blogs. These maps represent hundreds of hours of work by scientists and engineers. And many are fascinating works of art in their own right—we could spend hours poring over their fine details, patterns, and colors.

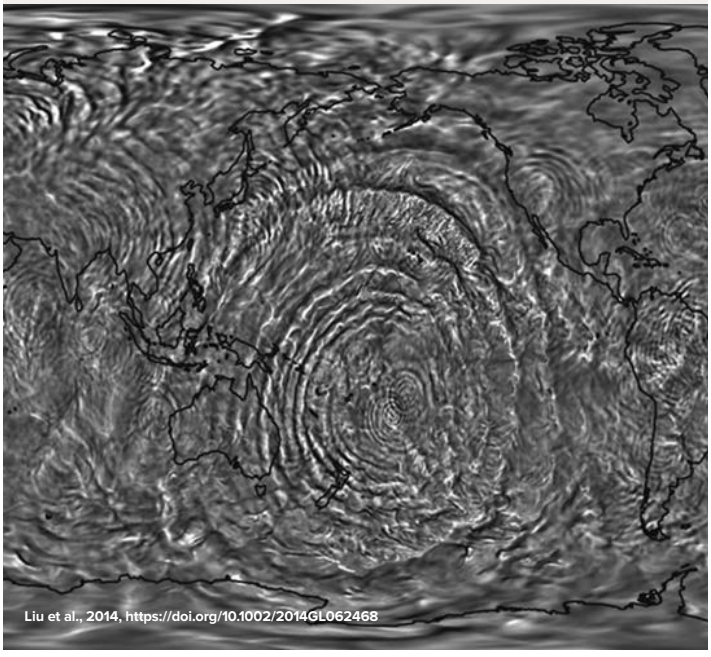
Below are 10 snips of our favorite such maps, in no particular order. Readers are highly encouranged to view these maps and associated videos online; see http:// bit.ly/Eos_art_maps. Come marvel with us!

1 Gravity Waves

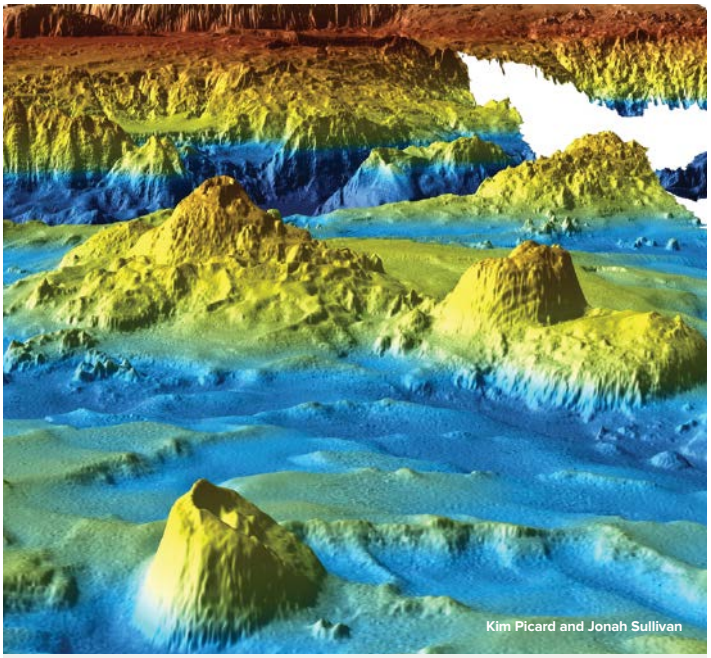
Is it an optical illusion? One of those magic eye pictures holding a secret message? It is neither.

This map shows gravity waves. The waves form when the atmosphere is disturbed vertically and gravity tries to restore equilibrium, similar to ripples produced when you drop a rock in water. Gravity waves transfer energy and create turbulence.

Here we see gravity waves across the planet, mapped within the lower thermosphere at an altitude of 100 kilometers. In the map, the waves ripple outward, triggered by a tropical cyclone east of Australia. Scientists created the map in 2014 using a whole-atmosphere general circulation model that resolves gravity waves down to tens of kilometers, from Earth's surface to the lower thermosphere. For more, see http://bit.ly/Eos-gravitywavesmap.



Liu et al., 2014, https://doi.org/10.1002/2014GL062468

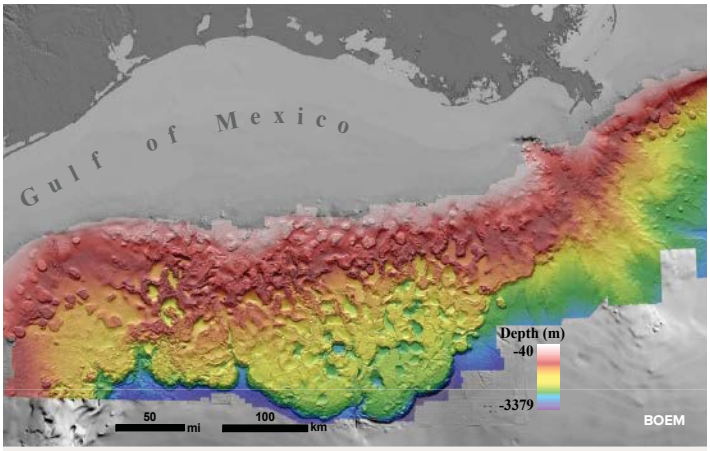


Kim Picard and Jonah Sullivan

2 Indian Ocean Seafloor

After Malaysia Airlines flight MH370 disappeared in March 2014, an unprecedentedly thorough deep-ocean search commenced. Survey teams used echo sounding techniques to scour the ocean floor for the missing aircraft. Data collected in the search helped to create some of the most detailed maps ever of the southeastern Indian Ocean. Here's a snip of one such map, looking northwest at a feature called the Diamantina Trench. For more on this and other related maps, see http://bit.ly/Eos-MH370map.

The detail in these maps, however, isn't replicated across the globe; much of the world's ocean floors remain poorly mapped. In some areas, knowledge of seafloor topography is worse than our knowledge of topography on Mars. Read an *Eos* opinion for intriguing maps of the extent to which the seafloor below your over-ocean flight has been coarsely mapped (http://bit.ly/Eos-flightpaths).



3 Gigapixel Gulf

Last year, the U.S. Department of the Interior's Bureau of Ocean Energy Management (BOEM) released the most highly detailed map ever of the Gulf of Mexico, and we can't stop staring at it. Comparing prior maps to this new one shows smudges resolving into dunes, smears becoming faults, and shapeless lumps transforming into crystal-clear salt domes. See for yourself at http://bit.ly/Eos-GOMmap.

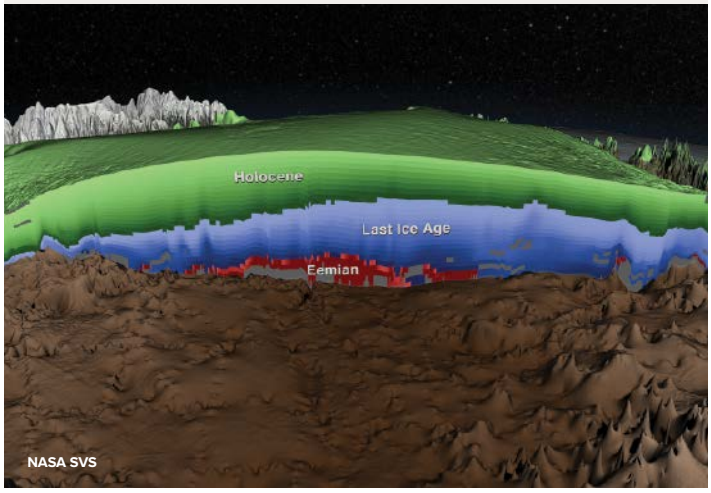
To create the rainbow landscape, project scientists combined more than 100 individual seafloor maps from 30 years of 3-D seismic surveys, many originally shot by 15 different companies involved in the oil and gas industry. Each pixel on this map is equal to the footprint of an American single-family home, and the map has 1.4 billion of them. And the lovely part? It's freely downloadable! See http://bit.ly/BOEM-GOMmap.

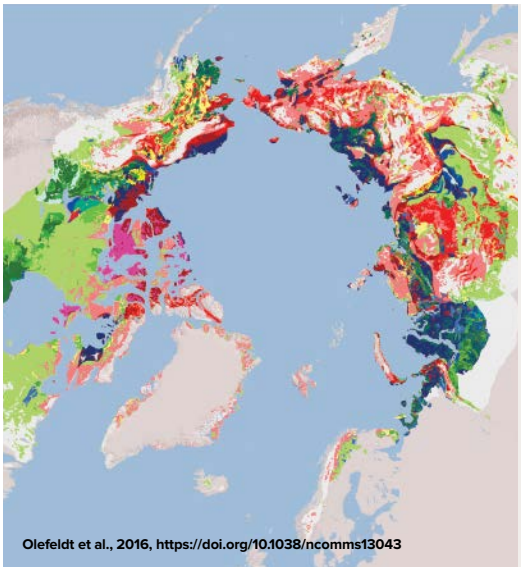
With this new map, scientists can study how benthic communities have fared after the 2010 Deepwater Horizon oil spill, investigate the origins of the Gulf's salt deposits, and more.

4 What's Under (and in) the Ice?

Complex landscapes lie underneath glaciers, but envisioning them requires some sophisticated remote sensing. For example, scientists have used ice-penetrating radar to create a map of ancient river systems that once flowed under the Greenland ice sheet (http://bit.ly/Eos-IceRivers). The ancient watershed stretches to the size of the Ohio River basin in the United States (more than 500,000 square kilometers). Researchers are also using a different technique—analysis of ice's surface morphology—to estimate what features may be under Antarctic ice (http://bit.ly/Eos-AntarcticaCanyons).

One ice-penetrating radar map captured our attention—in addition to showing features below Greenland ice, it shows classifications of the different ages of ice overlying it. See the video for yourself at http://bit.ly/Eos-GreenlandIPR.

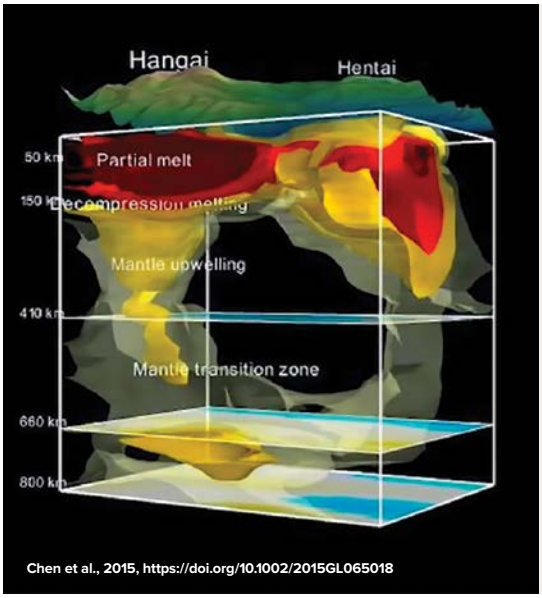



Olefeldt et al., 2016, https://doi.org/10.1038/ncomms13043

5 Mapping Vulnerable Permafrost

The permanently frozen soils of the Arctic hold 1,400 gigatons of carbon, about twice what is currently in the atmosphere. But that permafrost is melting. To better understand this potential, researchers released a map of regions around the Arctic that are particularly vulnerable to melting.

They created the map by combining satellite imagery from Google Earth with already existing data about the different soils and topography. Colors represent the dominant landscapes that will likely form if permafrost melts. Green shows future wetlands, blue indicates future lakes, and red shows future hummocks. The information can help pinpoint the degree to which areas will become sources of methane emissions if melted. For more, see http://bit.ly/Eos_ArcticGHGmap.

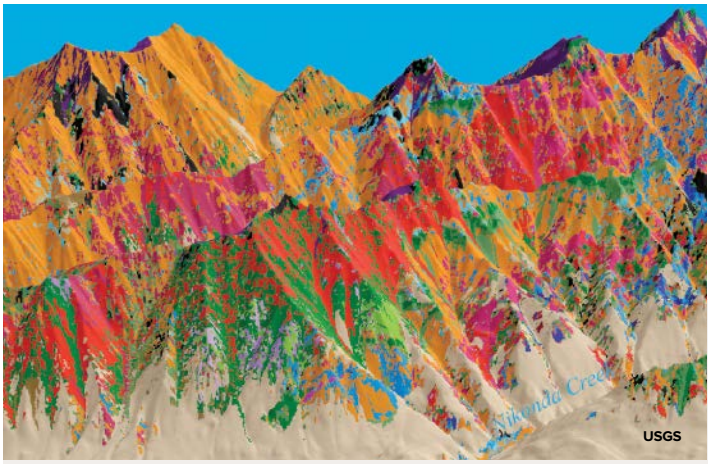


Chen et al., 2015, https://doi.org/10.1002/2015GL065018

6 Three-Dimensional Map of a Dome

Using 1.7 million seismic wave measurements from 227 earthquakes across East Asia, scientists created a 3-D image of the mysterious Hangai Dome in central Mongolia. They have long debated the exact mechanism that formed the dome: Did tectonic forces uplift it? Or was it the product of magma upwelling?

The new map indicates that at some point in the dome's past, warm rock rose up and melted magma. The heat from this magma likely buckled upper layers of rock, creating the feature's dome shape. Take a video tour of this map on AGU's *GeoSpace* blog (http://bit.ly/AGUBlog-Hangai).



USGS

7 Rainbow Hills

Did someone splash paint over this mountainscape, Jackson Pollock style? Sort of. This is a color-coded map of minerals likely scattered across mountains in Alaska's Wrangell–St. Elias National Park and Preserve.

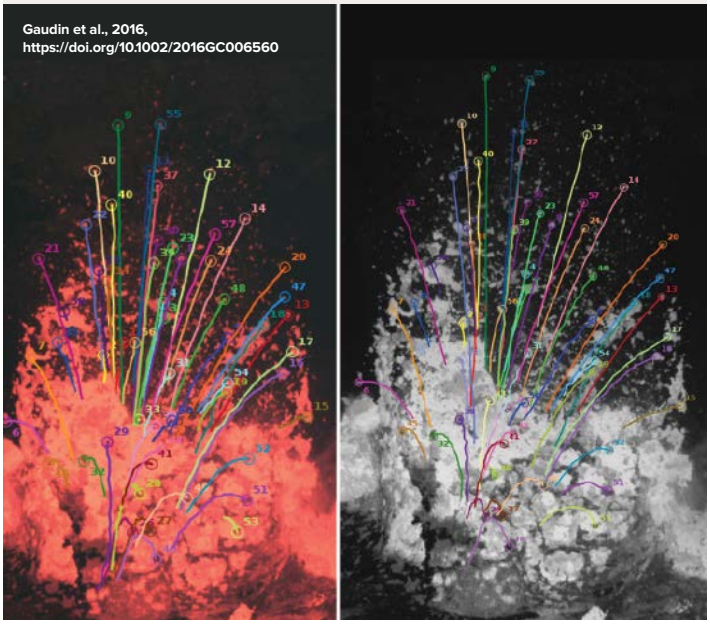
The scientists who created the map attempted to push the limits of hyperspectral imaging and measure wavelengths of light bouncing off minerals from a distance. Their goal? To simplify the search for resources like copper ore in Alaska's remote peaks.

Copper is known to be associated with the presence of muscovite (orange), a mineral that airborne hyperspectral images can readily detect. Although known locations of copper ore did correspond to the densest muscovite concentrations in the map, other minerals were found too. The result is a rainbow of signals from serpentine, muscovite, chlorite, calcite, gypsum, and more. For more on this technique and a key to the map, see http://bit.ly/Eos-AKmineralmap.

8 Volcano Bombs

In this map, scientists wanted to understand how volcano bombs—those bits of rock and magma pumped out by an eruption—move through the air. The researchers were curious to know their speeds, which direction they fly in, and how far they travel to better understand volcano hazards.

So they positioned high-speed cameras and tracked a few representative bombs as a bubble burst in Hawaii's Halemau'mau lava lake, capturing what look like streamers from fireworks or the threads of a Koosh ball. Watch video here: http://bit.ly/Eos-volcanobombs.

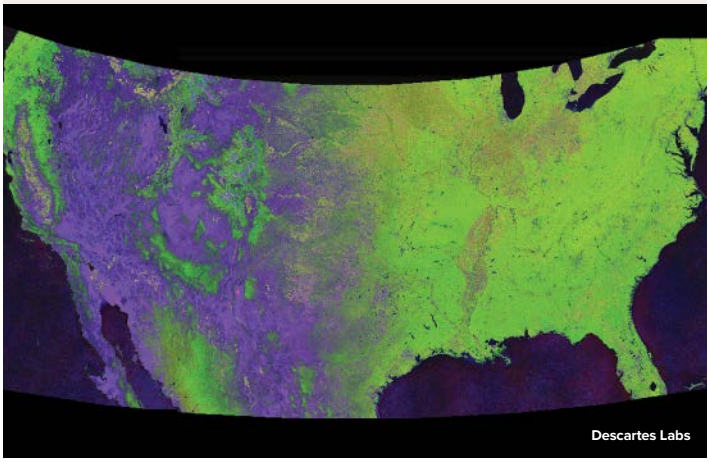

Gaudin et al., 2016, https://doi.org/10.1002/2016GC006560

9 A Living Atlas

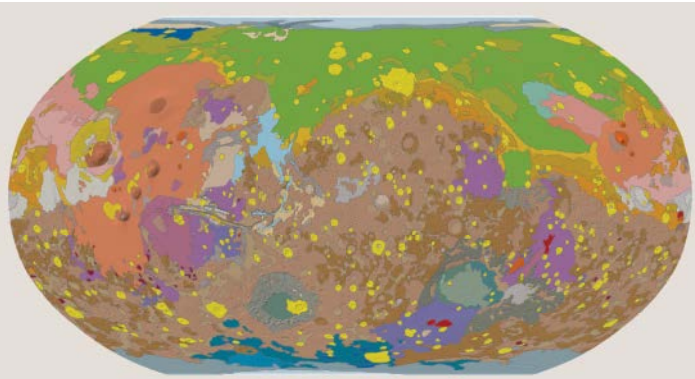
Want to watch land cover change over the past 15 years across the contiguous United States? Yeah, we do too. Catch a video, the product of a new living atlas (http://bit.ly/Eos-LivingAtlas). Below is a still shot from the video from 2015.

