VOL. 97 • NO. 20 • 15 OCT 2016

EOS

Earth & Space Science News

Pacific Rainfall Data Void

New Digital Maps of Alaska

Engaging in the Fight Against Harassment

THE GEOMAGNETIC BLITZ OF 1941

AGU American Geophysical Union

NEW in Fall 2016

GeoHealth

AN OPEN ACCESS AGU JOURNAL

GeoHealth will foster the intersection of Earth science disciplines (Earth processes, climate change, atmospheric and ocean sciences, hydrology, among others), with those of the health sciences, defined broadly (environmental and ecosystem health and services, human and agricultural health, geomedicine, and the impact of natural hazards).

Now Accepting Applications for Two Editors in Chief of *GeoHealth*

AGU is launching *GeoHealth* under Founding Editor Rita R. Colwell. We are seeking applications for two dynamic, well-organized scientists with high editorial standards and strong leadership skills to serve 4-year terms as the editors in chief (EICs) to lead this exciting journal starting in 2017 and beyond. One editor's main area of focus will be on the geosciences, while the other editor's main area of focus will be on health.

This is an important opportunity to help shape and lead this increasingly important, cross-cutting discipline. The EICs will be the principal architects of the scientific content of the journal. They are active scientists, well-known and well-regarded in their respective discipline. The EICs must be active in soliciting the best science from the best scientists to be published in the journal. Working with the other editors and AGU staff, EICs are the arbiter of the content of the journal. Among other functions, EICs will be responsible for:

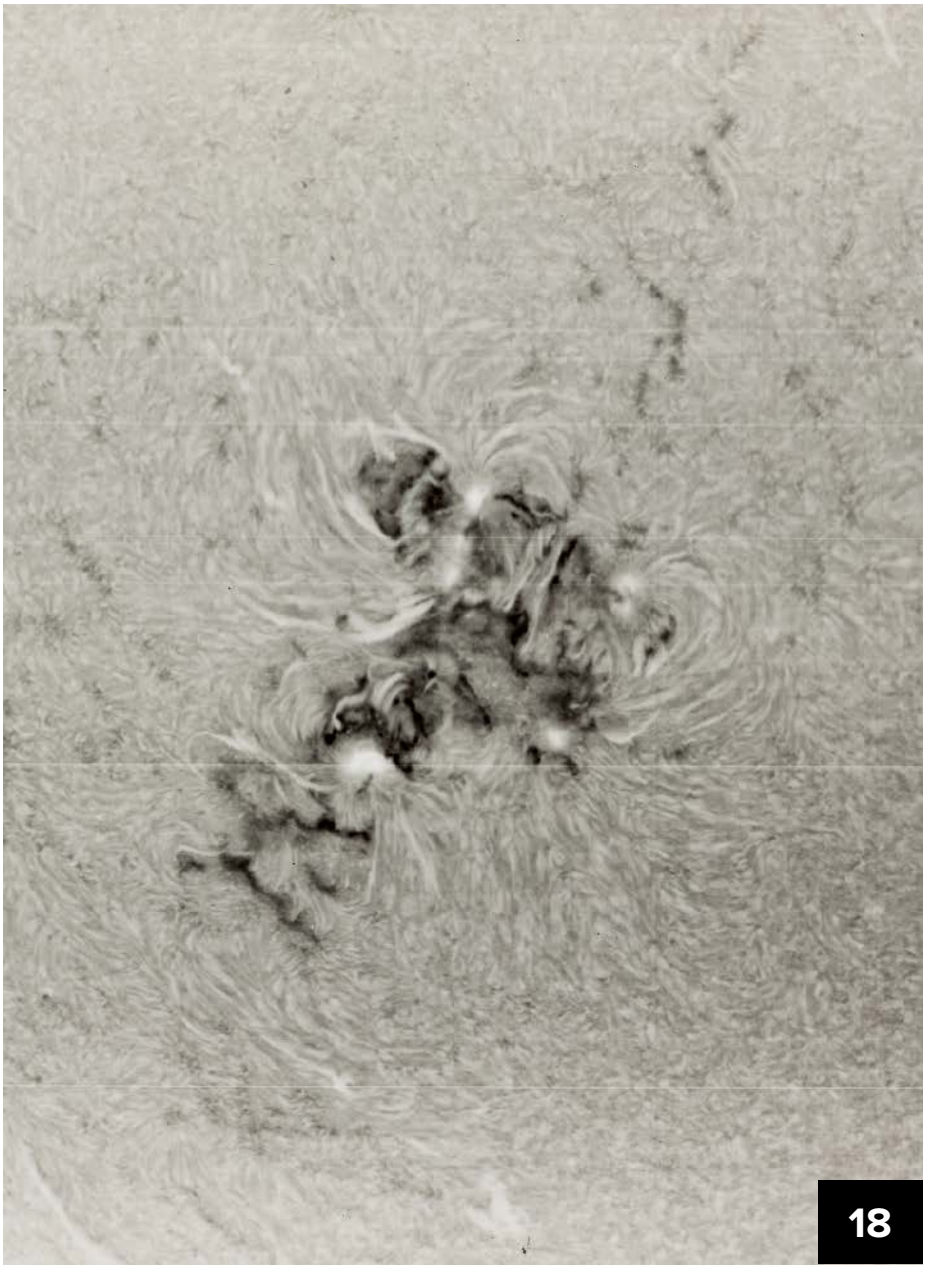
- **Acting as an ambassador to the author/editor/reviewer/scientist community.**
- **Setting the strategy for the journal.**
- **Leading the editor selection process.**
- **Assigning and balancing review work load.**
- **Making decisions related to scientific ethics.**
- **Reviewing and contributing to periodic monitoring reports.**
- **Conducting and attending meetings.**

If you would like to be considered for one of the Editor in Chief positions of *GeoHealth,* send your curriculum vitae with a letter of interest via email to pubmatters@agu.org. If you would like to nominate a highly qualified colleague, send a letter of recommendation to the same email address. **Please make sure that you specify *GeoHealth* in the subject line of the email.**

geohealth.agu.org

AGU PUBLICATIONS

15 OCTOBER 2016
VOLUME 97, ISSUE 20



COVER

The Geomagnetic Blitz of 1941

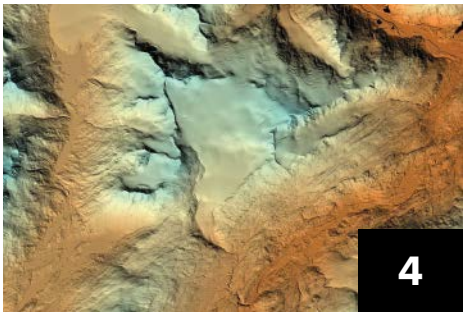
Seventy-five years ago, a massive geomagnetic storm disrupted electrical power, interrupted radio broadcasts, and illuminated the night sky in a World War II battle theater.

PROJECT UPDATE

Closing the Pacific Rainfall Data Void

A new climatology tool uses satellite data to map precipitation in a data-sparse region of the Pacific Ocean.

NEWS



New Digital Maps Depict Alaska in Unprecedented Detail

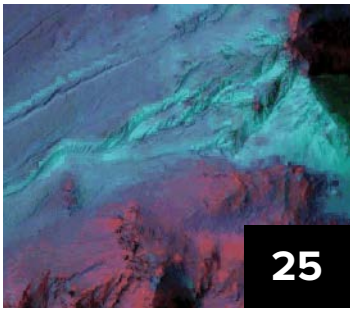
An improved understanding of climate change impacts is expected from enhanced terrain models.

RESEARCH SPOTLIGHT

27 Melting Ice Could Reveal Toxic Cold War Era Waste in Greenland

Political disputes could arise as countries assess who's responsible for the cleanup of the Cold War relics.

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
Wendy S. Gordon, Ecologia Consulting, Austin, Texas, USA; wendy@ecologiaconsulting.com
Carol A. Stein, Department of Earth and Environmental Sciences, University of Illinois at Chicago, Chicago, Ill., USA; cstein@uic.edu
José D. Fuentes, Department of Meteorology, Pennsylvania State University, University Park, Pa., USA; juf15@meteo.psu.edu
David Halpern, Jet Propulsion Laboratory, Pasadena, Calif., USA; davidhalpern29@gmail.com

Editorial Advisory Board
Mark G. Flanner, Atmospheric Sciences
Nicola J. Fox, Space Physics and Aeronomy
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
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
Michael A. Mischna, Planetary 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 Jacobsen, Production and Editorial Assistant; Yael Fitzpatrick, Manager, Design and Branding; Travis Frazier and Valerie Friedman, Electronic Graphics Specialists
Editorial: Peter L. Weiss, Manager/Senior News Editor; Mohi Kumar, Scientific Content Editor; Randy Showstack, Senior News Writer; JoAnna Wendel, News Writer; Liz Castenson, Editorial and Production Coordinator
Marketing: Jamie R. Liu, Manager, Marketing; Angelo Bouselli and Tyjen Conley, Marketing Program Managers
Advertising: Jeff Borchardt, Development Director; Tel: +1-202-777-7536; Email: advertising@agu.org

Eos (ISSN 0096-3941) is published semi-monthly, on the 1st and 15th of the month 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.

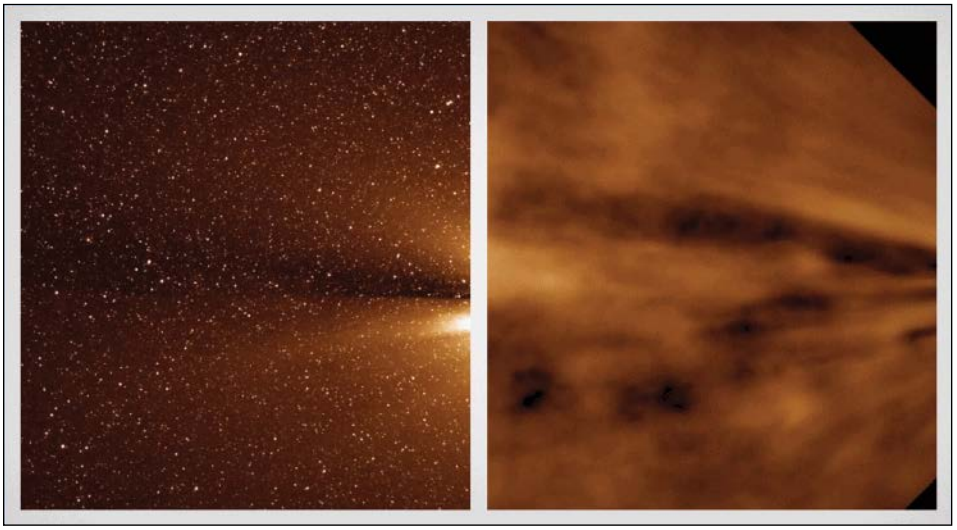
Member Service Center: 8:00 a.m.–6:00 p.m. Eastern time; Tel: +1-202-462-6900; Fax: +1-202-328-0566; Tel. orders in U.S.: 1-800-966-2481; Email: service@agu.org.

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

Christine W. McEntee, Executive Director/CEO

AGU American Geophysical Union

Scientists Get First Glimpse of Solar Wind as It Forms



NASA/STEREO, data from Craig DeForest, SwRI

Two views of the solar wind: STEREO's images (left) before computer processing and (right) after processing. Scientists used an algorithm to dim the light coming from the background star field.

What does solar wind look like when it first forms from the Sun's corona? Now, with new satellite images manipulated to remove background light, scientists can answer that question.

"This is part of the last major connection we need to make to understand how [the Sun] influences the environment around the Earth," Craig DeForest, an astrophysicist at the Southwest Research Institute in Boulder, Colo., told *Eos*. DeForest is the lead author on a recent paper describing the novel technique, published last month in the *Astrophysical Journal* (http://bit.ly/ApJ-Solar-Wind).

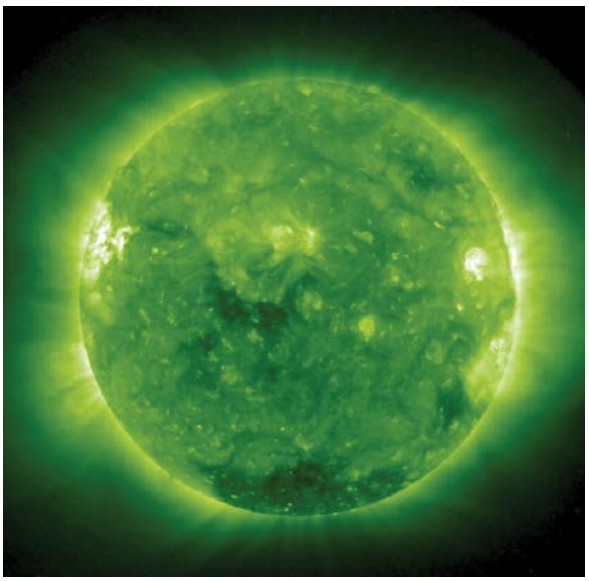
A Tricky Search

Back in the 1960s, scientists discovered the solar wind, a constant flow from the Sun of extremely high temperature plasma that's so hot the Sun's gravity can't hold it. Scientists knew that the solar wind was somehow connected to the Sun's corona—the bright layer of the Sun's atmosphere that can be seen during a solar eclipse—but until now, scientists weren't sure how one transitioned into the other.

This transition is important because "we're trying to understand, among other things, why the solar wind near the Earth is variable and gusty," DeForest said. This gustiness can affect things like the trajectory of coronal mass ejections—huge magnetic explosions from the Sun that, when they hit Earth, can knock out telecommunications, short out satellite circuitry, and damage electrical transmission lines.

But studying the transition between the corona and the solar wind is difficult because the solar wind is very faint against a background full of stars and interplanetary dust, DeForest said, making it hard to discern exactly what is happening as the solar wind gets created.

When scientists looked at previous images and "saw the [corona] fade, it was difficult to tell whether it was fading in an absolute sense or dropping below stellar background," DeForest continued.