The atlas can stitch together the most recent images and data from satellites like the Moderate Resolution Imaging Spectroradiometer and Landsat to create real-time maps of the continental United States. Because the platform is based in the cloud, it can access vast computing power, allowing satellite swaths to be meshed together in a matter of hours. By contrast, a person piecing together the same map would take weeks to finish the task.

These kinds of maps will help scientists track urban development or offer real-time forecasts for agricultural sectors.



Descartes Labs



Tanaka et al., 2014, https://doi.org/10.3133/sim3292

10 Geologic Map of Mars

This colorful global map shows the basins and volcanoes of Mars, one of our nearest planetary neighbors. It took 7 years of efforts to combine data from several Mars orbiters. The result pulls together high-resolution spatial data, mosaics of 100-meter-per-pixel infrared images, radar soundings of ice-rich rock, and data on the types of minerals that make up the rock.

This map has a scale of 1:20,000,000; digital versions give detailed context of individual features in time and space. Such context allows scientists to more precisely date craters and other formations on the Red Planet's surface. For more details, visit http://bit.ly/Eos-MarsMap.

Author Information

JoAnna Wendel (@JoAnnaScience), Staff Writer; and **Mohi Kumar** (@scimohi), Scientific Content Editor

TESS

Triennial Earth-Sun Summit

20 – 24 May 2018 • Leesburg, Virginia

Abstract Submission Deadline:

20 February 2018

11:59 P.M. ET

AGU 100 ADVANCING EARTH AND SPACE SCIENCE

AAS

Learn more and submit at

https://connect.agu.org/tess2018

Awardees and Prize Winners Honored at 2017 AGU Fall Meeting

Bahr, Duce, and Somerville Receive 2017 Ambassador Awards

Jean M. Bahr, Robert A. Duce, and Richard C. J. Somerville were awarded the 2017 Ambassador Award at the AGU Fall Meeting Honors Ceremony, held on 13 December 2017 in New Orleans, La. The award is in recognition for "outstanding contributions to one or more of the following areas: societal impact, service to the Earth and space community, scientific leadership, and promotion of talent/career pool."

Jean M. Bahr

Citation for Jean M. Bahr

Professor Jean M. Bahr is a recognized leader in the hydrogeological community for her research, dedicated service to the nation, inspirational leadership in high-profile advisory roles, and mentorship of many young students and especially women. As chair of the first National Research Council Everglades committee in 2001–2004, she led an effort that evaluated the scientific activities of the existing restoration plan and made recommendations for a research program to support restoration efforts. During her term as president of the Geological Society of America (GSA) in 2009–2010, the society finalized a number of position statements, including ones on climate change and on diversity in the geoscience community. In 2003, she was selected as the GSA Birdsall–Dreiss Distinguished Lecturer and delivered lectures at 64 universities and public venues.

In recognition of her high regard and outstanding leadership ability, Jean was elected in 2017 president of the American Geological Institute, a nonprofit federation of 45 geoscientific and professional associations (including AGU and GSA). In 2017, she was also appointed by President Barack Obama as chair of the Nuclear Waste Technical Review Board, an independent federal agency charged with reviewing the U.S. Department of Energy's programs to manage the disposal of spent fuel and high-level radioactive waste. Previously, Jean served on the National Research Council's Board on Radioactive Waste Management (1992–1997) and was part of the panel that made recommendations to the U.S. Environmental Protection Agency for the highly influential repository standard for Yucca Mountain. Jean has served AGU in many roles, including as editor of *Water Resources Research*.

Jean's mentorship of young colleagues is impressive. She has been major adviser to 44 graduate students—57% of whom are women—who are now serving as university professors and scientists working at national laboratories, consulting firms, environmental agencies, and advocacy groups. She served as faculty codirector of the University of Wisconsin–Madison innovative undergraduate Women in Science and Engineering Residential Learning Community from 2003 to 2005. She helped coordinate activities for the University of Wisconsin–Madison's Pre–College Enrichment Opportunity Program for Learning Excellence (PEOPLE) Program, which seeks to encourage minority high school students by providing opportunities for learning and involvement at the university. In recognition of the above efforts, Jean received the 2012 Association for Women Geoscientists Outstanding Educator Award.

In summary, Professor Jean Bahr is one of those rare individuals in science who not only has inspired students and colleagues with top-tier science and mentoring but also has worked tirelessly and unconditionally on behalf of Earth sciences, her fellow citizens, and the nation.

—Mary Lou Zoback, *Stanford University, Stanford, Calif.; and* **Efi Foufoula-Georgiou**, *University of California, Irvine*

Response

I'm honored to have been nominated for this award by Mary Lou Zoback, Efi Foufoula-Georgiou, and Sue Brantley and to have had my nomination supported by a number of other colleagues who, like the nominators, have exemplary records of scientific contributions as well professional service. I love the idea of being considered an "ambassador" for the Earth sciences. As I look back on my career, many of the activities that have brought me the most personal satisfaction (as well as frustration) were those that involved representing the geosciences in general, and hydrogeology in particular, in questions related to public policy. I have enjoyed sharing my passion for our science, as well as my conviction of its importance to society, with audiences ranging from students in introductory to graduate-level courses at the University of Wisconsin–Madison, to local civic groups, to the institutions I visited as a GSA distinguished lecturer, and to governmental decision makers. I have been fortunate to have had several international ambassador opportunities, including 2 years of sharing my (then meager) knowledge of hydrogeology with a technical team in Mali, West Africa, shortly after college and, more recently, representing the American Geosciences Institute and some of its member societies while presenting an invited short course in Bucaramanga, Colombia, last January.

My father, an electrical engineer, encouraged my early interest in math and science. My mother, who studied economics with one of those who popularized the term "spaceship Earth" in the 1960s, was a consistent, active model of her dedication to goodwill among people of many cultures and to creating a more just, healthy, and peaceful society. Together, they inspired me to find a career that would challenge me intellectually but that also had the potential to make a difference. During the first Earth Day, I saw a path that would easily combine these two. I entered college a few years later with the goal of becoming some type of environmental scientist, finding my way to a major in geology and geophysics courtesy of faculty who highlighted the fact that our planet is, after all, our environment. My graduate mentors from Stanford, Environment Canada, and the U.S. Geological Survey provided me with outstanding hydrologic training as well as tangible examples of how our science can be used to address environmental and societal problems. I have done my best to offer similar training and good examples to my advisees.

—Jean M. Bahr, *University of Wisconsin–Madison*

Robert A. Duce

Citation for Robert A. Duce

Dr. Robert A. Duce has made fundamental contributions to atmospheric transport of chemicals from the continents, their deposition to the ocean, and their impact on marine biogeochemistry and climate, with field and numerical studies in Antarctica, the Arctic, and all the world's oceans. He has provided crucial leadership to the atmospheric/oceanic sciences community nationally and internationally.

Professor Duce's pioneer research has fundamentally altered the direction of research in the chemical interactions between the atmosphere and the oceans. His work contributed to many detailed investigations of the Chinese sources for mineral aerosol, as well as understanding of the importance of mineral matter as a reactant surface for heterogeneous chemical reactions in the atmosphere and in affecting the radiative properties of the atmosphere. He was the first to evaluate the importance of atmospheric input as a source of nutrients in the surface ocean, particularly for the element iron.

Dr. Duce has also given his time generously for leadership in the atmospheric and marine chemistry community. He has been a leader in the development of integrated and interdisciplinary large-scale research programs in atmospheric chemistry. In 2016, he was appointed cochair (with Professor Barbara J. Finlayson-Pitts of University of California, Irvine) of the Committee on the Future of Atmospheric Chemistry Research, Board on Atmospheric Sciences and Climate, Division on Earth and Life Studies, National Academies of Sciences, Engineering, and Medicine.

His scientific contribution and leadership theme were echoed through the comments of several of his atmospheric chemistry colleagues, including Professor Paul Crutzen (1995 Nobel Prize in Chemistry winner), who wrote, "Over the past 3 decades Bob has also been a highly effective organizer of major international research efforts, which always have led to great advances in scientific knowledge." Professor Ralph J. Cicerone (former president of the National Academy of Sciences) stated, "And his considerable organizational skills and generosity in science have marked him as a leader in many

national and international organizations that conduct and/or plan research programs in oceanography, atmospheric chemistry and climate." Professor Mario J. Molina (1995 Nobel Prize in Chemistry winner) commented that "not only are his numerous scientific achievements of very high quality, but he also has made extremely important contributions through his community service, as documented by the large number of committees he has served on." In summary, Dr. Robert A. Duce excels in all criteria designated by AGU for the Ambassador Award.

—Renyi Zhang, *Texas A&M University, College Station*

Response

It is, indeed, a great honor to receive the AGU Ambassador Award, and I sincerely thank my colleague at Texas A&M Renyi Zhang for his generous citation. I have been blessed to be able to learn from and interact with so many outstanding individuals in the ocean and atmospheric sciences for 60 years. Working at both the scientific and administrative interfaces between these two disciplines has been particularly exciting and rewarding. This award is really for the many colleagues over the years who have worked toward a fundamental understanding of the importance of the air–sea exchange of chemicals to marine and atmospheric biogeochemistry and climate. Pioneers like Peter Liss, Joseph Prospero, William Fitzgerald, Tim Jickells, Maria Kanakidou, Mitsuo Uematsu, Tom Church, and many others have been central in the development of global-scale interdisciplinary and international research efforts to address these issues. And as all of us in academia know, we ride largely on the coattails of our graduate students and postdocs, and I have been so fortunate to have had many outstanding ones.

As we look back, we reflect on those who made the greatest professional impact on our early academic careers. Jack Winchester, my major professor at the Massachusetts Institute of Technology, was one of the most upbeat and positive individuals I have ever met. He taught me that there are no failed experiments or measurements or studies. Every such event that turned out differently from what one expected is a positive learning experience. Al Woodcock was completely self-taught, and he rose to be a senior scientist at the Woods Hole Oceanographic Institution. In the latter years of his career, he moved to the University of Hawai'i, where he taught me to look at and experience nature closely. He was the consummate natural scientist. John Knauss, the founding dean of the Graduate School of Oceanography at the University of Rhode Island and former National Oceanic and Atmospheric Administration administrator, had a major impact on my administrative career. John believed that one of his primary responsibilities as dean was to take as much administrative burden as possible off the faculty so they could focus on their research and teaching. And he did that remarkably well. I am particularly grateful to these three individuals for their impact on my life.

Finally, I thank my wife, Mary, and the rest of my wonderful family for having the love, patience, and forbearance that allowed me to do the things I love.

—Robert A. Duce, *Department of Oceanography and Department of Atmospheric Sciences, Texas A&M University, College Station*

Richard C. J. Somerville

Citation for Richard C. J. Somerville

Richard C. J. Somerville has always been a clear and effective communicator of climate science, as recently acknowledged by the AGU community in naming Richard winner of the 2015 AGU Climate Communication Prize. Richard's audience has been the general public at large, world leaders and policy makers, students, and fellow scientists. Successfully addressing and accurately informing an audience this diverse on topics as complex as global warming and global climate change truly require the communication skills of a seasoned and knowledgeable ambassador.

Richard has been an inspirational educator. Beginning in 1973 at the NASA Goddard Institute for Space Studies (GISS) in New York and later at the Scripps Institution of Oceanography, University of California, San Diego, he mentored dozens of currently active climate scientists. For his accomplishments in promoting excellence in education, Richard was honored by the San Diego Science Educators Association as an outstanding university science teacher.

He served as a coordinating lead author of the 2007 Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report for which IPCC shared the 2007 Nobel Peace Prize. His elegant book *The Forgiving Air* was an easily understandable account of the science behind global warming, winning in the process the Louis J. Battan Author's Award of the American Meteorological Society. In his 2011 *Physics Today* paper "Communicating the Science of Climate Change," Richard explained the climate change problem in exceptionally clear and concise terms to both physicists and the general public.

With a solid foundation in climate science and a research specialty in atmospheric dynamics, Richard's first permanent position was at GISS, where he led the effort to construct the first global general circulation model of the atmosphere specifically aimed at providing long-range seasonal weather forecasts. His effective leadership was the key ingredient to successfully retrofitting an early University of California, Los Angeles (UCLA), weather model into the general circulation model (GCM) that became the predecessor of the GISS Model II climate GCM.

At Scripps, Richard began to direct his attention more fully toward public service by promoting the core objectives of our leading science organizations, government agencies, nongovernmental institutes, and worldwide policy-making bodies. He served selflessly on advisory committees for nongovernmental organizations and for government agencies such as NASA, the U.S. Department of Energy, the National Science Foundation, the National Academy of Sciences, and the National Research Council. He was instrumental in helping to establish the Aspen Global Change Institute (AGCI) and has been serving on the AGCI Advisory Board since 1990. He was also chair of the Board of Trustees of the University Corporation for Atmospheric Research (UCAR).

—Andrew Lacis *and* **Michael Mishchenko**, *NASA Goddard Institute for Space Studies, New York*

Response

My field is climate science, and we scientists all know that the world faces serious challenges in this area. Meeting these challenges requires taking science into account. We must not only continue to do research that enables us to understand and predict climate change, but we must act energetically to help the world make use of the science that we create. Albert Einstein said it best in an address to students at the California Institute of Technology in 1931: "Concern for man and his fate must always form the chief interest of all technical endeavors…in order that the creations of our mind shall be a blessing and not a curse to mankind. Never forget this in the midst of your diagrams and equations."

The AGU Ambassador Award recognizes contributions in four areas: societal impact, service to the Earth and space community, scientific leadership, and promotion of talent/career pool. All four are critical in making our science "a blessing and not a curse to mankind." My work in these areas has always involved collaborations. Consider the Intergovernmental Panel on Climate Change. Writing the IPCC assessment reports is a team effort, and a selfless one, in which we scientists take time away from our own research to provide governments and the public with scientific information that is relevant to policy making but not prescriptive of policy. Persuading governments, especially the U.S. federal government, to *accept* the science is an unfinished task.

On a personal note, my Ph.D. dates from 1966. During my student years, I encountered almost no women students in meteorology or climatology, and there were very few prominent women scientists in the field. That has changed dramatically, and I have been fortunate to work with numerous outstanding women scientists during the last half century. Many of my graduate student advisees and postdoctoral fellows have been women. Among my female collaborators in the work for which the Ambassador Award is given, I must mention especially Catherine Gautier, Susan Joy Hassol, Cherilynn Morrow, Lynn Russell, and the late Sally Ride.

I thank Andy Lacis and Michael Mishchenko for nominating me for the Ambassador Award. I thank all the students, postdocs, and colleagues who have worked with me. I thank AGU for establishing the Ambassador Award and for honoring me with it. Finally, I thank Sylvia Bal, my wife of more than 50 years, for supporting me with constant love and exceptional tolerance.

—Richard C. J. Somerville, *Scripps Institution of Oceanography, University of California, San Diego, La Jolla*

Visit https://eos.org/agu-news to read citations for and responses from 2017 medalists.

Robert L. Wesson Receives 2017 Edward A. Flinn III Award

Robert L. Wesson received the 2017 Edward A. Flinn III Award at the AGU Fall Meeting Honors Ceremony, held on 13 December 2017 in New Orleans, La. The award honors an "individual or small group who personifies the Union's motto 'unselfish cooperation in research' through their facilitating, coordinating, and implementing activities."

Robert L. Wesson

Citation

Throughout his career at the U.S. Geological Survey (USGS), Rob Wesson's leadership of the National Earthquake Hazards Reduction Program (NEHRP) expanded the scope and impact of earthquake hazards research, in partnership with academic institutions, governments, and researchers around the world. He played keys roles in launching and maintaining NEHRP, in developing international cooperation in earthquake research, and in creating a supportive environment that fostered more than two generations of U.S. earthquake scientists.

As a principal coauthor of the Newmark–Stever Report, *Earthquake Prediction and Hazards Mitigation Options for USGS and NSF Programs,* he helped bring the U.S. earthquake program into existence and later helped develop the implementation plan of the Earthquake Hazards Reduction Act of 1977. As chief of the Office of Earthquake Studies, he directed NEHRP in its infancy, building coalitions and bridges between government agencies and between government and academic researchers, including a key role in establishing the Southern California Earthquake Center. Rob understood the importance of fully engaging the academic community in NEHRP. Under his leadership, the USGS shaped its extramural research program to allow university scientists working on critical problems to become full partners in NEHRP. This partnership remains today as a cornerstone of NEHRP.

Rob Wesson has the highest appreciation for the value of solid science but is always careful to ensure that individual and institutional engagement is not ignored. In the early 1970s, he seized on the thawing relations between the United States and the Soviet Union to conduct joint seismological fieldwork in Soviet Tajikistan (with U.S. government seismometers and radios). By gaining the trust and respect of the leading Soviet scientists, he helped open a door in the Iron Curtain for decades of fruitful collaboration between American and Russian scientists.

When the Loma Prieta earthquake struck in 1989, NEHRP was under increasing fiscal pressure, as the growth envisioned in the Newmark–Stever Report never happened. Rob used this destructive event to make compelling arguments for expansion of NEHRP, and he secured a major increase in the congressional appropriation that continues to this day.

Rob Wesson's ability to stimulate the U.S. research community, engage with international partners, and implement a complex and societally important program lies at the crossroads between research, policy, and practice and makes him a fitting recipient of the Flinn Award.