NASA/STEREO

An extreme ultraviolet light image of the Sun and its corona. Here the solar wind is very faint against a background of stars and interplanetary dust.

> "We're trying to understand, among other things, why the solar wind near the Earth is variable and gusty."

Unfixing the View

With computer-processed images from NASA's Solar Terrestrial Relations Observatory (STEREO), the scientists have finally observed this transition. The processing removed objects of "fixed brightness," DeForest said, like the dust cloud that fills the inner solar system and the background stars themselves. That left the moving and variable features of the solar wind itself.

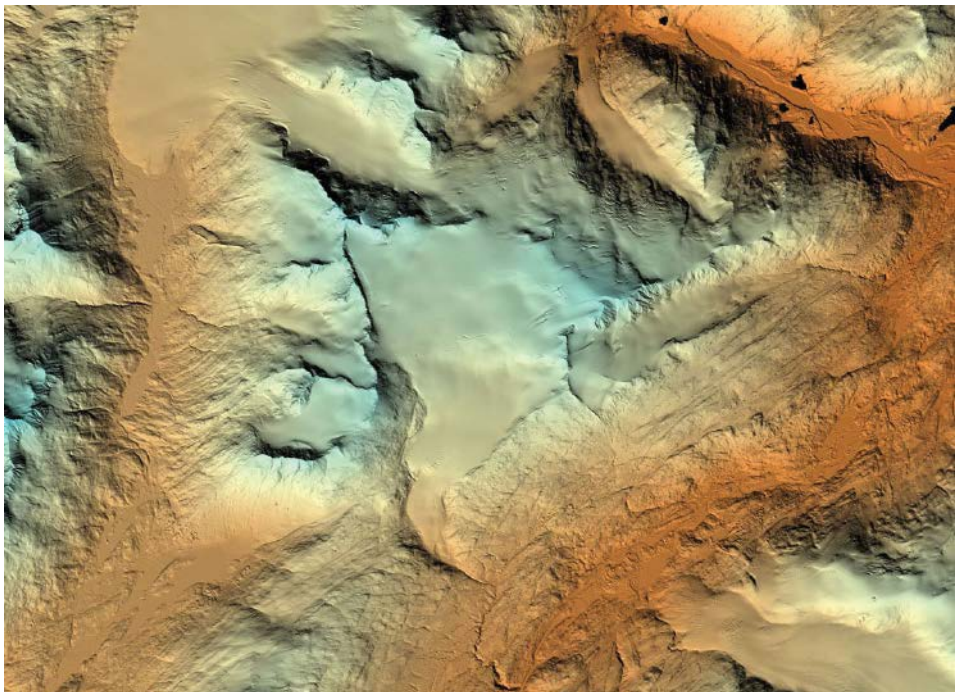
Scientists already knew that masses of particles in the corona are controlled by magnetic fields, which gives the Sun its "rays"—similar to those in a child's drawing, DeForest said. The new images revealed the farthest reaches of the magnetically controlled corona, showing that once the material travels about a third of the distance from the Sun to the Earth, the magnetic fields weaken enough that solar wind particles can disperse from the field lines and fan out more like an Earthly wind.

According to NASA, the solar wind transforms from rays to dispersed particles in a manner analogous to the way water from a water gun or hose breaks up into a spray: Closer to the water gun, the water is one mass, but as it moves farther from the gun, it disperses into many individual droplets.

Investigating the solar wind transition region will help scientists predict the arrival and strength of the Sun's outbursts—Earth-bound coronal mass ejections—after they pass through a full astronomical unit of the existing solar wind, DeForest said.

By **JoAnna Wendel,** Staff Writer

New Digital Maps Depict Alaska in Unprecedented Detail



NSF/NGA

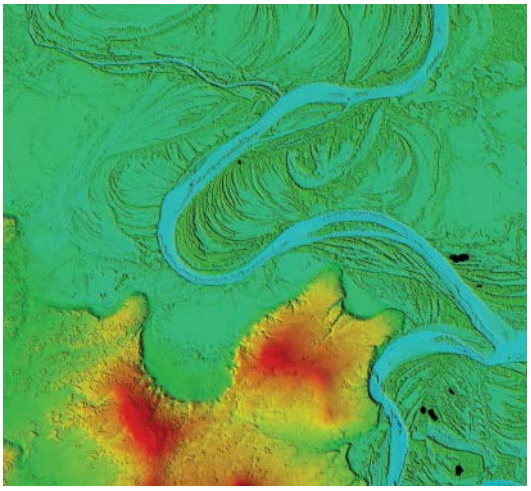
Wolverine Glacier in the coastal mountains of south central Alaska's Kenai Peninsula.

Recently unveiled high-resolution digital topographic maps of Alaska display, more sharply than ever before, the state's landscape. The images will help with decision making and provide a better understanding of the impacts of climate change, according to U.S. government officials.

The unclassified three-dimensional (3-D) digital elevation models (DEMs), which the U.S. National Geospatial-Intelligence Agency (NGA) and the National Science Foundation (NSF) released early last month, provide at least 2-meter resolution throughout the state. On 28 September, the agencies released the same sort of elevation model, but at lower, 8-meter resolution, for the entire Arctic.

According to a White House announcement of the Arctic model's release, NGA and NSF will come out with an even better digital rendering of land throughout the Arctic—at 4 times greater, 2-meter resolution—within a year.

To construct the new Alaska topographic models, image-processing algorithms converted stereo pairs of 2-meter-resolution imagery, captured by DigitalGlobe commercial satellites, into 3-D imagery, according to NSF. The agency noted that satellites can reimage even remote areas within shorter time intervals and at lower cost than aircraft. "In a changing Arctic, [the ability to capture new imagery more frequently] is huge," said Kelly Falkner, director of NSF's Division of Polar Programs.



NSF/NGA

The winding Koyukuk River in western Alaska is a 684-kilometer-long tributary of the Yukon River. The digital elevation models show, in greater detail than ever before, the unique boreal forest vegetation patterns in the river region.

Congressional Thumbs Up

Fabien Laurier, senior policy adviser with the White House Office of Science and Technology Policy, told *Eos* that the new Alaska models provide 15 times higher resolution than 30-meter-resolution models, which until now were the best publicly available for the state. By providing 2-meter resolution, he noted, the new models depict Alaska's terrain about as sharply as 1- to 2-meter-resolution models already available for most U.S. states and much of the industrial world.

That pleases Sen. Lisa Murkowski (R-Alaska), who told *Eos* that "Alaska and the Arctic are woefully left behind when it comes to mapping and charting across the board, so any progress is important to ensure the safety and well-being of our state. Although there is still a mountain of work to be done, I applaud the efforts of the NGA and NSF and look forward to their upcoming releases in 2017."

Game Changers

The models are "game changers," according to John Farrell, executive director of the U.S. Arctic Research Commission: "They can be used for a whole slew of purposes, from better understanding landscape evolution to just even simple navigation." The new tools can provide local communities with "science-based actionable knowledge" that could improve their resilience in the face of climate change and its impacts, Laurier added.