—Bill Ellsworth, *Stanford University, Stanford, Calif.*

Response

Thanks so much to Bill Ellsworth and colleagues for nominating me for the Flinn Award and to AGU for granting it. I am tickled. I got to know Ted Flinn long ago when he recruited me for a job. As I left grad school in 1970 to join the USGS, competition among institutions seemed a dominant theme in Earth science. Today, while this competition remains strong and healthy, our science is promoted and facilitated by a variety of collaborative structures. I am proud to have contributed. Bob Hamilton lured me to Reston in 1976. Immediately, I joined him in working on the Newmark–Stever report and the struggle for a significant funding increase for earthquake science and engineering. Bob had overseen the consolidation of the former National Oceanic and Atmospheric Administration programs into the USGS and engineered the beginning of USGS collaboration with university researchers. The Newmark–Stever process and the resulting funds enhanced collaboration among the USGS and the National Science Foundation; government, universities, and the private sector; and engineers and Earth and social scientists. This same widely shared vision led to the Earthquake Hazards Reduction Act of 1977. After contributing to the drafting of the act and an implementation plan prepared by the Office of Science and Technology Policy (OSTP) and fighting the first battles to maintain the funds, I left the earthquake program for the director's office at the USGS, just in time for the eruption of Mount St. Helens, then went back to OSTP for another earthquake report. After a brief respite in research, I returned to the management of the USGS earthquake and volcano programs in 1988, at what became a very busy time for the travails of earthquakes and volcanic eruptions but also for opportunities to increase support for research and mitigation actions. Building and maintaining support for significant research programs need to be viewed as a political process in that they require identifying and meeting the needs of a variety of constituencies with differing, and often conflicting, priorities—a commonly uncertain and stressful undertaking. Increased support for regional efforts, including the Southern California Earthquake Center and Alaska Volcano Observatory, grew from that time. I have felt the support of many people. Especially deserving note are Bob Hamilton, Vince McKelvey, Dallas Peck, Bill Menard, Doyle Frederick, Frank Press, Lynn Sykes, Kei Aki, Phil Smith, John Filson, Randy Updike, Virgil Frizzell, Art Frankel, Jill McCarthy, but many, many others. My deepest thanks to all.

—Robert L. Wesson, *Geologic Hazards Science Center, U.S. Geological Survey, Denver, Colo.*

Erik M. Conway Receives 2017 Athelstan Spilhaus Award

Erik M. Conway received the Athelstan Spilhaus Award at the 2017 AGU Fall Meeting Honors Ceremony, held on 13 December 2017 in New Orleans, La. The award honors an individual "for the enhancement of the public engagement with Earth and space sciences."

Erik M. Conway

Citation

Few people have done as much to advance the history, understanding, and communication of Earth and space science and technology as Erik Conway.

Erik received his B.S. in engineering and Ph.D. in the history of science and technology, with early work on the history of aviation and aerospace technology. His first two books, *High-Speed Dreams* and *Blind Landings,* were academic contributions of the first order and established him as a historian of technology of first rank. They also earned him his appointment as the historian of the Jet Propulsion Laboratory (JPL) in Pasadena, where he has worked since 2004.

Erik's work at JPL has been focused on documenting, understanding, and explaining the key role that NASA has played in the Earth and space sciences. This has led to numerous academic articles and presentations on the subject and also to Erik taking on the challenge of effective public communication, particularly with respect to NASA's contributions to the scientific basis for understanding climate change. Erik was one of the lead scientists who rewrote and reformulated the NASA website on climate change, climate.NASA.gov. The exceptionally clear page on evidence—https://climate.nasa.gov/evidence/—is one of the most useful resources for anyone looking for answers to skeptical questions about climate change or seeking to understand more fully the scientific basis for our current understanding.

People are naturally attracted to space as well as to the feats of scientific and engineering accomplishment that make space exploration possible. But its history has been filled with challenges—both technical and social—and there have been many costly failures on the way to success. Erik manages to convey the complex realities of what it takes to do space science and exploration while still maintaining a sense of joy, wonder, and accomplishment. So much work on the history of space science and exploration is undermined by hype or wishful thinking. One result of this is that the public does not understand what it really takes—either scientifically or financially—to launch a successful mission. Erik's work, in my view, is crucial in helping to create and sustain real understanding—the sort of understanding that is essential if public and governmental support for space science is to be sustained.

—Naomi Oreskes, *Harvard University, Cambridge, Mass.*

Response

I'm honored and humbled to receive the 2017 Athelstan Spilhaus Award from AGU. I've been fascinated by the geosciences and their histories since high school, and it has been wonderful to spend a career telling their stories. As a historian, I was traditionally trained at the University of Minnesota, though my advisers, Arthur Norberg and Sally Kohlstedt, did encourage me to eschew the passive voice early on. My colleagues in communications at JPL, especially Blaine Baggett, Michael Greene, and Randal Jackson, have helped me see the value in new kinds of media for my own work, and I thank them for that. I also have to thank Karen Yuen, and Michael and Randy again, for inviting me to help build the NASA cli-

mate change website, which has been a powerful platform for bringing that science to the public.

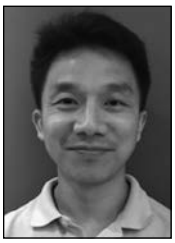
I owe my career as a NASA historian to Roger Launius, former chief historian of NASA, who hired me to write a history of supersonic transportation and got me started on examining the intersection between technological change and the Earth sciences. That work and my ensuing book projects brought me into contact with more geoscientists than the word limit would permit naming—I am well into the hundreds of hours of recorded interviews. Some of the more influential were Ben Santer, William L. Smith, Claire Parkinson, Crofton "Barney" Farmer, Moustafa Chahine, Michael Gunson, Daniel McCleese, Peter Barret, Annmarie Eldering, Leslie Tamppari, and Richard Zurek. My longtime lunch group at JPL, Tim Schofield, Eric Fetzer, Armin Kleinboehl, and David Kass, has also helped me understand many points of science, though not necessarily of an earthly nature.

It was Naomi Oreskes's idea for what became *Merchants of Doubt* that provided the opportunity for my "second career," as a historian and explainer of climate science and denial. I can't thank her enough for opening that fascinating window on the world. Working with Robby Kenner on the documentary version was an equally valuable experience. Jim Fleming's early effort to wrest the history of climate science from the hands of scientists was influential in shaping my thinking. Lynn Russell provided the opportunity to teach climate policy after many years out of the classroom, which has allowed me to reengage with climate and energy histories. Last, I thank my geophysicist wife, Andrea Donnellan, for putting up with the crazy life of a humanist.

—Erik M. Conway, *Jet Propulsion Laboratory, California Institute of Technology, Pasadena*

Hook Hua Receives 2017 Charles S. Falkenberg Award

Hook Hua was awarded the 2017 Charles S. Falkenberg Award at the AGU Fall Meeting Honors Ceremony, held on 13 December 2017 in New Orleans, La. The award is for "an early- to middle-career scientist who has contributed to the quality of life, economic opportunities and stewardship of the planet through the use of Earth science information and to the public awareness of the importance of understanding our planet."



Hook Hua

Citation

Hook Hua of NASA's Jet Propulsion Laboratory (JPL) richly deserves the Charles S. Falkenberg Award for 2017. Hook's primary professional contributions have been in applying emerging computer science techniques and technologies to Earth science to accelerate our understanding of the Earth, its phenomena, and its processes. Hook demonstrates the spirit and dedication of Dr. Falkenberg in his tireless efforts to improve our understanding of Earth science phenomena and processes by making instrument output more useful more quickly. His hallmark effort, the Advanced Rapid Imaging and Analysis (ARIA) Project and its related Synthetic Aperture Radar (SAR) Science Data Processing Foundry, embodies his ability to think strategically and execute ideas to completion with the science community in mind.

Hook has led a brilliant and talented team addressing the science data processing of SAR data. Both his own contributions and his leadership of the team in applying workflow tools, cloud computing, and machine learning techniques to the processing of data from multiple Earth science instruments are a credit to his skill and ability to attract very smart people to work with him. Hook's team has created and implemented innovations in science data processing that have accelerated the availability of SAR data for use by the solid Earth, hydrology, and hazard response communities. Hook and his team have transformed the discipline of science data processing by three different and important contributions: (1) workflow tools to pipeline processing, (2) automated quality control, and (3) expanding the use of cloud computing as an environment for quickly processing the high-volume output of these instruments.

The effect has been to move SAR data processing out of the realm of the artisan and into a true production capability, driving down the cost. The NASA–Indian Space Research Organisation (ISRO) SAR and Orbiting Carbon Observatory 2 instrument teams recognized the value of Hook's strategy in that they adopted his approach for their instruments.

Another of Hook's innovations has been the use of machine learning techniques in identifying anomalies in data to adjust the science data processing approach for a given scene, minimizing human intervention. Hook and his team were able to apply some advanced computer science techniques and then retest the scene. This reduced the labor and delays from manual rehandling of the data by scarce experts.

—Michael Little, *NASA Earth Science Technology Office, Greenbelt, Md.;* **Chris Lynnes**, *NASA Earth Science Data and Information System Project, Greenbelt, Md.;* **Curt Tilmes**, *NASA Goddard Research Center, Greenbelt, Md.; and* **Sue Owen**, *Jet Propulsion Laboratory, Pasadena, Calif.*

Response

I am deeply honored by this recognition of the 2017 Charles S. Falkenberg Award. It is very humbling to be recognized along with the prior recipients, who are great role models in the use of Earth science toward improving societal benefits.

I owe this recognition to Michael Little of NASA's Earth Science Technology Office and colleagues at JPL, other NASA centers, the Earth Science Data and Information System, Distributed Active Archive Centers, Federation of Earth Science Information Partners, Earth Science Data System Working Groups, and program management at NASA Headquarters, who all share similar passions. Particular appreciation goes to Curt Tilmes, Chris Lynnes, Steve Berrick, Sue Owen, Gerald Manipon, Brian Wilson, and Frank Lindsay, who gave me my first big break in the Advancing Collaborative Connections for Earth System Science (ACCESS) program over a decade ago. In addition, I have been blessed to work with a diverse and talented team of multidisciplinary scientists and technologists in the Advanced Rapid Imaging and Analysis (ARIA) Project at JPL/California Institute of Technology. Last but not least, I want to thank my family, who has supported these pursuits.

My roots in the late 1990s at JPL working on science data management and high-performance computing (HPC), and later applying HPC to interferometric SAR processing, exposed me to the pain points of Earth science data processing, such as long queue times and moving voluminous data to the computer. In 2009 we first proposed to do large-scale SAR processing "in the cloud." This proposal was naturally received with skepticism and uncertainty. But through perseverance and trust from the Earth Science Technology Office's Advanced Information Systems Technology Program, we were able to demonstrate that not only can SAR analysis be done in the cloud, but it can be more viable for addressing the computation and data volume challenges associated with large-scale SAR processing.

Six years later, NASA's Orbiting Carbon Observatory 2 (OCO-2) mission came to our team to help port Level-2 full physics processing to the cloud. This was the pivotal moment when a tier 1 NASA mission started to take cloud computing more seriously as a viable approach beyond just research projects. From this, we pioneered the exploitation of the AWS "spot market" for low-cost operational science data processing in a volatile computing environment.

Through real-world use of cloud computing in projects such as ARIA, the SAR Science Data Processing Foundry, and Getting Ready for NISAR (GRFN) project, we also had opportunities to innovate in pay-as-you-go approaches to custom on-demand and large-scale SAR analysis. It is humbling to see our efforts being used for disaster urgent response events such as earthquakes, floods, hurricanes, and volcano monitoring, even more so when we can see how effective cloud computing has been for generating rapid response SAR data products that are being used within hours by other agencies such as the Federal Emergency Management Agency for disaster response.

After years of perseverance, we finally see cloud computing for Earth science now becoming part of the baseline plan for NASA's upcoming large radar missions, Surface Water Ocean Topography (SWOT) and NASA-ISRO SAR (NISAR). We are finally crossing the "Valley of Death" from research to flight infusion. It is amazing to see firsthand the evolution of Earth science data systems finally transition to the paradigm of "data lakes," where we move computers closer to the data but do so in cost-effective and science-enabling ways. Doing so will require continued innovation (e.g., applied machine learning) that bridges the gaps between the research and flight project worlds.

—Hook Hua, *Jet Propulsion Laboratory, California Institute of Technology, Pasadena*

Hubert H. G. Savenije Receives 2017 International Award

Hubert H. G. Savenije received the 2017 International Award at the AGU Fall Meeting Honors Ceremony, held on 13 December 2017 in New Orleans, La. The award honors "an individual scientist, group, or a small team for making an outstanding contribution to furthering the Earth and space sciences and using science for the benefit of society in developing nations."

Hubert H. G. Savenije

Citation

Hubert Savenije, professor of hydrology at Delft University of Technology in the Netherlands, has had a long and distinguished record of research as a hydrologist and water resources engineer in many parts of the world, including Bangladesh, Vietnam, Indonesia, China, Nepal, Egypt, Ethiopia, Kenya, Mozambique, Zambia, Botswana, and Guatemala.

In the area of estuarine hydrology, Hubert has developed new analytical theories that deal with hydraulics, mixing, morphology, and salinity. His monograph *Salinity and Tides in Alluvial Estuaries* (now in its second edition) is unique in that it presents an integrated theory of estuaries, using examples from many estuaries around the world. His theory has provided guidance to decision makers to balance water abstraction upstream of estuaries with potential saltwater intrusion to satisfy irrigation demands. Dr. Savenije also contributed very significantly to the understanding of atmospheric moisture recycling in Africa long before it became mainstream in hydrology. He found that recycling is responsible for more than 80% of the rainfall in large parts of the Sahel, China, and South America.

In the area of catchment hydrology, Professor Savenije has explored hydrological responses at catchment scales across Africa, Asia, Latin America, and central Europe, including large river basins such as the Zambezi and the Nile. He has approached this through a combination of innovative fieldwork and modeling. He pioneered the concept of flexible landscape-based model structures as a way to develop parsimonious models and to use as diagnostic tools to develop generalized understanding. He developed parsimonious models for the Zambezi through the use of both hard and soft data, an achievement that is important for data-poor regions of the world. One of Professor Savenije's other immensely significant global research efforts is his contribution to the water footprint concept, which suggests that the major water problems of the world cannot be solved without holding consumers responsible for the costs of the ecological impacts of the agricultural produce they consume.

Society around the world has benefited enormously from Hubert Savenije's activities, not only through his water research but also from him being the initiator and cofunder in 2000 of WaterNet, a regional network of 50 universities in southern Africa for education, research, training, and outreach in integrated water resources management. Over the past 17 years, WaterNet has produced 467 extremely well trained M.Sc. graduates who are practicing water science and engineering in the region, thereby strengthening the capacity of southern African societies to deal with their water resources.

—Günter Blöschl, *Vienna University of Technology, Vienna, Austria*

Response

I am extremely happy with this award, which I see as international recognition for my hydrological work in different parts of the world, where I investigated and sometimes even helped to solve burning societal issues, such as floods, droughts, salinization, water scarcity, land subsidence, water logging, deficient agriculture, poverty, and lack of capacity to deal with these issues.

I had my education as a hydraulic engineer in Delft, in the 1970s. During my M.Sc. research, I went to Colombia for 2 months of fieldwork in the Magdalena River. Colombia completely changed my perspective on life, on my professional ambitions, and on what I wanted to contribute to society. I came to the conclusion that my energy would be wasted in the Netherlands, which I considered marginally interesting, both from a professional and a societal point of view. Professionally, there were no major challenges in a country where the water system was overtly engineered, but moreover, I considered the Dutch people so well off that I had the feeling that my efforts would contribute little to people's well-being. The developing world, on the other hand, had a "wealth" of water-related problems, many people suffering from these problems, and, professionally speaking, a far more interesting and dynamic natural environment.

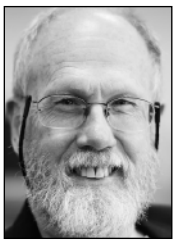
I wanted to go back to Colombia, but I ended up in Mozambique, working for the government as a hydrologist. I very much enjoyed working in Africa. Until this very day, the experience is invaluable to me. We stayed in Mozambique for 6 years, and both my children were born there. After Mozambique I worked for 6 years as a consultant in many parts of the world: Bangladesh, Indonesia, Malaysia, Vietnam, Zimbabwe, Kenya, Ethiopia, and Guatemala. I gained a wealth of experience, which benefited my own research, the many master's and doctoral students I supervised, but also, I hope, the people who suffered from many water-related problems.

Finally, what is probably the most important spin-off of all this work is the WaterNet capacity-building network that I helped to set up in southern Africa. Since 2000, it has produced 500 graduates in water sciences. This is a major contribution to water research, educational capacity, and professionalism in southern Africa's water sector. I am very grateful to the people of WaterNet who supported my nomination and to all the very good friends who nominated me for this very beautiful prize.

—Hubert H. G. Savenije, *Delft University of Technology, Delft, Netherlands*

Cerling and Ehleringer Receive 2017 Excellence in Earth and Space Science Education Award

Thure Cerling and James Ehleringer received the 2017 Excellence in Earth and Space Science Education Award at the AGU Fall Meeting Honors Ceremony, held on 13 December 2017 in New Orleans, La. The award honors "a sustained commitment to excellence in geophysical education by a team, individual, or group.



Thure Cerling

Citation

We are honored to cite Thure E. Cerling and James R. Ehleringer for empowering generations of students with a rich and interdisciplinary understanding of stable isotope techniques and their applications. Stable isotope data span the Earth system and provide unique and quantitative windows to biological and geochemical processes. As world-renowned scientists, Cerling and Ehleringer pioneered isotope studies and made them invaluable to biogeochemistry, ecology and paleoecology, forensics, and the climate sciences. Yet even as these fields expanded rapidly in the 1990s, Cerling and Ehleringer recognized that stable isotope biogeoscience was not open to all. Students at many smaller or foreign universities lacked access to expertise, training, and analytical resources. They also recognized that students from different disciplines had much to learn from each other. Therefore, they brought students together with top isotope scientists from many fields for an intensive course on isotope theory, analysis, and interdisciplinary applications. They created networks of collaborations and friendships among scientifically, culturally, and internationally diverse young scientists, who have gone on to become leaders in a wide range of the geophysical sciences.

James Ehleringer

Thure Cerling and Jim Ehleringer are the intellectual, inspirational, and organizational forces behind a hands-on, intensive, 2-week summer course offered annually since 1996. "Stable Isotope Biogeochemistry and Ecology" (affectionately known as IsoCamp) has trained more than 750 students from over 250 institutions in 37 countries across a multitude of scientific disciplines. The 2 weeks of IsoCamp include morning lectures from leading scholars on foundation principles, theory and process, and applications of stable isotope analyses. Students spend each afternoon in the field or in the isotope laboratory, where they are exposed to real-life problems, make their own isotope measurements, and participate in team-based projects. IsoCamp gives students both the fundamental knowledge needed to understand isotopic variations and the confidence to present interpretations of the results to their peers. Students advance rapidly from tentative newcomers, fueled by lectures, discussions, and growing experience in the field and lab. By the second week, students have gained the ability to envision their own projects and decide how best to apply an arsenal of available isotope methods and have built a lasting esprit de corps as they scramble to complete their projects before presentation.

Thure Cerling and James Ehleringer have created a transformative learning and networking experience for multiple academic generations of researchers and established the archetypical model of a successful summer short course for colleagues around the country.

—Brian N. Popp, *University of Hawai'i at Mānoa, Honolulu; and* **Katherine H. Freeman**, *Pennsylvania State University, University Park*

Response

We are very honored to accept the Excellence in Earth and Space Science Education Award for 2017. It is a privilege to join others before us who have received this award.

We first began offering Stable Isotope Biogeochemistry and Ecology (IsoCamp) as 2-week summer lecture and laboratory short courses in 1996. At that time, we did not anticipate that today we would still be offering IsoCamp, a team-taught multidisciplinary effort attracting students from across the nation and around the world! Given the benefit of time, it has been rewarding to follow the careers of students as they develop into researchers and leaders. We would like to believe that IsoCamp contributed to their successes.

Our vision was to offer lectures and hands-on laboratory experiences that brought together students and faculty from the many disciplines that use isotopes to study the Earth, climate, and biological sciences—from anthropology to zoology and from paleoclimatology to oceanography. We could see through our own students and visitors to our respective labs that a broader perspective of science would better prepare them to engage in the dizzying variety of stable isotopes applications. Realizing that we two could not provide the breadth of training, we recruited colleagues from across the stable isotope community to help teach IsoCamp. Each instructor has a passion for teaching and full engagement with students. Our acceptance of this award is also for these 20+ instructors who have contributed to teaching over the years—some are in the audience today. Thank you!

One of the great things about being in science is the training of new generations of scientists. We believe in cross-disciplinary training, in providing opportunities for the next generation, and in ensuring participation of both underrepresented and international students. IsoCamp gives students and faculty alike the opportunity for both social bonding and constructive science discussions, seeding long-term connections and collaborations. Every year this course establishes a network of 30 or so scientists who go forward in their respective careers having worked together to solve new problems and gain new skills.

We are thankful to the many students who have participated in IsoCamp, to the many faculty and staff who have helped us offer this course. And we especially thank our families, who welcome dozens of young scientists into their lives for a few weeks each year. This could not have happened without the support of Edna and Mahala!

—Thure Cerling *and* **James Ehleringer**, *University of Utah, Salt Lake City*

Bruno Faria Receives 2017 Africa Award for Research Excellence in Earth Science

Bruno Faria received the 2017 Africa Award for Research Excellence in Earth Science at the AGU Fall Meeting Honors Ceremony, held on 13 December 2017 in New Orleans, La. The award honors an early-career scientist from the African continent for "completing significant work that shows the focus and promise of making outstanding contributions to research in Earth or ocean sciences."

Bruno Faria

Citation

Dr. Bruno Faria from the National Institute of Meteorology and Geophysics in Mindelo, Cape Verde, is receiving the 2017 Africa Award for Research Excellence in Earth Science for his work to operate and maintain the seismic monitoring network of Cape Verde's active volcanoes, leading to a successful prediction of the 2014 eruption of Fogo volcano, and for his broad collaborations with and assistance to foreign Earth, ocean, and atmospheric scientists working in Cape Verde.

Bruno received a B.Sc. from the Catholic University of Louvain, Belgium, and a Ph.D. from the Instituto Superior Técnico, Lisbon, Portugal, in 2010. His research concentrated on geophysical monitoring of volcanoes, particularly Fogo volcano in Cape Verde. He developed a volcano monitoring network initially deployed at the time of the 1995 eruption of Fogo to extend it to other areas of potential hazard due to local reports of earthquakes. There was no geophysical record of volcanic activity in the country, so the network provided the data needed to establish an alert level system for use by national civil protection authorities. On this and related topics, Bruno has published seven papers since 2003.

Bruno also made time to collaborate with foreign scientists working in Cape Verde involved in volcano and earthquake monitoring, helping them to deploy instruments of their own for research purposes that aided the national monitoring mission. He also worked to establish and operate an atmospheric chemistry monitoring station in Cape Verde, on the island of São Vicente. These efforts led to coauthorship of the published research results. Bruno also fostered scientific research in his country by acting as a national scientific liaison in a suite of research cruises. At present, Dr. Faria still plays a key role in Cape Verde's volcano monitoring efforts and is dedicated to building up national monitoring infrastructure and raising the visibility of Cape Verde science in Africa and internationally.

—George Helffrich, *Earth-Life Science Institute, Tokyo, Japan*

Response

First, I would like to thank Dr. George Helffrich for his kind words and for my nomination. I would also like to thank all the colleagues who supported my nomination and the award committee members. I should stress that I am deeply honored and grateful to receive the 2017 Africa Award for Research Excellence in Earth Science.

At the beginning of my physics sciences studies at Université Catholique de Louvain, I used to dream about the geothermal prospection in Cape Verde, particularly in Fogo, where there is an active volcano. This led me to study—as a part-time study—volcanoes. Thus, at the end of my B.Sc. studies I had acquired some knowledge on how volcanoes work. Then the 1995 Fogo eruption happened. This was the end of my interest in geothermal exploration. Nevertheless, a new interest arose: the geophysical monitoring of volcanoes. Four years after the eruption, I had the great opportunity to collaborate with the first permanent monitoring geophysical network of Fogo volcano, a project led by Dr. João Fonseca. I started then a Ph.D. program, whose main goals were to understand the background seismic activity of Fogo volcano and to establish an alert level table for this volcano. Just 4 years after I finished it, the 2014 eruption of Fogo occurred, and my results were put to the test. Currently, all my attention and efforts are focused on a seismic crisis in Brava that began 2 years ago.

If my achievements have any merit, it is certainly because I was lucky to receive the contributions of so many people: Dr. V. Dehant, who gave me the good taste of the solid Earth geophysics; Dr. G. Helffrich, from whom I learned the fine structure of our planet and how to set up a seismic station correctly; Dr. S. Day, who tirelessly explained to me the structural geology of Fogo and how magma deforms the crust; Dr. João Fonseca, my Ph.D. adviser, whose open-minded thinking quickly gave me the guidelines for the research in volcano geophysics; and my colleagues at my institute and, particularly, the former administration. My family and Claudia, my life partner, were also crucial, especially my father, who showed me the way of science since my childhood and has always supported me without pressuring me. I'm deeply grateful to all of them!

—Bruno Faria, *National Institute of Meteorology and Geophysics, Cape Verde*

Get *Eos* highlights in your inbox every Friday.

To sign up for the *Eos Buzz* newsletter, simply go to publications.agu.org, scroll down, and enter your information in the **"SIGN-UP FOR *EOS BUZZ* NEWSLETTER"** section.

Melessew Nigussie Receives 2017 Africa Award for Research Excellence in Space Science

Melessew Nigussie received the 2017 Africa Award for Research Excellence in Space Science at the AGU Fall Meeting Honors Ceremony, held on 13 December 2017 in New Orleans, La. The award honors an early-career scientist from the African continent for "completing significant work that shows the focus and promise of making outstanding contributions to research in space science."

Melessew Nigussie

Citation

Melessew Nigussie received his Ph.D. in space physics from Bahir Dar University in conjunction with the International Centre for Theoretical Physics, Trieste, Italy, in 2014. He is the first Ph.D. graduate of the emerging and rapidly growing space physics program at his university. During his tenure as a student and early postgraduate scientist, Melessew authored a dozen papers providing the first thoughtful characterizations and analyses of the East African ionosphere using an innovative combination of models and ground- and space-based observations from multiple data sources. While answering numerous outstanding questions and raising many new ones, these studies are the first to document morphological and physical aspects of the structure, variability, and instability mechanisms unique to this poorly understood longitude sector and provide a solid basis for continued investigations of this dynamic region of the upper atmosphere. While Melessew's demonstrated scientific excellence resulted from focused scholarly efforts to obtain his academic degree, it may be serendipity that revealed the outstanding leadership and organizational skills at his command. During the course of his training, Melessew's thesis adviser, chairman of the Physics Department and founder of the Washera Geospace and Radar Science Laboratory (WGRSL), Professor Baylie Damtie, was promoted to president of the rapidly expanding 40,000-student Bahir Dar University. Dr. Nigussie stepped forward to take over day-to-day leadership of the WGRSL, assuming the principal role for several major projects, including the Blue Nile Coherent Backscatter Radar, and serving as the focal point for numerous international meetings and workshops hosted by the university. In addition to his leadership roles, he teaches and has supervised six master's degree students and cosupervised three Ph.D. students over the past few years. Since completing his Ph.D. in 2014, his research has led to better characterization and understanding of the equatorial African ionosphere. His leadership role in the Physics Department and research laboratory of his university has contributed to the development of infrastructure and human resources for space physics research in Africa, and he is a role model for young African scientists in the Earth and space sciences.

—Mark B. Moldwin, *University of Michigan, Ann Arbor; and* **Keith M. Groves,** *Boston College, Boston, Mass.*

Response

I am deeply gratified to be the recipient of the 2017 Africa Award for Research Excellence in Space Science from AGU, and I would like to express my sincere thanks to the selection committee who gave credit to the application of my nominator. I would like to thank also Sunanda Basu, who had a significant role in establishing this award as a way of advancing the strategic mission of AGU.

I am very happy in the space science research works that I and my group are doing at Washera Geospace and Radar Science Research Laboratory, Bahir Dar University. My main emphasis is to understand and model the spatiotemporal variability of the African equatorial ionosphere, which severely affects transionospheric propagating radio waves and hence the technologies that rely on them. For the works that I have done so far I would like to thank different organizations that have been involved in different ways; for example, Bahir Dar University and T/ICT4D at International Center for Theoretical Physics (ICTP), Italy, provided the opportunity for my Ph.D. education. I must also express my thankful feelings to AFOSR for funding my research proposal, through which I and my group are doing very good research at home.

My current scientific career is a result of the contribution of different individuals. During the transition from primary to high school, my educational journey was bumpy (2-year interruption after grade 8); thanks go to my uncle Shite Beyene, who passed away 2 years ago and who assisted me in continuing my high school education, and of course, his wife's and my parents' contributions are also undeniable. I would like to express my gratitude to my Ph.D. advisers, Dr. Baylie Damtie (Bahir Dar University), Professor Sandro Radicella (Abdus Salam International Centre for Theoretical Physics), and Dr. Endawoke Yizengaw (Boston College), who contributed a lot to my scientific skills. I must also express my sincere thanks to Dr. Keith Groves, who nominated me for this award. I would like to thank Dr. Patricia Doherty, Professor Sandro Radicella, Professor Mark Moldwin, and Dr. Endawoke Yizengaw, who are continually helping space science activities to grow and persist in Africa by coadvising Ph.D. and M.Sc. students, sponsoring students and young scientists to participate in workshops, and donating scientific instruments that can be used in Africa. Last but not least, I would like to thank my wife (Metages Walelign) and children (Christian and Michael) for their patience when I leave for scientific work. I appreciate all that has been done for me, and this will glue me more to space science research and related activities.

—Melessew Nigussie, *Washera Geospace and Radar Science Laboratory, Bahir Dar University, Bahir Dar, Ethiopia*

Richard Monastersky Receives 2017 Robert C. Cowen Award for Sustained Achievement in Science Journalism

Richard Monastersky received the 2017 Cowen Award for Sustained Achievement in Science Journalism at the AGU Fall Meeting Honors Ceremony, held on 13 December 2017 in New Orleans, La. The award honors "a journalist or team of journalists who have made significant, lasting, and consistent contributions to accurate reporting on the Earth and space sciences for the general public."

Richard Monastersky

Citation

Over the past 3 decades, Rich Monastersky has reported Earth science stories from all seven continents—including from the South Pole and the top of the Greenland ice cap. His résumé includes more than 1,000 articles in outlets including *Science News,* where he worked as Earth sciences editor, and the *Chronicle of Higher Education,* where he was a general science reporter. Since 2008, he has been an editor at *Nature,* where among other things he conceptualizes, commissions, and edits Earth science features.

Rich has covered the emergence of climate change as a major scientific and political issue, both nationally and internationally. He reported on the Loma Prieta and Northridge earthquakes, which exposed vulnerabilities to earthquake hazards in the United States. And he covered a string of other major geoscience stories, from the launch of the Pluto-bound New Horizons spacecraft to the devastating Fukushima tsunami.

Rich is consistently ahead of the pack in identifying and writing important articles. A 1991 piece on earthquake early warning systems in California put him at least 2 decades ahead of most other reporters. A 1991 feature, reported from Greenland, hints at the crucial climate insights to come from these paleoenvironmental studies. A 1995 article on iron fertilization is among the earliest reporting on geoengineering ideas. A 2006 piece definitively chronicles the political battles over the "hockey stick" graph of rising carbon dioxide levels. And a 2015 feature is a graphic novel, conceived and written with a comic artist as a way to explore climate science and international negotiations in advance of the Paris climate talks as a way to reach new audiences.

Through his mentoring of young reporters, Rich has also been instrumental in shaping the next generation of science journalists to tackle pressing Earth science topics. Many features he has edited have garnered major awards, including "The Rock That Fell to Earth," by Roberta Kwok, winner of AGU's 2010 Walter Sullivan Award for feature writing.

Rich himself is no stranger to honors, having acquired AGU's David Perlman news writing award in 2002 and the American Association for the Advancement of Science's journalism award twice (in 2001 and 2005). The Cowen Award cements this richly deserved legacy.

—Alexandra Witze, Nature, *Boulder, Colo.*

Response

I am profoundly honored to receive this award and want to thank AGU for its commitment to promoting science journalism. I also thank Alex for nominating me and for writing such a wonderful citation.

It is especially rewarding to be recognized by AGU because I have spent much of my journalism career covering Earth and planetary sciences. I got hooked in 1986 while reporting one of my first stories for *Science News* magazine about experiments that strung an electrical wire between mountain peaks to investigate electricity inside clouds. Soon after that, I joined researchers rafting through the Grand Canyon, and my path in science journalism has been an amazing adventure ever since. I have been privileged to tag along with researchers as they fly over rivers of lava, drill through the Greenland ice sheet, pilot rovers across the surface of Mars, and land a spacecraft on a distant asteroid. I thank these scientists and countless others for answering all of my questions and for sharing their contagious curiosity about the universe.

I would never have reached this point without the support and guidance of many editors and colleagues along the way. There are too many to name them all, but special thanks go to Joel Greenberg, who gave me my first job in journalism; Patrick Young and Julie Ann Miller during my years at *Science News;* Jennifer Ruark and Richard Byrne at the *Chronicle of Higher Education;* and Oliver Morton and Helen Pearson at *Nature.*

As an editor now, I have the good fortune to work with many immensely talented writers. I would like to thank them for their creativity and dedication, which give me hope that science journalism will grow stronger even as it goes through a period of tremendous change.

It doesn't seem that long ago that I was just getting started in this business. In those early days, I was lucky enough to meet some of the giants of science journalism such as Walter Sullivan, David Perlman, and Bob Cowen, who were welcoming with young reporters. They set a high bar, and I hope to live up to their example.

Bob recently wrote to me that he didn't consider his decades in the business as "work." Rather, he said, "it was a lifetime adventure." I couldn't agree more.

—Richard Monastersky, Nature, *Washington, D. C.*

Courtney Humphries Receives 2017 David Perlman Award for Excellence in Science Journalism–News

Courtney Humphries received the 2017 David Perlman Award for Excellence in Science Journalism–News at the AGU Fall Meeting Honors Ceremony, held on 13 December 2017 in New Orleans, La. The award recognizes "a journalist for a news story or series in any medium except books that makes information about the Earth and space sciences accessible and interesting to the general public."

Courtney Humphries

Citation

Courtney Humphries stands out in the science writing community for her fascination with urban ecology. She's drawn less to storied mountain peaks and shimmering valleys than to the gritty and adaptive landscapes found in the scraps of green space in American cities.

It illuminates her journalistic work, dating back almost a decade to her widely praised book *Superdove,* which explores the surprisingly complex nature of city-dwelling pigeons. She's described that work as "the hidden history behind a ubiquitous bird." That emphasis on the rarely seen nature of our everyday environment will tell you how important this is, an exploration of how life both thrives and fails in our human-altered world.

Courtney was a Knight Science Journalism Fellow in the 2015–2016 academic year, and she used the time to strengthen her background in this area. She studied urban ecology at Boston University, with an emphasis on the carbon and nitrogen cycles of the city. She investigated the environmental issues surrounding urban streams and suburban forests. She turned that into some outstanding reporting, ranging from a story for *Undark* on the global impacts of suburban development to a series of articles for *Architect* on energy-efficient building designs.

Her story "Where Forests Work Harder," which received the 2017 David Perlman Award, is a case in point. Published in *CityLab,* the article takes an in-depth—and unexpectedly revealing—look at the suburban forests surrounding Boston. Courtney walked through these forests in slow, tree-by-tree detail, with scientists who were carefully comparing the respiration of trees growing along the edges of cities with those in both more rural and more urban environments.

As she noted, their findings were surprising, even to the scientists. Trees living at the "edges" tended to thrive, grow faster, take in more carbon dioxide. The researchers suggested that nearby human activities might create a kind of garden environment that fosters this growth. That didn't mean that the scientists were advocating for patchy small forests over the extensive forests of the protected wild. Not at all. But they did at least see some environmental good news in the results.