The terrain modeling of Alaska and the Arctic is creating an archive of high-resolution imagery of the region at a critical time, said Tom Heinrichs, director of the Geographic Information Network of Alaska at the University of Alaska Fairbanks. "Both the DEM itself and the source stereo-pair imagery will be invaluable to future scientists seeking a snapshot of the Arctic during the onset of a period of major global climate change," he predicted.

A public-private partnership—including NSF, NGA, the University of Minnesota's Polar Geospatial Center, the U.S. Geological Survey, the Environmental Systems Research Institute, Inc., and others—is carrying out the modeling project in response to a 2015 White House executive order, "Enhancing Coordination of National Efforts in the Arctic" (http://bit.ly/exec-order-arctic).

By **Randy Showstack,** Staff Writer

Caverns Hold Clues to Past Megadroughts

To better understand the past and future of California drought, some scientists are heading underground.

Jessica Oster, a geochemist at Vanderbilt University in Nashville, Tenn., wants to create a high-resolution profile of the climate of the western United States, including precipitation and temperature data, throughout the Holocene to better understand the region's history of megadroughts—droughts that last decades to centuries.

"There is evidence of a period of megadroughts in the paleoclimatic record of the western U.S., but the atmospheric drivers that caused them are a puzzle," Oster said.

This evidence comes from tree rings and lake deposits, which serve as good proxy records of past climate. But data from thinly layered, slowly growing cave formations are more highly resolved in time because they grow from dripping water, Oster told *Eos*.

Drip Record

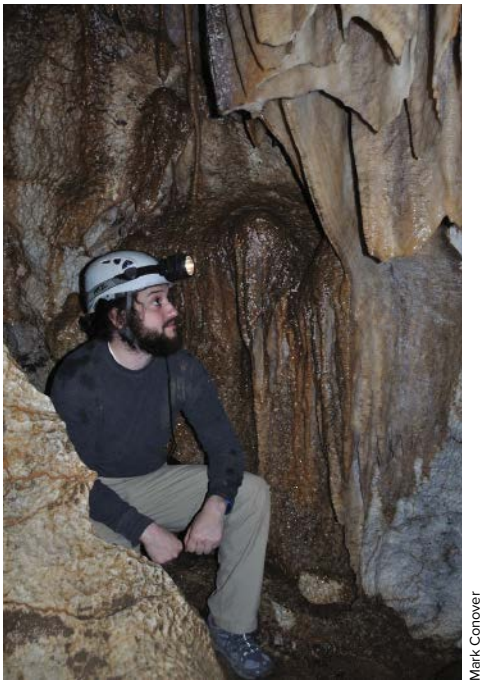
When the water drips into the cave, it evaporates, leaving minerals behind to form cones that rise from the cave's floor or hang from its ceiling. In layers only millimeters to centimeters thick, cave formations can hold a record of climate from as long as 500,000 years in the past on seasonal or annual timescales, Oster said. In addition, different formations might record different periods with some overlapping years, giving scientists more opportunities to confirm their findings.

The cave formations also provide a more complete environmental picture. Rainwater not only contains the characteristic isotope makeup revealing where on the globe the water came from but also records information about the vegetation above the cave from carbon isotopes it collects as it seeps down through the ground.

All over the world, scientists study cave formations to reconstruct ancient climates. In China last year, scientists found ancient inscriptions in Dayu Cave describing periods of extreme drought. By studying Dayu Cave's stalagmites and stalactites, the researchers were able to confirm that these droughts really happened.

Jessica Blois

Cave formations inside White Moon Cave near Santa Cruz, Calif. Studying the formations may help scientists better understand California's drought history.



Mark Conover

A former student of Jessica Oster peers at White Moon Cave's delicate formations.

Learning from the Past

Over the next 5 years, Oster and her colleagues and students will analyze cave formation samples from California's White Moon Cave, near Santa Cruz, and Lake Shasta Caverns in northern California. They will coax out ancient tales of cold and hot, dry and wet climates reaching back as far as 33,000 years, using ratios of elemental isotopes left behind in the mineral layers. Adding these data to already existing research on other caves in Oregon and the Sierra Nevada, Oster will have the data she needs to study the western United States, she told *Eos*.

Because every cave is different, the researchers also set up weather stations and collect samples of precipitation to study how each cave's formations translate what's happening above ground. For instance, water from storms originating in the northern Pacific contains different isotopic signatures than that from the tropical Pacific.

With reconstructions of the western U.S. paleoclimate, researchers can run climate model simulations that they can test against the proxy records for ancient climate patterns that they expect to glean from the caves. This comparison will help them better understand the region's drought history, which in turn will help them understand the drought future of the western United States, Oster said.

By **JoAnna Wendel,** Staff Writer

Atmospheric Chemists Should Tackle Risks to Society, Report Says

The field of atmospheric chemistry should improve its predictive capability to better anticipate and help people prepare for potential environmental and human health challenges, a recently released report urges. This and other steps recommended by a committee of the U.S. National Academy of Sciences (NAS) could help to reduce air quality risks related to multiple factors.

Those factors include—among others—increasing energy demands, intensifying industrial and agricultural activities, and a growing and more urbanized population, according to the report, which is entitled *The Future of Atmospheric Chemistry Research* (see http://bit.ly/NAS-Atmos-Chem) and was released on 25 August.

"The future challenges for atmospheric chemistry involve nothing less than the health of the planet's climate, the health of ecosystems, and the health of humans everywhere," the report states. Atmospheric chemistry research has a history of helping with societal challenges, including contributing to guiding policies that have cut urban smog, acid rain, and chemicals implicated in depleting stratospheric ozone, the committee states.

The report calls for a broad research program in atmospheric chemistry and identifies five priority areas of research to help guide the field over the next decade—a period during which the committee anticipates flat federal funding. Although the field of atmospheric chemistry has expanded over the past several decades, "the amount of funding for research in the field has not increased substantially," the report notes.

At a 25 August briefing about the report, committee cochair Barbara Finlayson-Pitts said that even assuming a flat budget, creative proposals from the atmospheric chemistry community could continue to move the field forward.

Finlayson-Pitts, a professor of chemistry at the University of California, Irvine, said that an overall goal is that by about 2030 "we could predict accurately what will happen if we change anything that impacts the atmosphere." She said that would include natural and anthropogenic emissions and their spatial and temporal distributions, temperature, and relative humidity.

She elaborated that if atmospheric chemists "could predict what is going to happen and what would change if we change [those] inputs in various ways, that would be the goal."

Finlayson-Pitts told *Eos* that a bigger budget would not change the committee's recommendations, "but it would get us to that predictive capability much faster."

"Given how fast the atmosphere is changing, with climate change and a changing population and so on, it is going to be hard to stay ahead of the curve. So the faster we can do this, the better off we are going to be in terms of avoiding the worst impacts of a lot of these issues in times to come," she said.

Science Goals for the Next Decade

The report focuses on two priority science areas for advancing fundamental atmospheric chemistry. For one, the report calls for developing a more robust predictive capability to understand the distributions, reactions, and lifetimes of gases and particles. For the other, it recommends quantifying emissions and the

Leo Fung, CC BY 2.0 (http://bit.ly/ccby2-0)

Emissions pour into the air from smokestacks in Chongquing, China. A 25 August report points to some urgent challenges for the field of atmospheric chemistry to address more fully, including air pollution.

deposition of gases and particles in a changing Earth system.