The story is filled with nuance and context, illustrating the sophisticated approach she brings to such reporting. It offers an outstanding example of essential principles of good science writing—that a journalist who does her homework provides justice to the subject and service to her readers.

—Deborah Blum, *Massachusetts Institute of Technology, Cambridge*

Response

It is an incredible honor to receive the David Perlman Award, and it's especially poignant to receive it in the year that its namesake—the incomparable science editor at the *San Francisco Chronicle*—retired from daily journalism at the age of 98.

Receiving an award in his name gives me not only a high standard of journalism to aim for but also a model of lifelong service to the public and to one's own curiosity.

This story is about carbon dynamics in suburban forests, but it's also about what we can learn from the everyday, human-influenced landscapes around us. It illustrates how we affect other species and ecosystems in unexpected ways.

This news article benefited considerably from time I spent as a Knight Science Journalism Fellow at the Massachusetts Institute of Technology, where I was able to devote some unencumbered months learning about ecology, climate change, and urban ecosystems. Later, when an interesting paper came along, I was able to pitch and write a story quickly because of previous knowledge and relationships I'd established as a Knight Fellow.

So I'd like to put in a plug for fellowships, boot camps, and other programs that help journalists learn about research outside of the news cycle. They simply make our stories better.

I'd like to thank Deborah Blum, the director of the Knight Fellowship, for her support and kind words here. I'm grateful to Mark Byrnes, my editor at *CityLab,* who said yes to a cold pitch from a new writer about a topic that might seem esoteric and who shepherded the story through to publication. I'm also grateful to Lucy Hutyra, who allowed me to sit in on her urban ecology class at Boston University, and to Andy Reinmann, who gamely took a couple hours out of his week to tromp through the woods with me at short notice. I'm also appreciative of the other scientists—Nick Haddad, Robert McDonald, and Jonathan Thompson—who took the time to offer perspective and background well beyond what was quoted in the story.

—Courtney Humphries, *Freelance Journalist, Boston, Mass.*

Visit Eos.org for more AGU News.

Tony Bartelme Receives 2017 Walter Sullivan Award for Excellence in Science Journalism–Features

Tony Bartelme received the 2017 Walter Sullivan Award for Excellence in Science Journalism–Features at the AGU Fall Meeting Honors Ceremony, held on 13 December 2017 in New Orleans, La. The award recognizes "a journalist for a feature story or series in any medium except books that makes information about the Earth and space sciences accessible and interesting to the general public."

Tony Bartelme

Citation

Writing about plankton would not seem to be the most glamorous assignment or the easiest ticket onto the front page of South Carolina's largest newspaper. After all, you are trying to convince readers of the importance of a life-form most people have barely heard of and one that's often invisible to the naked eye.

But that's exactly the sort of material that *Post and Courier* special projects reporter Tony Bartelme gravitates toward: compelling stories that lie on the margins of our knowledge, offering clues to life's great mysteries. A three-time Pulitzer Prize finalist and author of *A Surgeon in the Village: An American Doctor Teaches Brain Surgery in Africa,* Bartelme has demonstrated time and again why he is one of the most masterful explanatory journalists of our time.

In "Every Other Breath," Bartelme explored climate change issues "hiding in plain sight."

He accompanied scientists through the verdant marshes of South Carolina's Lowcountry to the turquoise waters of Bermuda to detail the mysterious world of plankton, the creatures that produce half of the world's oxygen. He dove in the waters off the Florida Keys to chronicle coral bleaching, trudged through knee-deep tides to explain sea rise on the Charleston peninsula, and used a rare thermal imaging camera to show readers what emissions of carbon dioxide look like from buses, planes, and other everyday sources.

The *Post and Courier* is said to be the first newspaper or magazine to use such a device for a news story.

Endlessly curious and with a storyteller's gift for rich, colorful prose, Bartelme produced a stunning narrative series that blended cutting-edge science, history, and vivid anecdotes to drive home to readers the importance of pressing climate issues that often go unnoticed even as they threaten to change the world around us.

—Glenn Smith, The Post and Courier, *Charleston, S.C.*

Response

I'm honored and humbled to receive this year's Walter Sullivan Award. And I'm also excited because it gives me a chance to highlight what medium-sized papers can do with support from exceptional management and owners.

I work at what some might think is a dinosaur—a family-owned newspaper. But instead of a dinosaur, let's call it an alligator—an animal that survived the mass extinction 65 million years ago and human threats more recently but has begun to rebound. The *Post and Courier* also has weathered difficult economic challenges but hasn't lost sight of what's important: creating in-depth stories about complex community issues and then doing them in a way that matters to readers.

"Every Other Breath" was an example. It began with a conversation. A scientist told me he'd seen a 40% drop in zooplankton in the marshes by his lab. On the basis of that conversation, I went to my boss with an unusual request: "Hey, I'd like to learn about…ahem…plankton for a few months." Long pause. "And, oh, I have to go to Bermuda to do this."

The boss said yes, and that led to a story about one of the most important science issues hardly anyone is talking about. Hardly anyone but scientists. My goal was to bridge the gap between readers and the incredible people who are digging deep into climate-related issues. This is an expensive process. It requires lots of time because these scientists have to educate me, often for hours, about what they do.

I owe a tremendous debt to the scientists who patiently walked me through their work. And I feel very fortunate for the passport the *Post and Courier* gave me to meet these dedicated people. I'd like to thank Glenn Smith, the newspaper's exceptional project editor; Doug Pardue, a colleague and mentor who supported the project in its early stages; and Mitch Pugh, the paper's far-seeing executive editor. Videographer Chris Hanclosky built amazing videos, and designer Chad Dunbar put all the pieces together in a compelling way. The newspaper has a number of owners, and I'd like to express my gratitude to them, as well as to John Barnwell, chief executive officer of the parent company, and the newspaper's publisher, P. J. Browning.

Thanks, finally, to AGU and its members for their work, which, increasingly, carries the highest stakes.

—Tony Bartelme, The Post and Courier, *Charleston, S.C.*

Michael Strasser Receives 2017 Asahiko Taira International Scientific Ocean Drilling Research Prize

Michael Strasser was awarded the 2017 Asahiko Taira International Scientific Ocean Drilling Research Prize at the AGU Fall Meeting Honors Ceremony, held on 13 December 2017 in New Orleans, La. The Taira Prize is a partnership between AGU and the Japan Geoscience Union (JpGU) and is made possible through a generous donation from the Integrated Ocean Drilling Program Management International (IOPD-MI). The prize honors an individual for "outstanding transdisciplinary research accomplishment in ocean drilling."

Michael Strasser

Citation

Michael "Michi" Strasser is a key science driver for increasing our understanding of submarine mass movements through scientific ocean drilling. He has enthusiastically conducted research on mass transport deposits induced by historic mega earthquakes in the Nankai Trough and also by the 2011 Japan Trench mega earthquake and tsunami. His achievements have significantly contributed to our understanding of the causes and mechanisms of such deformable sediments and their tectonic backgrounds. Importantly, these scientific achievements are also highly relevant to human society in terms of natural geohazards.

Beginning with his Ph.D., he initiated his research with the study of Swiss lake sediments and proposed a novel method to reconstruct magnitudes and source areas of prehistoric earthquakes. By combining sedimentology, exploration geophysics, and geotechnical methods on seismic slope stability, he quantified prehistoric earthquake intensities produced by subaquatic sediment failure. In 2007–2008, he participated in the Nankai Trough Seismogenic Zone Experiment sailing on the D/V *Chikyu* as a member of the scientific team during Integrated Ocean Drilling Program (IODP) Expedition (Exp.) 316. As a shipboard sedimentologist, he clarified the origin and evolution of a tsunamigenic thrust system based on slope failure sediments. In 2010, he assumed a leadership role in proposing the Nankai Trough Submarine Landslide History (NanTroSLIDE) project, again using the D/V *Chikyu,* and served as a co–chief scientist during IODP Exp. 333. One of the most fascinating scientific achievements resulting from IODP Exp. 333 was his 2011 paper, which presents several novel aspects of a submarine landslide study combining the use of X-ray computed tomography and 3-D seismic interpretations of the targeted area.

In 2011, he established his own lab at the Swiss Federal Institute of Technology Zurich and systematically pursued a conceptional research scheme to study earthquake-triggered subaquatic landslides and sediment stability along subduction margins. Major scientific achievements emanating from these projects include important discoveries of transient geochemical signals in the slump deposit that constrained the triggering of the slump associated with the 2011 Japan Trench mega earthquake and the history of methane release from hydrate dissociation induced by recent offshore earthquakes. Michi's research has expanded further to include trans- and interdisciplinary directions to integrate both observational and theoretical processes. His interdisciplinary research achievements have broadened to include the impacts of active margin tectonics on the deep carbon cycle and biosphere and the integration of numerical modeling using IODP data. Since 2010, he has been serving as a leader of the international scientific community, for example, as cochair of the United Nations Educational, Scientific and Cultural Organization's (UNESCO) International Geoscience Programme IGCP 585 and 640 and as subchair of the Proposal Evaluation Panel of IODP.

As a recipient of the Asahiko Taira International Scientific Ocean Drilling Research Prize, Michael Strasser is honored for his outstanding contributions to the investigation of submarine mass movements using multidisciplinary approaches through scientific ocean drilling.

—Yasuhiro Yamada, *Center for Ocean Drilling Science, Japan Agency for Marine-Earth Science and Technology, Yokohama*

Response

I feel deeply honored to receive the Taira Prize. I thank AGU, the Japan Geoscience Union (JpGU), and IODP for establishing this prestigious prize and express my supreme gratitude to Yasuhiro Yamada for his gracious citation.

The enthusiastic lectures by Judy McKenzie, Gretchen Bernasconi, and Gerald Haug triggered my fascination for studying Earth's structure and history through scientific ocean drilling. I cannot overemphasize the encouragement and support I received from them to apply for the ODP student trainee program in 2002. I had the good fortune to join the *JOIDES Resolution* with fantastic international colleagues during Leg 205 to study subduction zone processes offshore Costa Rica. I am thankful to co–chief scientists Julie Morris and Heinrich Villinger and staff scientist Adam Klaus, who nurtured my scientific growth from a student trainee to a shipboard sedimentologist.

After this cruise, I did my Ph.D. project on lakes with Flavio Anselmetti, who taught me how to conduct my own little IODP-style project in lakes as model oceans and introduced me to the fascinating research of subaquatic mass movements and paleoseismology. Thereafter, I had the great opportunity to be involved in the IODP Nankai Trough Seismogenic Zone Experiment (NanTroSEIZE), to get exposed to the tremendous technological opportunities of *Chikyu,* and to establish exciting interdisciplinary collaboration with many NanTroSEIZE scientists. I would particularly like to thank Greg Moore, Achim Kopf, Mike Underwood, and Gaku Kimura in addition to the NanTroSEIZE chief scientists Harold Tobin and Masa Kinoshita and all co–chief scientists of Expeditions 316, 333, and 338, who were mostly influential on my research developments. They encouraged and supported me in writing my first drilling proposal to study submarine mass movement, which was implemented during Expeditions 333 and 338. Similarly, I am deeply thankful for the great momentum created by my colleagues within the UNESCO IGCP 585 and 640 projects, in particular, Angelo Camerlenghi and Roger Urgeles, to foster submarine landslide research within IODP. In representation of all not mentioned colleagues and friends within the bigger "IODP family," I also thank Dick Kroon as past chair of the Science Evaluation Board, the panel membership of which provided me with yet another highly rewarding experience in learning how outstanding new research proposals are emerging. I acknowledge my host institutions, ETH Zürich, MARUM Bremen, and the University of Innsbruck, for all their support, and also my students for conducting their research projects with me. Finally, I thank my wife and family for all their incredible support.

—Michael Strasser, *University of Innsbruck, Innsbruck, Austria*

Stefan Rahmstorf Receives 2017 Climate Communication Prize

Stefan Rahmstorf was awarded the 2017 Climate Communication Prize at the AGU Fall Meeting Honors Ceremony, held on 13 December 2017 in New Orleans, La. The Climate Communication Prize is funded by Nature's Own, a purveyor of fossils, minerals, and handcrafted jewelry in Boulder, Colo. The prize honors an "AGU member-scientist for the communication of climate science, and highlights the importance of promoting scientific literacy, clarity of message, and efforts to foster respect and understanding of science-based values as they relate to the implications of climate change."

Stefan Rahmstorf

Citation

Stefan Rahmstorf has a unique ability to explain science in a highly understandable yet accurate way to diverse audiences, from children to government ministers. He has perfected this ability in writing hundreds of blog articles: He was cofounder of *RealClimate* in 2005 and the German *KlimaLounge* blog in 2008. His articles are devoted to public understanding of research in the best sense: They do not merely explain results but showcase the scientific method, the way scientists think. He takes his audience seriously in not "dumbing down" the science but using every opportunity to deepen their understanding.

Stefan is remarkable in the breadth of the topics of which he has a firm grasp, not only in his popular writing but also in his research: paleoclimate, ocean circulation, sea level, extreme weather events, global temperature evolution, and more. His scientific publication record is outstanding; he has been honored for his scientific work by being elected a Fellow of AGU in 2010. He has played an important role in advancing both the scientific and public debates on the issues of sea level rise, the slowdown of the Gulf Stream system, and the impact of global warming on increasing extreme weather events.

He has (co)authored four popular books. *The Climate Crisis* (with David Archer) explains the findings of the Intergovernmental Panel on Climate Change in plain language, lavishly illustrated. *Our Threatened Oceans* (with Katherine Richardson) provides a highly readable overview of the state of the world ocean. His first book, *Der Klimawandel* (with me), was published also in Korean, Vietnamese, Russian, and Arabic and as an audiobook. Stefan is a father of two, and his latest book is the award-winning children's book *Wolken, Wind und Wetter.*

Stefan has acted as a mentor to many young scientists, encouraging and helping them to speak to the media or write their first blog post. He has advised the German government as a member of the German Advisory Council on Global Change for 8 years. He is a sought-after public speaker, has appeared hundreds of times on radio and TV, and has written countless newspaper articles and commentaries, some of which have been translated into 15 languages. He has a large social media following and is regularly contacted by leading international media.

It was an honor for us to nominate him, and he rightly deserves to be the first scientist working outside the United States to receive the AGU Climate Communication Prize!

—Hans Joachim Schellnhuber, *Potsdam Institute for Climate Impact Research, Potsdam, Germany*

Response

I am thrilled and humbled to receive this award! Let me first of all thank John Schellnhuber for being such a great communicator and role model and for supporting my climate communication work for more than 20 years now. I also thank those who supported this nomination. I could not do this work without a great network of colleagues around the world with whom I am in constant exchange of information and insights. Many would deserve this prize.

We all share a passion for science. But in addition to that, we are driven by deeply caring for humanity and by the conviction that scientific insight and foresight can prevent avoidable human suffering. Climate change is not just an "environmental" issue; it is foremost a massive problem for human society. A stable climate is a foundation of human civilization. Without it, we could not rely on harvests to feed us every year or build lasting cities on the oceans' shores. Two centuries of climate science have established beyond reasonable doubt that human activities are causing a global warming that is about to catapult us well out of the stable Holocene climate of the past 10,000 years, the period during which human civilization thrived.

Those who understand this threat to humankind have a duty to speak up. All the more so as there are powerful interests on the other side whose income depends on the general public not understanding the science and who have no scruples to go to great lengths to obfuscate scientific findings. This has been amply documented, for example, by the work of Harvard science historian Naomi Oreskes.

That shouldn't deter us from talking truth to power—and to the ostriches, as last year's winner of the AGU Climate Communication Prize, my good colleague Richard Alley, explains in his excellent video series *How to Talk to an Ostrich.* It's not enough to do good science. As atmospheric scientist and Nobel laureate Sherwood Rowland was quoted as saying in the 1986 *New Yorker* article "Annals of Chemistry: In the Face of Doubt" by Paul Brodeur, "What's the use of having developed a science well enough to make predictions if, in the end, all we're willing to do is stand around and wait for them to come true?"

So I would like to encourage many more climate researchers to get engaged in climate communication. You might even win a prize. But even more rewarding, you will likely help humanity navigate through the climate crisis with less suffering and loss.

—Stefan Rahmstorf, *Potsdam Institute for Climate Impact Research, Potsdam, Germany*

Exciting Section and Focus Group News

As many of you may know, AGU has been working for the past several years to understand how our science structure could be expanded to better enable people to collaborate and connect to others with shared interests and goals. The Affiliation and Engagement Task Force investigated a wide variety of options that might better serve the needs of AGU today, and into the future, before recommending a new model to the AGU Board of Directors and the Council. This change is of critical importance because our ability to affiliate and engage has a broad impact, including on how we do our science, run our meetings, interact with nonmembers, honor achievements, and self-govern. In short, we are developing an evolving model of engagement that will allow AGU to accomplish its vision of galvanizing a community to collaborate and communicate the power of science.

Our ability to pilot engagement activities under this new model with groups seeking an improved connection with AGU, including Earth and space science educators, those working at the intersection of art and science, and more, has been incredibly exciting, and I look forward to what the future brings.

Another exciting recent change that has come from the affiliation and engagement work was the decision to begin referring to all sections and focus groups as sections. When the structure of these two groups was first created, there was a more marked difference between the way science was represented by sections and focus groups. As the science evolved and became more interdisciplinary, that difference became far more arbitrary, and simplifying the naming structure will now make membership in the groups less confusing for members and will make forming new groups easier. However, nothing is changing in the structure of the existing groups, their governance, or how they interact with their members. This is only a name change.

Finally, I'm so pleased to announce the formation of the first new AGU section since Biogeosciences was formed more than 15 years ago: the GeoHealth section. GeoHealth was established to expand and energize this critical, emerging, interdisciplinary area of science and to build productive connections among scientists and decision makers from allied disciplines, including those who are not traditionally members of AGU. The formation of this section is the result of a pilot process recently approved by the AGU Council.

Societal grand challenges require more significant research collaborations across disciplines and geographies. The GeoHealth section is one of several efforts under way at AGU to foster and facilitate the work and collaboration of researchers at the interface of the geosciences, ecology, health sciences, and other allied disciplines. The Council and the Board strongly supported the development of a crosscutting GeoHealth program, given the growing importance of this field of study and the opportunity to bring together experts from multiple disciplines.

In addition to the new section, GeoHealth at AGU included an interdisciplinary SWIRL theme at the 2016 and 2017 Fall Meetings; the launch of the AGU journal *GeoHealth* (see http://bit.ly/AGU-GeoHealth); and the formation of meeting partnerships with other organizations, including the Planetary Health Alliance, which held its first meeting in April 2017.

The GeoHealth section will have its own sessions at the 2018 Fall Meeting. Other meetings are planned for this year, and the new section will help guide them. These include leading two conferences in fall 2018, one on air pollution in Xi'an, China, and a Geoscience and Society Summit, which will feature a mix of scientific presentations and workshops focused on addressing global and local challenges around sustainability and resilience.

Through these initiatives—publication of research, discussions of policy, growing partnerships with other stakeholders, and other engagement opportunities—AGU seeks to increase the influence of this transdisciplinary field. Because AGU recognizes that the community expands beyond the Earth and space sciences, we created an open GeoHealth discussion forum. I invite you, your colleagues, and your friends to join in on the conversation (see http://bit.ly/GeoHealthConnect).

The introduction of the GeoHealth section brings this area of science to the forefront for AGU members, allowing for seats on the Council and involvement in task forces and committees, including the Fall Meeting Program Committee. This involvement in these decision-making bodies will provide further support and opportunities for researchers to address key agricultural, ecological, and health issues.

The AGU Governance Committee is currently in the process of selecting founding leaders for the GeoHealth section and working on the transition to elected leadership in 2018.

The AGU sections reflect the scientific breadth of the more than 60,000 members of our Union. GeoHealth successfully connects many of our members (Hydrology, Atmospheric Sciences, Global Environmental Change, Seismology, Natural Hazards, and others) with researchers in disciplines currently not well represented within AGU, including those working in planetary health, medical geology, and health, as well as with decision makers across the globe to focus on such topics as public health, epidemiology, toxicology, medicine, veterinary medicine, and more.

When joining AGU or renewing their 2018 membership, AGU members can now select GeoHealth as their primary or secondary section. We hope you will join the GeoHealth section and volunteer for the unique opportunity to provide input and help shape the future of the discipline.

AGU is dedicated to meeting the challenges posed to human and environmental health head-on. Our new GeoHealth section along with AGU's united effort to advance science will position us at the forefront of discovery and lead to much-needed knowledge and solutions to our most pressing issues.

By **Chris McEntee** (email: agu_execdirector@agu.org), Executive Director/CEO, AGU

Conducting research at the intersection of environmental and health sciences?

Read the new open-access journal *GeoHealth*.

geohealth.agu.org

Run-Ups of Unusual Size

A wave crashes on the shore. Sometimes two or more breaking waves in the surf zone can combine into one powerful wave rolling onshore. Credit: fulltimegypsy/iStock/Getty Images Plus/Getty Images

Beaches are a major source of revenue for coastal towns in the United States, as flocks of tourists try to catch summer rays. A major threat to these coastal economies, however, is beach erosion. Waves near the shore can gradually pull large amounts of sand away from the coastline and deposit them in sandbars offshore, resulting in narrower beaches (and less room for sunbathing tourists to lay down their towels).

A recent study by *García-Medina et al.* deals with the physics of waves that cause beach erosion, something that has been studied since at least the 1950s. In particular, this team of researchers looked at what causes large wave run-up, which is the highest vertical point that a wave reaches once it hits the beach. The size of the wave run-up is critical to the likelihood of beach erosion, as large wave run-up can dislodge sediment high up on the shoreline and carry it back down to the ocean. Large wave run-up can also pull unsuspecting beachgoers into the water and cause fatalities. Such incidents are called "sneaker" waves on the West Coast of the United States and are the leading cause of drownings along the Oregon and northern California coasts.

The researchers examined how a phenomenon called bore-bore capture—when two or more breaking waves in the surf zone combine into one powerful wave rolling onshore—can lead to extreme wave run-up events. To evaluate the effects of bore-bore capture on wave run-up, they implemented a mathematical model with the ability to simulate the typical behavior of waves on a gently sloping beach. On beaches like this, a wave breaks near the shore, seawater washes up on land (that incoming water is called swash), and a mixture of seawater and sand retreats back into the sea (backwash).

Using their model, the researchers found that when two or more bores merge, the combination creates a wave run-up that could be more than 50% larger than the sum of the run-ups that would have been caused by the individual waves in isolation. So bore-bore capture allows waves to combine in a way that enables them to pack a much more powerful punch. But although bore-bore capture is a necessary component of large wave run-up, it is not the sole culprit. Much of the momentum propelling these waves up the shore comes from the interaction between bores and infragravity waves (smaller but longer waves that can be generated by wave groups).

Beach erosion is costly for communities in terms of lost income from tourism, but it also decreases property values, threatens infrastructure such as roads, destroys animal and plant habitats, and can increase the risk of flooding. Further, deaths due to large run-up events (associated with sneaker waves) are tragic and a major hazard. Knowing more about the mechanisms behind large wave run-up, as illustrated in this study, is an important part of understanding—and ultimately preventing—these harmful events. (*Journal of Geophysical Research: Oceans*, https://doi.org/10.1002/2017JC012862, 2017) **—Sarah Witman, Freelance Writer**

Modeling Beijing's Water Crisis

According to legend, China was born in a huge flood, but today the northern part of the country is starved for water. Beijing, China's capital city, is located in this arid region, and the megacity supports its 22 million residents with increasingly limited water sources. Only 100 cubic meters is available per person per year—anything less than 1,000 cubic meters per capita annually is considered "water scarce" by United Nations standards.

Beijing has come to rely more and more on groundwater, which currently makes up more than 70% of its total water supply. Because the population of the city is expected to rocket to more than 50 million by 2050, management of this subterranean resource is both critical and complex.

Residents in Beijing, China, line up to get water provided by a restaurant. Megacities like Beijing face increasingly limited water resources as populations rise. Credit: caizier/iStock Editorial/Getty Images Plus/Getty Images

In a new study, *Hyndman et al.* provide a novel glimpse into the dynamics of the groundwater system beneath the megacity. The researchers created a model that takes into account Beijing's developing landscape and found that urbanization has increased the recharge of groundwater.

The key factor is land use change. Urban development has edged large water consumers like agriculture and industry out of Beijing's municipality. An urban landscape not only uses less water than agriculture but also loses less to evapotranspiration, the phenomenon that occurs when water evaporates from the soil or is drawn up from the ground by plants and transpired from their leaves.

The research team's model of Beijing's water system provides a better fit to observations than previous groundwater models did. It integrates data on the water used by plants in different stages of growth, hydrology and topography, population growth, water use, temperature and precipitation, and other factors that influence groundwater recharge. Essentially, the researchers modeled the interactions between human water use and environmental factors to create a holistic picture of the real-world water system.

The researchers hope that their model, which may be applied to other groundwater systems around the globe, will inform policy makers about the long-term effects of policy decisions.

Although urbanization has improved Beijing's groundwater recovery, it has not solved the megacity's water woes. The greater recovery rate still does not ensure enough water to meet demand or even offset the steady decline of groundwater in the area. Further, runoff from city surfaces often contributes to the pollutants already troubling China's water sources.

The city is desperately striving to meet its water demands through various methods, including improvement of wastewater treatment and engineering projects to divert water from the Yangtze River in the southern part of the country. As efforts to solve the water crisis continue, this model is a useful tool to better understand water conditions and changes in Beijing. (*Geophysical Research Letters*, https://doi.org/10.1002/2017GL074429, 2017) **—Elizabeth Thompson, Freelance Writer**

Measuring Earth's Elasticity

When an earthquake occurs, it sends a wave of energy through Earth's crust. The wave's speed depends on the crystalline structure and orientation of the minerals within the layers of rock. It also depends on the directionally dependent variation in its velocity, called seismic anisotropy.

Measuring seismic anisotropy can help scientists predict how earthquakes will propagate, determine what minerals lie within Earth's crust, and examine how the crust deformed over geological timescales. But researchers often lack detailed measurements of the anisotropic characteristics of a given region. Now, by comparing anisotropic measurements from geologic regions worldwide, researchers have compiled a data set that could improve these predictions.

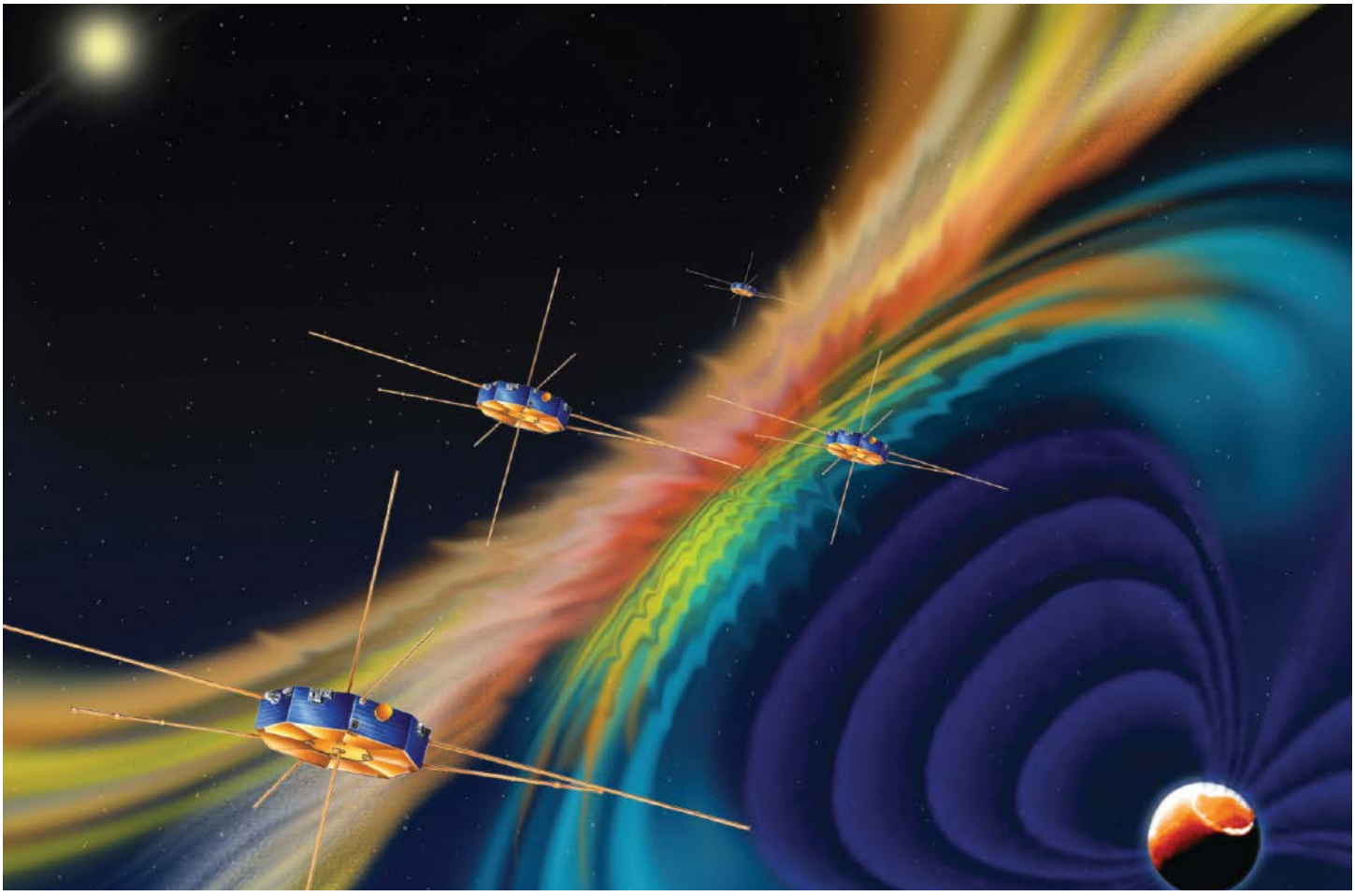
Many factors contribute to seismic anisotropy, including the spatial arrangement of minerals in such different types of rock as gneiss, schist, and sandstone. Also important are the pores and fissures within and between rock layers. Researchers can calculate the seismic anisotropy of crustal rocks by calculating the properties of individual component minerals or by measuring the velocity of ultrasonic pulses as they travel through the rock's fabric. The resulting multidimensional mathematical representations of local anisotropy are called tensors.

Scientists often use generic mathematical assumptions to estimate rocks' anisotropy, an approach that can introduce error. To find more accurate values for different regions and types of rock, *Brownlee et al.* compiled 94 anisotropy tensors from around the world, including from Scotland, New Guinea, Italy, the United States, and Japan. They compared the laboratory tensor measurements with computer models that simulate the patterns of anisotropy likely to develop under various conditions.

A geologist examines a schist outcrop in southern California prior to collecting a sample for elastic tensor characterization. Credit: Sarah Brownlee

Lacking local data, most models assume that tensors will display a characteristically elliptical, hexagonal symmetry. But the different samples of crustal rocks analyzed in the various labs, which contained a range of minerals, displayed more diverse symmetries than the team expected. What's more, they showed that the higher the levels of anisotropy in a swath of crustal rock were, the less elliptical its symmetry was likely to be. This surprising relationship should help researchers better predict how energy will disperse through Earth's crust and understand how crustal rocks have deformed in the past. (*Tectonics*, https://doi.org/10.1002/2017TC004625, 2017) **—Emily Underwood, Freelance Writer**

Jets of Ionospheric Cold Plasma Discovered at the Magnetopause



Artist's conception of the four Magnetospheric Multiscale (MMS) spacecraft investigating magnetic reconnection at the boundary of Earth's magnetosphere. Credit: Southwest Research Institute, CC BY 2.0 (http://bit.ly/ccby2-0)

The Sun and the Earth both produce powerful magnetic fields, and their intersection creates a complex system of physics that determines the space weather experienced by our planet.

The solar wind—a constant stream of charged particles (plasma) emitted from the Sun—collides with Earth's magnetic field, like water flowing around a rock in a river. The collision of the two magnetic fields produces a phenomenon known as magnetic reconnection, in which the field lines of both the planet and its star snap together following the perturbation. The process releases jets of high-energy plasma, which can produce auroras and disrupt communication systems when they collide with Earth's magnetic field.

Scientists believe that plasma from the magnetosheath—the magnetically weak layer of the magnetosphere where Earth's field makes contact with the outflowing solar wind—is the dominant driver of magnetic reconnection. However, a new publication by *Li et al.* shows that "cold" plasma from the planet's ionosphere may play a larger role than previously thought.

The difference between "hot" and cold plasma is a measure of temperature. Researchers have known for some time that hot plasma (in the kiloelectron volt range) from the ionosphere plays a role in reconnection, but the new study shows that cold ions (those originally in just the electron volt range) can also be found flowing out of the ion jets produced by reconnection.

The observation comes from a quartet of NASA satellites named the Magnetospheric Multiscale mission. The spacecraft are designed to fly in a tight formation—as close as 6.5 kilometers apart—and collect data about the magnetic and plasma environment in space. Sensors on board the craft allow the researchers to detect the flow of ions and identify their origins.

On a 1 November 2015 pass through the Earth's magnetopause, the satellites detected a high density of cold plasma coming from the ionosphere at the reconnection site. The discovery is significant because the cold ions can change the physics in the magnetosphere, influencing both the rate and the structure of the reconnection process and thus contributing to how solar storms affect our planet and its environment. (*Journal of Geophysical Research: Space Physics*, https://doi.org/10.1002/2017JA024287, 2017) **—David Shultz, Freelance Writer**

Summer Rainfall Patterns in East Asia Shift with the Wind

Every summer, the East Asian monsoon brings rainfall to China, Korea, Japan, and surrounding regions. Over one third of the global population resides in the paths of these warm storms. Because of their societal impact, the rains have been the subject of much research investigating their dynamics.

In a new study of East Asian monsoon rains, *Chiang et al.* investigate the causes behind year-to-year changes in the geographic patterns of rainfall that occur over the course of each summer. They used wind and rainfall data to test a hypothesis proposed by Chiang and other colleagues in 2015, which had previously been supported only by model simulations.

The 2015 hypothesis proposed that changes in rainfall patterns are caused by shifts in the timing and duration of four well-known stages of varying rainfall patterns that occur over the course of every summer monsoon; these stages are labeled by the authors as spring (April through mid-May), pre-Meiyu (mid-May through mid-June), Meiyu (mid-June to mid-July), and midsummer (mid-July through mid- to late August; also known as the post-Meiyu period). In turn, shifts in the timing and duration of these stages may be caused by northward drift of westerly winds relative to the Tibetan Plateau.

To test this idea, the researchers probed daily wind and rainfall data gathered from 1951 to 2007. They analyzed the rainfall data using a computational tool called a self-organizing map, which automatically groups the complex data, revealing the rainfall patterns associated with each stage. They used this technique to investigate the annual timing and duration of the stages, including Meiyu, or "plum rain," a particularly rainy period over central eastern China that occurs in the early summer.

The analysis revealed a link between the timing of Meiyu and typical geographic rainfall patterns in July and August. Specifically, during years in which July and August saw less rain in central eastern China and more rain in northeastern and southeastern China, Meiyu ended early, and the next stage, midsummer, lasted longer.

Further analysis revealed a link between Meiyu timing changes and shifting wind patterns. Over the course of a typical summer, westerly winds that flow across the Tibetan Plateau and into eastern China gradually shift north of the plateau. During years when Meiyu ended early, these westerly winds migrated northward earlier than usual.