Another three areas highlighted by the report would help the field meet societal challenges by improving climate modeling and weather forecasting, clarifying the role of atmospheric chemistry in human health impacts, and understanding atmospheric chemistry feedbacks in natural and managed ecosystems.

The report points to some urgent current challenges related to atmospheric chemistry, including air pollution, which causes one out of eight deaths globally, according to the World Health Organization. Climate change and the evolving mix of energy sources also pose pressing challenges to human health and the environment, according to the report.

Dual Role of Atmospheric Research

Atmospheric chemistry research encompasses basic and applied research, which the report refers to as a dual role. The report notes that "on the one hand [atmospheric chemistry's role is] to observe, learn, and discover for the sake of fundamentally understanding the Earth system and the underlying chemical, physical and biological processes." But the field must also fulfill another role, the report adds, "to advance research to address those challenges that directly affect society. Atmospheric chemistry research alone cannot solve these major problems, but it is also true that they cannot be solved without it."

The report, sponsored by the U.S. National Science Foundation (NSF), also recommends a series of infrastructure goals. These call for NSF to ensure the development of tools to accomplish science goals, take the lead in coordinating with other agencies to co-develop long-term research sites, and better utilize past and current data sets.

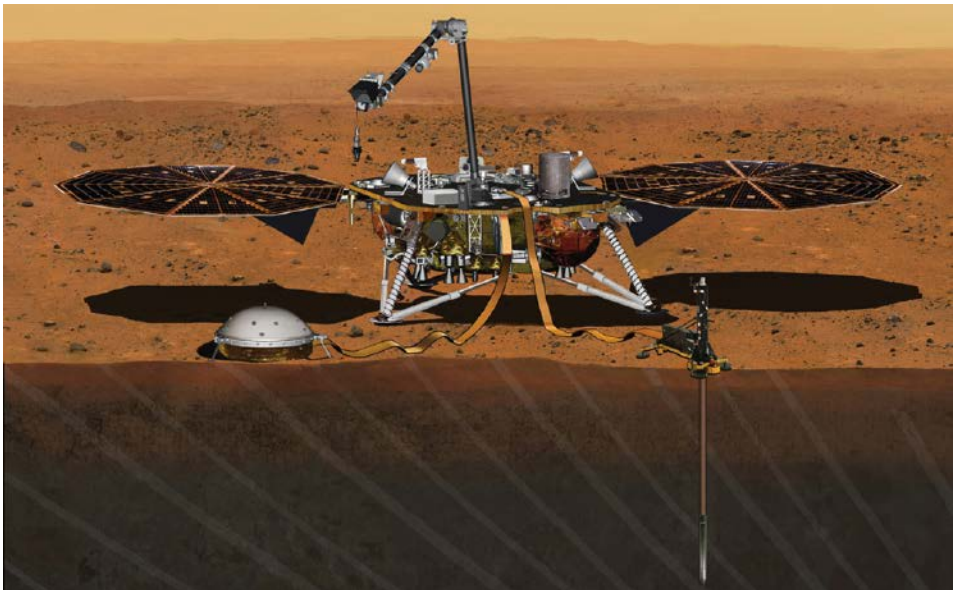
Agency Response

Sylvia Edgerton, program director for NSF's atmospheric chemistry program, told *Eos* that the committee did a good job in making recommendations while recognizing a flat budget. She said that one reason she wanted NSF to support the report was to get more visibility for the field. "People don't recognize the importance" of atmospheric chemistry, she said.

At the briefing, Finlayson-Pitts said that atmospheric chemistry "has a very impressive track record in solving problems that really affect human health and welfare, and we believe that it has a very bright and impactful future ahead."

By **Randy Showstack,** Staff Writer

Launch Approved for Next Mars Mission



NASA/JPL-Caltech

An artist's concept depicts NASA's new Mars lander, InSight, which in late 2018 will study the inner workings of the Red Planet with a seismometer and a heat probe that penetrates the ground.

NASA's Science Mission Directorate has approved the 5 May 2018 launch of the agency's next Mars mission, a lander called InSight (Interior Exploration using Seismic Investigations, Geodesy and Heat Transport). By November of that year, scientists can expect to begin using InSight to study the deep interior of the Red Planet.

"Mars is the place" to study seismic activity on another planet, James Green, Planetary Sciences Division director at NASA, told *Eos*. NASA's Viking landers had instruments to take seismic measurements, but because they weren't well seated onto Mars's surface, the measurements didn't quite work, Green said. With InSight, "this is really the first time we're going to get high-quality seismic data of a terrestrial-sized planet," he continued.

"Our robotic scientific explorers such as InSight are paving the way toward an ambitious journey to send humans to the Red Planet," said Geoff Yoder, acting associate administrator for NASA's Science Mission Directorate, in Washington, D. C. "It's gratifying that we are moving forward with this important mission to help us better understand the origins of Mars and all the rocky planets, including Earth."

"We expect Mars to tell us then if it's an active planet or not—so is it shaking? Are there Mars-quakes?" Green said. With the Mars Reconnaissance Orbiter's High Resolution Imaging Science Experiment instrument, scientists have observed avalanches on Mars. So something's shaking, Green said, and he is optimistic that NASA will get "fabulous data right off the bat."

Originally set to launch in March of this year, the $675 million project was delayed due to a vacuum leak in its primary instrument, the Seismic Experiment for Interior Structure. The instrument is designed to measure ground movements as small as half the radius of a hydrogen atom, and it needs perfect seals around its main sensors, which operate in a vacuum. With this instrument, mission scientists can study any potential seismic activity on the planet to help prepare for crewed exploration.

NASA's Jet Propulsion Laboratory has been tasked with redesigning the instrument. France's space agency, the Centre National d'Études Spatiales (CNES), will aid in developing sensors for the new instrument.

The delay, which will cost an extra $153 million, will not cancel or delay any current missions, NASA reported.

By **JoAnna Wendel,** Staff Writer

John A. Knauss (1925–2015)

John A. Knauss

John A. Knauss, physical oceanographer of the equatorial oceans and founder of University of Rhode Island's (URI) Graduate School of Oceanography (GSO), died on 19 November 2015 in Saunderstown, R.I. He was 90.

Knauss played a key role in the development of many of the iconic programs and institutions that are part of oceanography today. From heading the U.S. National Oceanic and Atmospheric Administration (NOAA; 1989–1993), to serving as AGU's president (1998–2000), to helping found the National Sea Grant Program, to serving as a delegate to the United Nations Convention on the Law of the Sea (UNCLOS), Knauss fiercely supported oceanography and marine policy.

Early Life, Education, and Military Service

Knauss, born in Detroit, Mich., on 1 September 1925, was not initially trained as an oceanographer. He studied meteorology at the Massachusetts Institute of Technology through the U.S. Navy's V-12 program, earning a B.S. in 1946.

As was common at the time, Knauss's early work was intertwined with military service. He became an ensign in the U.S. Navy and served as a weather forecaster for the San Diego area, based out of Naval Air Station North Island.

After his service commitments ended, Knauss became a physicist with the Navy Electronics Laboratory in San Diego. He later studied physics at the University of Michigan, where he received his M.S. in 1949.

Work at ONR and Scripps

After earning his master's degree, Knauss started working in Washington, D. C., in the recently founded Office of Naval Research (ONR). There he helped disburse federal funds to oceanographers. He interacted regularly with Roger Revelle, who inspired Knauss to pursue oceanography as a career.

Knauss left ONR for the Scripps Institution of Oceanography (SIO) to study with Revelle, who had, by 1950, returned to La Jolla to be the institution's director. Knauss focused his research on the equatorial Pacific undercurrent, also known as the Cromwell Current, and was the first scientist to fully characterize it. He found that the undercurrent is a major component of Pacific Ocean circulation. He also discovered a similar current in the Indian Ocean.

In 1959, after an interruption in his studies to once again work with the Navy at ONR, he received a Ph.D. in oceanography from SIO.

> In 1962, the University of Rhode Island recruited Knauss to be the founding dean of its Graduate School of Oceanography.

Founding GSO

In 1962, URI recruited Knauss to be the founding dean of GSO, a new oceanographic institution 6 miles away from the main campus, on Narragansett Bay.

Working with SIO, Knauss acquired a mothballed 180-foot, 1000-ton World War II Army vessel for $500 through the federal government's educational surplus program. Renamed the R/V *Trident*, the vessel provided a research platform from which GSO faculty and students studied oceanography across the world for 15 years.

As dean, Knauss also oversaw the acquisition in 1977 of the R/V *Endeavor*, which is owned by the National Science Foundation. *Endeavor* will celebrate its fortieth year as an active research vessel next year.

A Focus on Marine Affairs

Knauss served as URI's provost for marine affairs (1969–1982) and vice president of marine programs (1982–1987). Throughout his career at URI, he never lost sight of the great potential of GSO to help foster marine programs at the main campus. Through his leadership, marine studies became an important university-wide theme.

For example, Knauss helped found the Department of Geography and Marine Affairs at URI—the first marine affairs degree program in the country. He also helped establish the first ocean engineering department in the United States, as well as a resource economics department with a strong marine focus. He even helped to transform URI's Animal Sciences Department into the Department of Fisheries, Animal, and Veterinary Sciences.

He retired from URI in 1990 and served in an emeritus capacity until his death.

Advancing National and Global Marine Initiatives

Knauss had a close relationship with Rhode Island's senior senator, Claiborne Pell, who crafted legislation encouraged by Knauss and Athelstan Spilhaus to create the National Sea Grant Program. The National Sea Grant College Program and Act was passed in 1966. In recognition of Knauss's leadership role in its development, the National Sea Grant Program established, in 1979, the John A. Knauss Marine Policy Fellowship, allowing recent graduates to work on Capitol Hill.

Knauss was appointed by President Lyndon Johnson to be the only academic oceanographer on the influential Commission on Marine Science, Engineering and Resources, better known as the Stratton Commission. The commission produced a report, *Our Nation and the Sea: A Plan for National Action*, in 1969 (see http://bit.ly/NOAAStratton).

The report examined how the United States could better utilize oceans and gave recommendations on the infrastructure the nation needed to achieve this goal. On the basis of this report, Congress created NOAA and passed the Coastal Zone Management Act. The National Sea Grant Program became part of NOAA when the latter was established.

Fittingly, Knauss later became the leader of the agency he helped to create—he

URI

Knauss serving on a panel with colleagues at the first Sea Grant Conference, held in 1965 in Newport, R.I. The panel members are discussing possibilities and complications of Sea Grant from a university's point of view.

served as NOAA administrator from 1989 to 1993.

Knauss also thought it essential that oceanographers enjoy the freedom to carry out research on the high seas. He was appointed as a delegate to UNCLOS (1970–1982), where he helped to ensure that researchers could access continental margins beyond the 200-nautical-mile limit of exclusive economic zones.

Abundant Honors

Knauss received a number of awards and honors in recognition of his contributions, including AGU's Ocean Sciences Award and Waldo Smith Award, the National Sea Grant Award, and several awards conferred by URI. He was a fellow of the American Association for the Advancement of Science (AAAS), AGU, and the Marine Technology Society.

In addition to serving as president of AGU, he also served terms as president of AGU's Oceanography section. He held office as vice president of AAAS, president of the Association of Sea Grant Program Institutions, and chair of the University-National Oceanographic Laboratory System.

Knauss found the absurd delightful and was a member of the American Miscellaneous Society, formed "to see the lighter side of heavier problems." With co-members Art Maxwell and Gordon Lill, Knauss created the society's Albatross Award—given to scientists who make unusual contributions to oceanography.

The prize comes with a large stuffed albatross that Knauss supplied (after begging it from a curator at the Scripps Aquarium-Museum). Immediately after creating the award, the trio awarded it to themselves for their creativity. The albatross continues to be awarded and passed around today.

A Lasting Legacy

At the time of Knauss's retirement, GSO comprised 12 buildings across 165 acres and hosted the R/V *Endeavor*, a ship that has now registered more than 1 million nautical miles in support of science.

A GSO tribute to Knauss notes that "at the time of his death, the Dean and Director of the Scripps Institution of Oceanography, the Vice President and Dean of the Graduate Program at Woods Hole Oceanographic Institution and the Dean of the Graduate School of Oceanography are all alumni of the Graduate School of Oceanography and were graduate students with John Knauss as their dean" (see http://bit.ly/GSOKnauss). As John Farrington of the Woods Hole Oceanographic Institution put it at GSO's fiftieth anniversary celebration in 2011, Knauss was the "Dean of Deans of oceanographic institutions."

Knauss truly created a lasting legacy. His vision, his dedication to oceanography, and the many fruits of his labors will continue to inspire generations of oceanographers to come.

By **Margaret Leinen,** Scripps Institution of Oceanography, University of California, San Diego, La Jolla; email: mleinen@ucsd.edu; **Bruce Corliss,** Graduate School of Oceanography, University of Rhode Island, Narragansett; and **Robert A. Duce,** Department of Oceanography and Department of Atmospheric Sciences, Texas A&M University, College Station

Preparing to Face the Future of Agriculture in the United States

Third Annual Long-Term Agroecosystem Research (LTAR) Meeting
Venus, Florida, 22–26 February 2016

Providing a safe and plentiful food supply for a growing population poses a critical challenge to agriculture in the United States and around the globe. In the face of challenges that include population increase, changing climate, excess nutrients, and invasive species, the world will need more productive, sustainable, and profitable farming systems. These farming systems must meet future societal needs, as well as maintain biodiversity, mitigate or adapt to climate change, and improve the quality of air, soil, and water.