Heavy rains soak Shanghai during the East Asian summer monsoon in July 2009. From year to year, the geographic patterns of monsoon rainfall may vary. New research shows a connection between shifting rainfall patterns and the northward migration of winds that sweep across East Asia. Credit: Jakub Hałun, CC BY-SA 4.0 (http://bit.ly/ccbysa4-0)

Overall, the data support the 2015 hypothesis, but more research is needed to confirm the role of the westerly winds and determine how they might control the timing of Meiyu, midsummer, and other stages. These findings could ultimately help improve seasonal rainfall forecasts and aid efforts to predict how climate change might affect East Asian rainfall in the future. (*Geophysical Research Letters*, https://doi.org/10.1002/2017GL072739, 2017)

—Sarah Stanley, Freelance Writer

Microfossils Illuminate Ancient Ocean Currents

Globalization, the close interaction of forces around the globe, is typically thought of as a relatively recent concept. For Earth's oceans, however, the phenomenon is as old as the sea. Water flow around landmasses and underwater topography builds up into large currents that define our oceans. As landmasses have shifted throughout history, ocean currents have shifted along with them.

To understand those shifts, *Fontorbe et al.* used marine microfossils in ocean sediment to trace ocean currents from the Oligocene and Eocene eras, between 50 million and 25 million years ago.

The researchers focused on an area in the central Pacific Ocean, near Hawaii. They collected microfossils from sediment cores and isolated samples from sponges, which occupy the seafloor, and radiolarians, or protozoa that live in the first 200 or so meters of the water column—the part illuminated by sunlight.

By examining the ratios of silicon isotopes that these organisms took up from their environments, scientists can determine the concentrations of silicon dissolved in the water around them. Newer deepwater formations contain less dissolved silicon than older ones, so a sharp change in silicon concentration in an area could indicate a shift in where its water is coming from.

The researchers found that around the transition between the Eocene and Oligocene, between 37 million and 34 million years ago, isotope ratios from both radiolarians and sponges suggest a shift from low to high silicon concentrations.

This period was also a tumultuous time for Earth. Volcanism and meteorite strikes, tectonic shifts, and a changing climate combined to alter ocean currents. Previously, the southern part of the Pacific Ocean was relatively closed in, and the stronger currents from the north fed the Hawaii region. However, about 37 million years ago, Antarctica and the southern tips of Australia and South America drifted apart, opening up greater circulation in the Southern Hemisphere. The new influxes strengthened the southern currents, driving their silicon-rich waters northward into the central Pacific.

The team's results align with previous research on Pacific currents, and they help paint a fuller picture of the shifts in the ocean's past. Ocean currents play a critical role in climate, weather, and nutrient transfer. The researchers' findings about the currents of the past will help us better understand how the oceans flow today. (*Paleoceanography*, https://doi.org/10.1002/2017PA003090, 2017) **—Elizabeth Thompson, Freelance Writer**

AGU's Career Center is the main resource for recruitment advertising.

All Positions Available and additional job postings can be viewed at Eos.org at **https://eos.org/jobs-support.**

AGU offers printed recruitment advertising in *Eos* to reinforce your online job visibility and your brand.

Visit **employers.agu.org** to view all of the packages available for recruitment advertising.

- *Eos* is published monthly. Deadlines for ads in each issue are published at **http://sites.agu.org/media-kits/eos-advertising-deadlines/.**
- *Eos* accepts employment and open position advertisements from governments, individuals, organizations, and academic institutions. We reserve the right to accept or reject ads at our discretion.
- *Eos* is not responsible for typographical errors.

* Print-only recruitment ads will only be allowed for those whose requirements include that positions must be advertised in a printed/paper medium.

Atmospheric Sciences

Division Director, Division of Atmospheric and Geospace Sciences, National Science Foundation (NSF), Alexandria, VA

NSF's Directorate for Geosciences (GEO) seeks candidates for the position of Division Director for the Division of Atmospheric and Geospace Sciences (AGS). The AGS Division Director serves as a member of the GEO leadership team and as the Directorate's principal spokesperson in the area of atmospheric and geospace sciences research. The incumbent is responsible for the overall planning, budgeting and management of funds for the Division, which includes the National Center for Atmospheric Research and other research facilities as well as the Atmosphere and Geospace sections. The Division Director has managerial and oversight responsibilities for the effective use of resources and supervision of division staff in meeting organizational goals and objectives. Facility oversight and management are important aspects of the Division and thus experience with facilities is desired. The incumbent leads all activities of the Division of Atmospheric and Geospace Sciences, assessing the needs and trends in geosciences research and education, developing breakthrough opportunities, implementing overall strategic planning, and policy setting. The Division Director supervises and provides leadership and guidance to senior AGS staff (Section Heads), program officers, administrative and support personnel. The responsibilities of the Division Director include the coordination of activities with other relevant organizations within the Foundation, other Federal agencies, professional organizations and international partners. Information about the Division's activities may be found at website: http://www.nsf.gov/geo/ags/about.jsp.

Appointment to this Senior Executive Service (SES) position may be on a Career or a one-to-three year SES limited-term appointment, with a salary range of $163,519,500 to $181,600. Alternatively, the incumbent may be assigned under the provisions of the Intergovernmental Personnel Act (IPA).

Announcement AGS-2018-0001, with position requirements and application procedures, is currently open until March 1, 2018 and found on the USAJOBS Home Page by the following link: https://www.usajobs.gov/GetJob/ViewDetails/483046300. If you have questions about the application process contact Sandra DeLeon at 703-292-2415 or email: execsrch@nsf.gov.

Hearing impaired individuals may call TDD 703-292-8044. nsf.gov.

NSF is an equal opportunity employer committed to employing a highly qualified staff reflecting the diversity of our nation.

Hydrology

Post-Doctoral Research Positions available at University's Mohammed VI Polytechnique (UM6P) in Ben Guerir, Morocco

UM6P is actively searching to fill multiple post-doctoral research positions at its new Ben Guerir campus. Well-qualified candidates are sought with research interests in the general areas of:

- Water resource management and climate change
- Precision agriculture, rhizobacteria and bio-fertilizers
- Industrial optimization and circular economies
- Green Chemistry for phosphate processing
- Urban metabolism and smart development

This UM6P post-doctoral program is intended to serve as a pipeline for future faculty hires at the university, so candidates should have genuine interest in living and working in Morocco while pursuing research on critical issues of sustainable development in Africa.

By virtue of the joint UM6P-MIT Research Program (UMRP) successful candidates will enjoy opportunities to collaborate with participating MIT faculty as Visiting Scholars at the Institute for extended periods working on joint UMRP projects. UMRP consists of six research projects supervised by MIT faculty on the topical areas listed above.

Potential candidates are invited to email a concise statement of personal and research interests along with their CV and contact information to the UMRP executive director at umrp@mit.edu. Responses will be forwarded as appropriate to the hiring authorities at UM6P for immediate consideration on a rolling basis. Candidates of interest will be contacted directly by UM6P for additional information and interviews.

Interdisciplinary

Assistant Professor of Crustal Dynamics at the University of Wyoming, Department of Geology & Geophysics.

The University of Wyoming Department of Geology & Geophysics invites applications for a tenure-track, Assistant Professor position in Crustal Dynamics. The successful candidate will be expected to build a vibrant, extramurally funded research program in the broadly defined area of crustal processes and contribute to the teaching mission of the department. We seek applicants who complement existing research strengths within the department and across the university. Research focus is open including, but not limited to, lithospheric deformation, basin analysis, Earth surface processes, and the interplay of crustal processes with the biosphere or atmosphere. We particularly encourage applicants who address questions from the grain scale to the global scale and who integrate field, theoretical, experimental, and/or modeling approaches.

The department comprises 26 faculty across a range of modern geoscience disciplines with access to exceptional laboratory, field, and computational resources that support cutting-edge research including: Materials Characterization Laboratory, Geochemical Analytical Laboratory, Wyoming Center for Environmental Hydrology and Geophysics, Wyoming High Precision Isotope Laboratory, Stable Isotope Facility, Cosmogenic Nuclide Laboratory, Wyoming High-Performance Computing Center. More information about the Department can be found at http://www.uwyo.edu/geolgeophys/

The complete announcement and the online application can be found at https://tinyurl.com/UWyoGeoJob1.

Review of applications will begin on January 5, 2018. Direct inquiries to Brandon McElroy, bmcelroy@uwyo.edu.

Assistant Professor, Sedimentology/Sedimentary Processes (Tenure-Track)

The George Mason University Department of Atmospheric, Oceanic, and Earth Sciences (AOES) in the College of Science invites applications for a full-time, tenure-track Assistant Professor position in sedimentology/sedimentary processes beginning August 2018. George Mason University has a strong institutional commitment to the achievement of excellence and diversity among its faculty and staff, and strongly encourages candidates to apply who will enrich Mason's academic and culturally inclusive environment.

Responsibilities:

The successful candidate is expected to pursue a vigorous, externally funded research program, involve students in research, aspire to teaching excellence, and engage in interdisciplinary collaboration. Teaching will be at both the undergraduate and graduate levels, including sedimentary geology and other areas of expertise. The successful candidate will also provide service activities to the department, college and university.

Required Qualifications:

Applicants must have completed a Ph.D. in the geological sciences, or a closely related field, prior to the first day of this appointment. The department seeks a dynamic person with a broad background in sedimentary geology.

Preferred Qualifications:

Candidates with interests in interdisciplinary collaborations and field-based research are particularly desirable. Preference will be given to candidates whose research includes paleoclimatology and/or paleoceanography.

About Mason and the Department:

The Department of Atmospheric, Oceanic, and Earth Sciences offers undergraduate degrees in Geology, Earth Science and Atmospheric Science, an M.S. in Earth Systems Science, and a Ph.D. in Climate Dynamics. Our faculty includes geologists, atmospheric scientists, paleontologists, and oceanographers. The successful candidate will be encouraged to forge research ties with other parts of the Mason community. Excellent opportunities also exist for collaborations with the U.S. Geological Survey, Carnegie Institute of Science, and the Smithsonian Institution.

Additional information about the AOES department may be found at http://cos.gmu.edu/aoes/.

For more information about the College of Science, visit http://cos.gmu.edu.

Special Instructions to Applicants:

For full consideration, applicants must apply for position number F115Az at http://jobs.gmu.edu/; complete and submit the online application; and upload a cover letter, CV, philosophy of teaching statement, research statement, list of three professional references with contact information (with e-mail addresses), and examples of published work and teaching evaluations (if available) into the field labelled 'Other Doc'.

George Mason University is an equal opportunity/affirmative action employer, committed to promoting inclusion and equity in its community. All qualified applicants will receive consideration for employment without regard to race, color, religion, sex, gender identity, sexual orientation, national origin, disability, or protected veteran status.

Director, Division of Earth Sciences, National Science Foundation (NSF), Alexandria, VA

NSF's Directorate for Geosciences (GEO) seeks candidates for the position

of Director for the Division of Earth Sciences (EAR). The EAR Division Director serves as a member of the GEO leadership team and as the Directorate's principal spokesperson in Earth sciences research. The incumbent is responsible for the overall planning, budgeting and management of funds for the Division, which includes the Disciplinary Programs and the Integrated Activities sections. The Division Director has managerial and oversight responsibilities for the effective use of division staff and resources in meeting organizational goals and objectives. Facility oversight and management are important aspects of the Division. The incumbent leads all activities of EAR, assessing the needs and trends in Earth sciences research and education, developing breakthrough opportunities, implementing overall strategic planning, and policy setting. The Division Director supervises and provides leadership and guidance to senior EAR staff (Section Heads), program officers, administrative and support personnel. The responsibilities of the Division Director include the coordination of activities with other relevant organizations within the Foundation, other Federal agencies, community organizations and international partners. Information about the Division's activities may be found here.

Appointment to this Senior Executive Service (SES) position may be on a Career or a one-to-three-year SES limited-term appointment, with a salary range of $163,519 to $181,600. Alternatively, the incumbent may be assigned under the provisions of the Intergovernmental Personnel Act (IPA).

Announcement EAR-2018-0001, with position requirements and application procedures, is found on the USAJOB Home Page. The link listed on the NSF webpage will take the user to the USA Jobs announcement https://www.usajobs.gov/GetJob/ViewDetails/483044300. If you have questions about the application process contact Sandra DeLeon at 703-292-2415 or email: execsrch@nsf.gov. Hearing impaired individuals may call TDD 703-292-8044.

NSF is an equal opportunity employer committed to employing a highly qualified staff reflecting the diversity of our nation.

Head and Professor, Department of Earth, Atmospheric, and Planetary Sciences, Purdue University

Purdue University invites applications for the position of Head of the Department of Earth, Atmospheric, and Planetary Sciences to start as early as August 2018. We seek a recognized researcher with a proven track record of leadership, vision, and mentoring. The successful candidate will have a clear plan to continue to increase the visibility, stature, and intellectual leadership of the department and the College of Science. The department head will demonstrate a commitment to excellence in teaching. The EAPS department is an interdisciplinary department with 40 faculty whose diverse research topics range from the Earth's mantle through the atmosphere, to the surfaces of other planets, to sustainable communities. We currently have new research initiatives in energy and environment, natural disasters and hazards, and data science. Department faculty are also involved in University-wide multidisciplinary research in planetary science, geochronology, climate change, and environmental science. Further information about the Department can be found at https://www.eaps.purdue.edu/ and additional materials are available upon request.

The Department of Earth, Atmospheric, and Planetary Sciences is one of seven departments in the College of Science with involvement in numerous interdisciplinary programs and centers. Beyond the College, Purdue's strengths in Engineering, Agriculture, Veterinary Medicine, Pharmacy and the Health and Human Sciences contribute to a robust research and educational environment. Further information on the College of Science is available on the website at www.science.purdue.edu.

Qualifications: The successful candidate will have a Ph.D. in Earth, Atmospheric, and Planetary Sciences or a related discipline, an outstanding record of scholarly achievement and a history of extramurally funded research commensurate with the rank of full professor at Purdue, exceptional and proven leadership abilities, a vision for the Department in the university, state, and nation, a commitment to excellence in undergraduate and graduate education, an enthusiasm for engagement, and a dedication to championing diversity and inclusion.

Applications: Interested candidates should submit a cover letter, curriculum vitae with the names and e-mail addresses of three references, a statement of research and teaching accomplishments, and a vision statement for the future of EAPS research and education. Applications should be submitted to http://hiring.science.purdue.edu. Inquiries should be directed to Ken Ridgway, Chair of EAPS Head Search Committee, ridge@purdue.edu. Review of applications will begin February 15, 2018 and will continue until the position is filled. A background check is required for employment in this position. Purdue University's Department of Earth, Atmospheric, and Planetary Sciences is committed to advancing diversity in all areas of faculty effort, including scholarship, instruction, and engagement. Candidates should address at least one of these areas in their cover letter, indicating their past experiences, current interests or activities, and/or future goals to promote a climate that values diversity and inclusion.

Purdue University is an EOE/AA employer. All individuals, including minorities, women, individuals with disabilities, and veterans are encouraged to apply.

Postdoc position available in Hong Kong University of Science and Technology (HKUST) and University of California, Los Angeles (UCLA).

We are seeking one postdoctoral researcher to work on a collaborative project between the Hong Kong University of Science and Technology (HKUST) and University of California, Los Angeles (UCLA). The collaborative research aims at understanding the physical processes between the Pearl River Estuary and the adjacent shelf, in response to seasonal monsoon and buoyancy forcings. This project is under a funded program for diagnosing the causes and variability of hypoxia in the Hong Kong water (OCEAN-HK; https://ocean.ust.hk/). The postdoctoral researcher will be jointly advised by Jianping Gan (HKUST) and Jim McWilliams (UCLA). The position is based in HKUST, but required frequently to spend time in UCLA. He/She will have the opportunities to collaborate with an interdisciplinary research team and participate in the field experiments. The position is for 1-year contract and renewable. Solid training in fluid mechanics and computer programming are highly desirable. Application will remain open until the positions are filled. To apply, please send a complete CV with past research experience and references to Prof. Jianping Gan (magan@ust.hk) and Prof. James McWilliams (jcm@atmos.ucla.edu).

Postdoctoral Research Associate Position, University of Washington, Seattle, WA

(JISAO) seeks three postdocs researching atmospheric science, oceanography, climate science, and fisheries science and management. JISAO encompasses a range of scientific interests including large-scale atmospheric-ocean interaction, ocean/atmospheric dynamics, biogeochemical cycles, ocean acidification, marine ecosystems, climate impacts on ocean and land ecosystems, high-latitude climate, paleoclimate, ocean/atmospheric model development and evaluation, and climate forcing and feedbacks, including both aerosol and clouds. JISAO operates jointly between the UW and NOAA research laboratories in Seattle, particularly the Pacific Marine Environmental Laboratory (PMEL).

Terms of appointment are for one year, renewable for a second year. Positions are not project specific; applicants define research within JISAO programs and are strongly encouraged to collaborate with UW and PMEL scientists. Applicants who demonstrate research relevance to both JISAO and PMEL programs are preferred. Successful applicants must hold a recent Ph.D. to assume a postdoc.

Applicants submit electronically: curriculum vitae, publication list, brief research proposal (no more than

Carleton UNIVERSITY
Canada's Capital University

TIER-2 CANADA RESEARCH CHAIR TENURE-TRACK POSITION AT THE ASSISTANT OR ASSOCIATE PROFESSOR LEVEL

Carleton University's Department of Mechanical & Aerospace Engineering invites applications for a **Tier-2 Canada Research Chair tenure-track position at the Assistant/Associate Professor level**. The successful candidate will have research strength in areas of quantifying and reducing greenhouse gas and other emissions from the energy sector. Applicants will have research expertise strongly aligned with the objectives of environmental sustainability through emissions quantification and reduction, pollutant source identification and attribution, greenhouse gas (GHG) mitigation strategies, or novel combustion technologies.

Applicants must have a Ph.D. in Mechanical engineering or a related field, and a commitment to undergraduate and graduate teaching, research and the engineering profession.

The appointment will be conditional upon the candidate preparing and submitting an application for a Tier-2 Canada Research Chair.