In 2013, the U.S. Department of Agriculture (USDA) established the Long-Term Agroecosystem Research (LTAR) network. This network consists of 16 Agriculture Research Service (ARS) and two non-ARS sites located in distinctive hydroclimatic environments. It responds to and prepares for these agricultural challenges and enables long-term, transdisciplinary science across farm resource regions in the conterminous United States.

A group of more than 80 scientists from the LTAR network convened at Florida's Archbold Biological Station in February for the network's third annual meeting. Attendees came to discuss and propose near-term analyses, core experiments, measurement protocols, data archiving, and instrument specifications for the network sites. They had expertise in water, climate, soil, crops, remote sensing, ecology, biogeochemistry, and soil microbiology.

The various working groups provided briefing updates at plenary sessions, and breakout group sessions allowed participants to discuss the status of the network's ongoing efforts and revise measurement and experiment plans for future research. The meeting also included field visits to Archbold's MacArthur Agro-ecology Research Center and the nearby University of Florida Range Cattle Research and Education Center.

The participants developed guidelines and selected statistical procedures to compare energetic and economic agroecosystem performance of a common experiment with two scenarios: business as usual and aspirational. The business-as-usual scenario is designed to provide baseline conditions for current production systems and management strategies. In contrast, the aspirational scenario seeks more sustainable agriculture while increasing production and reducing costs and on- and off-site environmental impacts.

Discussions on this common experiment included the size and number of experiment replicates, starting dates of experiments, instruments needed, sensor calibration, and data transfer. In addition, breakout discussions produced recommendations on how to make future observations from such experiments and from the LTAR network in general available on the Web, what common formats to use, what temporal aggregation to apply, and what quality control and quality assurance workflow to implement.

One major question emerged from the meeting discussions: What approach is best to characterize current and future conditions across agroecosystems that vary from rangelands to croplands? Although site-specific needs prevented participants from reaching complete agreement, attendees recognized that the participating scientists had to agree on protocols for analyses in order to obtain consistent multiscale assessments and to allow intersite comparisons.

The participants identified several next steps. One was establishing a collaborative Internet portal to share ideas and to foster continued dialogue. Another was starting a set of manuscripts to characterize water, carbon, and nutrient cycles; changes in precipitation and runoff; phenology (studying cyclic phenomena) and its link to productivity; and wind erosion across the LTAR network. The next annual LTAR meeting will be held in spring 2017 in El Reno, Okla.

Gerardo Armendariz/USDA

Long-Term Agroecosystem Research (LTAR) network sites are distributed across the farm resource regions of the United States.

By **Eleonora Demaria, David Goodrich,** and **Philip Heilman,** Southwest Watershed Research Center, Agricultural Research Center, U.S. Department of Agriculture, Tucson, Ariz.; email: eleonora.demaria@ars.usda.gov

Senior Scientists Must Engage in the Fight Against Harassment

iStock.com/cometary

It is unacceptable that many members of our science community experience harassment and discrimination, causing them to feel unsafe and unwelcome. To enact the needed changes within our culture, it is vital that all community members take action.

In particular, senior community members who have influence over policies and institutional environments can provide crucial leadership toward removing known harassers from positions of power, discouraging inappropriate behavior, and supporting victims.

Harassment: A Known "Secret" with Broad Reach

Over the past year, many cases of sexual harassment within professional settings have come to light in the media—including within science, technology, engineering, and math (STEM) fields. The cases that make it to the media are egregious and extend over years and multiple victims.

Often, the harassment was a known "secret," with rumors and warnings—the "whisper network"—extending deep into the community. Unsurprising yet tragic, the harassment is often allowed to continue.

For example, a well-known astronomy professor at the University of California, Berkeley (UC Berkeley), harassed women, with reported incidents extending back decades before any action was taken. Even then, it was only after victims and allies pointed out the milquetoast nature of the official institutional response that the professor retired from astronomy [*Ghorayshi,* 2015; *Witze,* 2015].

> Current practices allow the harasser to be passed between institutions before investigations can occur or conclude.

There are far too many other recent examples of harassment within academia. A few have been publicized in the national media, such as the astrophysicist at the California Institute of Technology [*Ghorayshi,* 2016], the molecular biologist at the University of Chicago [*Harmon,* 2016], and several more employees at UC Berkeley, including six faculty members [*Levin,* 2016; *Warnke,* 2016]. Many others are known only to those who are "fortunate" enough to receive warnings [*Kirkpatrick,* 2015].

Furthermore, many surveys have shown that academia is rife with harassment of all sorts—sexual or race-based harassment and discrimination against LGBTQ individuals or those with disabilities—causing various amounts and types of harm [e.g., *Atherton et al.*, 2016; *Bohannon*, 2013; *Rosenthal et al.*, 2016] (see also http://bit.ly/RicheySurvey).

A Broken Culture

This harassment occurs largely because our science community does not have a culture that sufficiently discourages those types of actions. Neither does it enforce policies to punish appropriately those who are found guilty and to protect those who can be harmed.

Harassers are able to continue harming members of our community because of systems that downplay or outright ignore complaints [*Kirkpatrick,* 2015; *Anonymous,* 2016]. What's more, current practices allow the harasser to be passed between institutions before investigations can occur or conclude, prompting some legislators to draft bills that would legally stop this [*Cornwall,* 2016].

In cases where punishment is actually administered, it is often inappropriately light and does not adequately enable the victims [*Smith and Freyd*, 2014] or other members of the community to feel comfortable with their environment. For example, faculty members at UC Berkeley have condemned the university's drawn-out handling of campus sexual harassment investigations that leave the accused on campus and in contact with students [*Warnke*, 2016]. At the California Institute of Technology, one victim elected to finish her doctoral degree elsewhere rather than remain at the institution where her harasser continued to be employed [*Ghorayshi*, 2016], although the harasser was originally put on a 9-month suspension that's now been extended an additional year [*Kingkade*, 2016].

Although some within our community are now openly recognizing the problems that were only whispered about before, we need more recognition of this issue, with people from all career levels involved and invested. Part of the reason this sort of harassment carries such power is that institutional, system-level policies often protect the powerful and the status quo—and thus, changes focused solely on what individuals can do within their daily interactions are not sufficient.

How Do We Change This Broken Culture?

Efforts for change cannot and should not rest primarily on the shoulders of those who have been or who fear becoming victims. Nor should efforts for change rely only on junior community members, who often do not have the necessary experience, information, or influence to determine what specific actions can be taken, particularly if harassment involves high-profile scientists.

For these reasons, it is crucial that the senior members of our community be informed and involved in these discussions. They interact with the largest spheres of our community and are often the most visible members and thus have a much larger influence in setting our community's culture and tone. In addition, they have the greatest ability to improve institutional policies and enforcement measures because of their greater influence and experience within those types of discussions.

Nine Steps That Senior Scientists Can Take to Actively Stop Harassment

Back in April, we and others informally circulated a letter within the astronomy, physics, and planetary science communities, calling on senior members of these communities to engage in these discussions and to take actions toward ending harassment.

In particular, the letter identifies nine types of actions that senior members can engage in that would disrupt the ability of serial harassers to continue damaging our community. These actions are meant to serve as guiding principles that will enact change. We hope they will provoke senior scientists to engage in deep personal thought and in community discussions toward identifying specific ways to change the cultures of their institutions.