Send your application including a curriculum vitae, the names of three referees, and statements on your teaching and research in one single PDF file.

Email: **Hiring.MAE@carleton.ca**

5 pages, double-spaced, excluding bibliography and figures) describing research to be pursued during a two-year tenure, and names of four individuals for letters of reference. A letter of support from a mentor at UW or PMEL is strongly encouraged. Research mentors may be JISAO research scientists, PMEL research scientists, and/or UW faculty members in relevant departments. Mentors can be found at [http://jisao.washington.edu/research/postdocs].

Applications should be received prior to January 19, 2018. Applications received after that date are not likely to be considered. See online ad for further information about submission.

Research Scientists-Natural Hazards and Structures

FM Global is a leading property insurer of the world's largest businesses, providing more than one-third of FORTUNE 1000-size companies with engineering-based risk management and property insurance solutions. FM Global helps clients maintain continuity in their business operations by drawing upon state-of-the-art loss-prevention engineering and research; risk management skills and support services; tailored risk transfer capabilities; and superior financial strength. To do so, we rely on a dynamic, culturally diverse group of employees, working in more than 100 countries, in a variety of challenging roles.

Responsibilities

Exciting and interesting technical challenges await when you join a world-class research team dedicated to reducing the impact of natural hazards. As a leader in property loss-prevention, FM Global has been on the forefront of innovation since 1835 paving the way for many insurance industry firsts. As part of our research division, you'll work alongside a unique group of scientists across engineering, earth, and atmospheric sciences to protect the value of FM Global's clients' businesses by developing methods to identify hazards, assess risk, and produce loss prevention solutions that are efficient and cost-effective.

Interested in a career with our Structures and Natural Hazards group? We have an opening with

• Hydrological Sciences team studies fluvial and pluvial flood hazards.

o Heavy precipitation: investigate the physical and statistical properties of flood-causing precipitation using rain gauge and remote sensing data, and numerical weather model outputs.

o Hydrologic flood modeling: estimate flood discharges at global to local scales, modeling the water fluxes from precipitation to river overflow.

o Hydrodynamic flood modeling: one and two dimensional, small to large scale, using commercial software and developing in-house models.

The following are some of the areas where we are always seeking specialized research professionals. Please note that there are job openings currently available. By applying to this opportunity, you are expressing interest in a Research Scientist job in Norwood, MA should an opening become available:

• Geological Sciences team studies the hazards and effects of earthquakes and tsunamis.

o Seismology and geology: characterize seismic sources, propagation, and site response for hazard evaluation.

o Ground motion: investigate factors that influence earthquake ground motions; construct site response maps.

o Tsunami: characterize subduction zone earthquakes; model tsunami initiation, propagation, and run-up.

o Shake table: subject specimens to shaking; develop loss prevention solutions to mitigate shaking damage.

• Meteorological Science team studies severe weather, climate change, and other atmospheric perils, and the impacts on building envelope components.

o Hazard: develop hazard maps for extreme weather events including tropical cyclones, thunderstorms, tornadoes, hail, and winter storms.

o Numerical modeling: model weather, climate, and wind-induced coastal storm surge.

o Wind: develop wind load recommendations for building components and cladding using boundary layer wind tunnel testing and computational fluid dynamic simulations.

o Mitigation: identify solutions to reduce loss from building envelope failures.

• Structural Mechanics team covers response and damage of structural and non-structural systems, contents and equipment.

o Finite element modeling: model structures, non-structural components, equipment, and fracture mechanics; analysis of commercial and industrial materials and products.

o Loading: evaluate structural vulnerability, damage, and risk under natural hazard and fire loading.

o Material properties: study thermal and mechanical properties of materials used in construction and mechanical equipment.

o Mitigation: identify and develop loss prevention solutions for structural systems, components, and products to reduce the risks associated with natural hazards and fire.

• Qualifications

Qualifications include a Ph.D. degree, strong research record in the area of interest, and excellent written and verbal communication skills. A solid background in probability and statistics, proven technical programming and modeling experience, and knowledge of model physics, principles, setup, calibration, validation and sound analysis practices are highly desired. Senior applicants must have demonstrated project management abilities. The job title and compensation depend on qualifications and experience.

Email Applications: tiara.adducie@fmglobal.com

Smithsonian Institution

TWO POSITIONS IN PETROLOGY AND MINERALOGY AT SMITHSONIAN'S NATIONAL MUSEUM OF NATURAL HISTORY

The Department of Mineral Sciences within the National Museum of Natural History in Washington, DC, is advertising two Federal Research Geologist positions; US citizenship is required for these positions. One position is in the field of PETROLOGY (Announcement 18A-JW-303331-DEU-NMNH; **https://www.usajobs.gov/GetJob/ViewDetails/486936100**), and one is in the field of MINERALOGY (Announcement 18A-JW-303332-DEU-NMNH; **https://www.usajobs.gov/GetJob/ViewDetails/486938500**). All application materials must be submitted through USA Jobs by **Feb. 2, 2018** referencing the appropriate announcement number; materials sent to members of the Department will not be considered. Applicants that wish to be considered for both jobs must submit two separate application packages.

For additional information please visit **http://mineralsciences.si.edu**

The Smithsonian Institution is an Equal Opportunity Employer.

Near Surface Geophysics

The Department of Geosciences within the College of Arts and Sciences Seeks Candidates for Assistant / Associate Tenure Track Professor – Western Michigan University

Qualifications: The candidate must possess an earned Ph.D. in the geosciences or a closely-related field from an accredited institution by July 1, 2018. The successful candidate will have a demonstrated record of high-quality research, and show potential for excellence in teaching.

Responsibilities: Responsibilities of the new faculty member include: (i) generating and managing a robust, externally-funded, research program, (ii) publishing in high-quality, peer-reviewed scientific journals, (iii) teaching undergraduate and graduate courses, and (iv) contributing to the success of a campus initiative on the applications of unmanned aircraft systems in geological and environmental sciences. The tenure track, Assistant or Associate Professor, alternate academic year, will be expected to engage in geophysical research and teaching (e.g., gravity, magnetic methods, electrical methods, ground penetrating radar, and/or seismic imaging). Research expertise in the use of aerial or satellite geophysical data to interpret geological or hydrological processes will be given special consideration.

Department: The Department of Geosciences, which is comprised of 13 faculty members, is research-active and nationally-ranked. The department confers B.S., M.A., M.S. and Ph.D. degrees. The strengths of the department include hydrogeology, geochemistry, remote sensing, glacial geology, and sedimentary geology as well as environmental and resource analysis. A new initiative is underway to develop educational programs on the applications of unmanned aircraft systems (UAS) in geophysical and environmental sciences. Housed within the department is the Michigan Geological Survey, which supports and advocates for programs of applied research within the State of Michigan. The Michigan Geological Repository for Research and Education, an important departmental component, houses a variety of subsurface samples and data related to both hydrocarbon and water resources in the region. The Department of Geosciences is located in Kalamazoo, Michigan, with some research and teaching conducted at the WMU campus in Punta Gorda, Florida. Learn more about the Department of Geosciences at http://wmich.edu/geology/. Interested individuals are encouraged to meet departmental faculty at the forthcoming AGU Fall meeting.

Western Michigan University: Western Michigan University (WMU), located in Southwest Michigan, is a vibrant, nationally recognized student-centered research institution with an enrollment of nearly 25,000. WMU delivers high-quality undergraduate instruction, has a strong graduate division, and fosters significant research activities. The Carnegie Foundation for the Advancement of Teaching has placed WMU among the 76 public institutions in the nation designated as research universities with high research activities.

Salary: Competitive and commensurate with qualifications and experience, with an excellent benefits package,

Expected Start Date: July 1, 2018

Application Deadline: Review of applications will begin January 12, 2018 and continue until the position is filled.

Please visit wmich.edu/hr/jobs for detailed information and application procedures.

Required application documents: Faculty Credential Summary; a letter describing qualifications, accomplishments, and professional experiences related to the position, and comprehensive vita; names, titles, postal and e-mail addresses, and telephone numbers of three references.

WMU is an Equal Opportunity/Affirmative Action Employer. Minorities, women, veterans, individuals with disabilities, and all other qualified individuals are encouraged to apply.

Ocean Sciences

Assistant Professor of Ocean Engineering, University of Southern Mississippi

The University of Southern Mississippi (USM) Division of Marine Science (DMS) invites applications for two tenure-track positions in ocean engineering at the assistant professor level. This newly established Ocean Engineering baccalaureate program creates an opportunity to blend engineering approaches with DMS established expertise in marine and hydrographic sciences. These positions offer the successful candidates the possibility to contribute to the implementation and growth of our ocean engineering program. This program is expected to combine strengths in ocean sampling technologies, technology fabrication, and coastal hydrodynamics with innovative application of ocean engineering solutions. The Division of Marine Science (http://www.usm.edu/marine) is home to an interdisciplinary program of graduate and undergraduate study and research in marine systems. DMS offers Marine Science B.S., M.S., and Ph.D. degrees, and a Hydrographic Science M.S. Applicants must hold a Ph.D. in civil, environmental, or ocean engineering, or a related field, and have demonstrated research experience in ocean environment studies, through application of in situ, laboratory, and/or numerical modeling methodologies. Post-doctoral experience is desirable. Applicants should submit a letter of interest outlining their qualifications for the position, including a research plan, teaching philosophy with a curricular plan, a curriculum vitae, and names and contact information of at least four references. All application materials will be accepted online at https://jobs.usm.edu (#0004764). For inquiries about the position, contact Dr. Maarten Buijsman, chair of the search committee, at maarten.buijsman@usm.edu or 228.688.2385. Applicant review will begin February 1, 2018 and continue until the position is filled. The anticipated start date is August 2018.

Division Director, Division of Ocean Sciences, National Science Foundation (NSF, Alexandria, VA

NSF's Directorate for Geosciences (GEO) seeks candidates for the position of Division Director for the Division of Ocean Sciences (OCE). The OCE Division Director serves as a member of the GEO leadership team and as the Directorate's principal spokesperson in the area of ocean sciences research. The incumbent is responsible for the overall planning, management and commitment of budgeted funds for the Division, which includes the Ocean, Integrative Programs, and Marine Geosciences sections. The Division Director has managerial and oversight responsibilities for the effective use of division staff and resources in meeting organizational goals and objectives. Facility oversight and management are important aspects of the Division and thus experience with facilities is desired. The incumbent leads all activities of OCE, assessing the needs and trends in geosciences research and education, developing breakthrough opportunities, implementing overall strategic planning, and providing leadership on implementation of national ocean policy. The Division Director supervises and provides leadership and guidance to senior OCE staff (Section Heads), program officers, administrative and support personnel. The responsibilities of the Division Director include the coordination of activities with other relevant organizations within the Foundation, other Federal agencies, community organizations and international partners. Information about the Division's activities may be found at website: http://www.nsf.gov/geo/oce/about.jsp.

Appointment to this Senior Executive Service (SES) position may be on a Career or a one-to-three years SES limited-term appointment, with a salary range of $163,519 to $181,600. Alternatively, the incumbent may be assigned under the provisions of the Intergovernmental Personnel Act (IPA).

Announcement OCE-2018-0001, with position requirements and application procedures, is found on the USAJOB Home Page by the following link: https://www.usajobs.gov/GetJob/ViewDetails/483044800. If you have questions about the application process contact Sandra DeLeon at 703-292-2415 or email: execsrch@nsf.gov. Hearing impaired individuals may call TDD 703-292-8044.

NSF is an equal opportunity employer committed to employing a highly qualified staff reflecting the diversity of our nation.

Endowed Chair in the Division of Marine Science, University of Southern Mississippi

The University of Southern Mississippi (USM) is seeking applications for a newly-established Endowed Chair in its Division of Marine Science (DMS). The Division of Marine Science (http://www.usm.edu/marine) is home to an interdisciplinary program of graduate and undergraduate study and research in marine systems. This is a permanent, tenure track position for which we are seeking a candidate who can flourish within the multi-disciplinary environment of our department. The Division is located at the Stennis Space Center and benefits from close working relationships with a number of on-site federal agencies, including several of the Navy divisions, USGS and NOAA. Although candidates with accomplishments in biological oceanography or ocean technology will be given enhanced consideration, qualified candidates from other sub-disciplines of oceanography will also be considered. The successful candidate should demonstrate superior potential to contribute across Marine Science and promote the continued interdisciplinary growth of our academic and research programs.

Applicants should submit a letter of interest outlining their qualifications for the position, including a research plan, teaching philosophy with a curricular plan, a curriculum vitae, and names and contact information of at least four references. Salary packages will be nationally competitive and commensurate with experience. Applications must be submitted online at https://jobs.usm.edu (posting #0004769). For inquiries about the position, contact Vernon Asper, Chair of the Search Committee, at 1-228-688-3178 or vernon.asper@usm.edu. Review of applications will begin immediately and will continue until the position is filled, with an anticipated start date of August 2018.

Seismology

Hamilton Endowed Professor in Earth Sciences, Southern Methodist University

Position No. 06029. The Roy M. Huffington Department of Earth Sciences at SMU announces a search to fill a named tenure-track or tenured professorship (the rank is open) honoring WB Hamilton. We are seeking applicants with active research programs that are focused on nuclear test monitoring using array seismology, explosion and earthquake source studies, and/or infrasound, with experience in state-of-the art instrumentation and telemetry. The successful applicant will exhibit the ability to (1) maintain active research programs that involve national and international collaborators and to support those programs with external funds obtained from a diverse range of funding agencies, (2) oversee professional staff, and (3) mentor students at both the undergraduate and graduate level. The successful applicant will also have a commitment to full participation in the educational mission of the department, which is to provide professional training in the Earth sciences in a liberal arts environment. As the fourth holder of the chair, which was established in 1921, the successful candidate will extend existing departmental research strengths. These strengths include research on problems in the national interest such as natural hazards; earthquake seismology–including induced seismicity; nuclear test ban monitoring; and natural resources–including geothermal energy. The expected start date is August 1, 2018. Applications can be submitted electronically to: https://apply.interfolio.com/47665 Applicants should include curriculum vitae, statements of research and teaching interests, and contact information for three references. To insure full consideration applications must be received by January 15, 2018, but the committee will continue to accept applications until the position is filled. The committee will notify applicants of its decisions after the position is filled.

Southern Methodist University will not discriminate in any program or activity on the basis of race, color, religion, national origin, sex, age, disability, genetic information, veteran status, sexual orientation, or gender identity and expression. The Executive Director for Access and Equity/Title IX Coordinator is designated to handle inquiries regarding nondiscrimination policies and may be reached at the Perkins Administration Building, Room 204, 6425 Boaz Lane, Dallas, TX 75205, 214-768-3601, accessequity@smu.edu.

Hiring is contingent upon the satisfactory completion of a background check.

Volcanology, Geochemistry, and Petrology

Electron Microprobe Operator/ Laboratory Manager, University of Oklahoma

The Office of the Vice President of Research supports an electron microanalysis laboratory built around a Cameca SX100 microprobe as a core research facility of the University (https://ors.ou.edu/Microprobe/OUEMPLHome.html). This includes a fully funded, fullt-time staff position as Electron Microprobe Operator/Laboratory Manager with a starting salary of $55K-$60K. This position is open until filled.

Duties include daily operation of the microprobe and sample preparation for all clients, daily lab maintenance, periodic instrument maintenance (filament, roughing vacuum, etc.), coordinating major service with Cameca engineers, scheduling and bookkeeping of usage by clients, billing and payments, and an annual summary report of laboratory activity. The appointment permits the operator to utilize the electron microprobe for research and personal use. Adjunct professor status and teaching opportunities in the School of Geology & Geophysics are possible for individuals who hold a Ph.D.

Qualifications for the position include (1) a Master's or Ph.D. degree in geosciences or relevant discipline, (2) experience with designing analytical procedures for quantitative EMPA, (3) knowledge of the chemistry of major and minor elements in common rock-forming minerals, and (4) experience with EMP operation including basic maintenance.

Applicants must submit an ONLINE application at https://jobs.ou.edu for requisition number 173902. Computers and personal assistance are available at the Office of Human Resources, 905 Asp, Rm.205, Norman, OK 73069.

The University of Oklahoma is an Affirmative Action, Equal Opportunity Employer. Women and minorities are encouraged to apply. Protected veterans and individuals with disabilities are encouraged to apply.

Postcards from the Field

Ironing out the Arctic carbon cycle!

To understand the role of iron in the Arctic carbon cycle, the Cory Lab extensively sampled iron-rich surface waters in the Alaskan Arctic. Here I am taking such a sample.

Acidic, iron-rich seeps draining from the Brooks Range bring reduced iron downstream into river valleys. In rivers, most of the iron is oxidized and precipitates out as iron (oxy)hydroxides.

Iron (oxy)hydroxides give the river and surrounding rocks and soils the orange-red color seen in the picture. During storm events, the precipitated iron is transported downstream out of the valleys onto the Arctic plains, where the iron is reduced again by microbes. Upon reoxidation, the reduced iron in the Arctic soils and soil waters produces reactive oxygen species that might be important in oxidizing organic carbon present in Arctic soils and soil waters.

—Adrianna Trusiak, University of Michigan, Ann Arbor

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

ESSOAr β

Earth and Space Science Open Archive

A New Earth and Space Science Open Community Preprint Server

It will be free to post and free to read preprints, posters, and conference presentations in 2018

ESSOAr will enable:

- Faster dissemination of science
- Increased discoverability of research
- DOIs for submitted content
- Links to final manuscripts

Empowered by:

AGU 100 ADVANCING EARTH AND SPACE SCIENCE

Atypon

Advisory Board Members*:
American Geophysical Union
American Geosciences Institute
American Meteorological Society
Association for the Sciences of Limnology and Oceanography
Earth Science Information Partners
European Geosciences Union
Geochemical Society
Geological Society of America
Japan Geoscience Union
Society of Exploration Geophysicists

Learn more at **essoar.org**

*as of 1 December 2017

ADVANCING EARTH AND SPACE SCIENCE

AGU: Founded in 1919

centennial.agu.org

#AGU100