Senior community members are called to do the following:

1. Do all you can to protect the victims of harassment.
2. Research and understand the problems regarding harassment and their solutions.
3. Instead of just working to do the minimum required by law, work to create the best possible environment for all.
4. Call out behavior that promotes harassment, even if it is not illegal; intervene to protect vulnerable members of the community.
5. Make sure your institution's and/or group's antiharassment policies are worded with clear definitions, reporting procedures, and consequences.
6. Take antiharassment policies seriously and enact the disciplinary actions that are a part of them.
7. Remove harassers from positions of power or venues where they can continue to harass, and do not allow them to just be passed between positions or institutions.
8. Stop collaborating with harassers and their enablers.
9. Stop appointing harassers and enablers to positions of power.

> Senior members of our community have the greatest ability to improve institutional policies and enforcement measures.

During the first month the letter was circulated, nearly 400 members of our community expressed support for this letter, with signatories spanning all career levels and a wide range of institutions. Already this letter has prompted discussions within several academic departments, pooling the perspectives and resources of students, postdocs, and faculty members into—one hopes—a careful and introspective examination of each department's policies, history, and culture.

This letter is still open for signatures, and we hope you will add your name to this effort (see http://bit.ly/FightHarassment). We ask all letter readers to talk to others about the issue of harassment and to identify the individual efforts in which they can engage. Our hope is that such action will enact changes at both the individual and institutional levels.

A Loss to STEM

Those who experience discrimination and harassment suffer in many ways. For example, post-traumatic stress disorder can result from sexual and racial harassment [see *Stockdale et al.*, 2009; *Williams*, 2015], and this decreases the energy and attention that victims can devote to their work. In addition, in efforts to avoid discrimination and harassment, a person may be forced to make a choice between personal safety and engagement with relevant scientific training, mentors, and/or collaborators [e.g., *McKinney et al.*, 1988]. Choosing personal safety, then, can also limit access to research facilities and participation in professional meetings [e.g., *Anonymous,* 2016].

Because of all of this, discrimination and harassment discourage and sometimes actively push people out of STEM endeavors. Although it is impossible to measure this loss, we can see it in the gradual decrease in the number of women and people of color as one moves up the career levels and in the anecdotal evidence of so many members of underrepresented groups who enter our fields with strong interests and desires and yet leave or contemplate leaving because of feeling unwelcome, unsupported, and/or overwhelmed by unnecessary and unfair obstacles [e.g., *Jahren,* 2016; *Williams et al.,* 2014].

We should find this unacceptable, as this means that people and ideas are being left out of our pursuit for knowledge. We should be disappointed in our community and our institutions that the passions and energies that could yield scientific contributions are being turned away and sent down other career paths.

Redefining What's Acceptable

Grassroots efforts to combat harassment are enhanced by parallel pushes within funding agencies to stop supporting harassers [e.g., *Bolden*, 2016; *Lauer et al.*, 2016] and for professional societies to stop conferring honors on

Read about an AGU-sponsored workshop on sexual harassment in the sciences

http://bit.ly/Eos_harassment_workshop

and tolerating harassers [e.g., *Marín-Spiotta et al.*, 2016]. In tandem, we can take active leadership roles in redefining what is acceptable within our communities.

We—all of us—need to do our part to reshape our culture into what we want "normal" and "acceptable" to be: an environment where all can contribute without being made to feel unsafe or unwelcome on the basis of factors such as race and gender, where harassment isn't allowed to jeopardize our passionate quest for knowledge, and where we treat harassment as we would falsifying data or plagiarism—as a type of scientific misconduct.

References

Anonymous (2016), Sexual harassment must not be kept under wraps, *Nature, 529*(7586), 257, doi:10.1038/529257a.

Atherton, T. J., R. S. Barthelemy, W. Deconinck, M. L. Falk, S. Garmon, E. Long, M. Plisch, E. H. Simmons, and K. Reeves (2016), LGBT climate in physics: Building an inclusive community, report, Am. Phys. Soc., College Park, Md.

Bohannon, J. (2013), Survey of peers in fieldwork highlights an unspoken risk, *Science, 340*(6130), 265.

Bolden, C. (2016), Letter from NASA to its grantee institutions, *Rel. 16-009,* NASA, Washington, D. C. [Available at http://www.nasa.gov/sites/default/files/atoms/files/bolden_letter_20160115.pdf.]

Cornwall, W. (2016), U.S. lawmaker's plan to combat sexual harassment by scientists could get complicated, *Science,* doi:10.1126/science.aae0257. Published on 20 January 2016. [Available at http://www.sciencemag.org/news/2016/01/us-lawmaker-s-plan-combat-sexual-harassment-scientists-could-get-complicated.]

Ghorayshi, A. (2015), Here's how Geoff Marcy's sexual harassment went on for decades, *Buzzfeed.* Published on 11 November 2015. [Available at https://www.buzzfeed.com/azeenghorayshi/how-harassment-stays-secret.]

Ghorayshi, A. (2016), He fell in love with his grad student—Then fired her for it, *Buzzfeed.* Published on 12 January 2016. [Available at https://www.buzzfeed.com/azeenghorayshi/ott-harassment-investigation.]

Harmon, A. (2016), Chicago professor resigns amid sexual misconduct investigation, *New York Times.* Published on 2 February 2016. [Available at http://www.nytimes.com/2016/02/03/us/chicago-professor-resigns-amid-sexual-misconduct-investigation.html.]

Jahren, A. H. (2016), She wanted to do her research. He wanted to talk 'feelings,' *New York Times.* Published on 4 March 2016. [Available at http://www.nytimes.com/2016/03/06/opinion/sunday/she-wanted-to-do-her-research-he-wanted-to-talk-feelings.html?_r=0.]

Kingkade, T. (2016), Caltech professor punished for harassment won't return to campus for another year, *Huffington Post.* Published on 1 July 2016. [Available at http://www.huffingtonpost.com/entry/caltech-christian-ott-research_us_5775440de4b0cc0fa136bafe.]

Kirkpatrick, J. (2015), It's not just Marcy, and the grapevine won't save us [posted on behalf of anonymous author], *Women Astron.* Published on 24 November 2015. [Available at http://womeninastronomy.blogspot.cl/2015/11/its-not-just-marcy-and-grapevine-wont.html.]

Lauer, M., H. Valantine, and F. S. Collins (2016), Policy: NIH push to stop sexual harassment, *Nature, 531*(7592), 35, doi:10.1038/531035b.

Levin, S. (2016), Disturbing details of sexual harassment scandal at UC Berkeley revealed in files, *Guardian.* Published on 6 April 2016. [Available at http://www.theguardian.com/us-news/2016/apr/06/uc-berkeley-staff-sexual-harassment-scandal.]

Marín-Spiotta, E., B. Schneider, and M. A. Holmes (2016), Steps to building a zero-tolerance culture for sexual harassment, *Eos, 97,* doi:10.1029/2016EO044859. Published on 28 January 2016.

McKinney, K., C. V. Olsen, and A. Satterfield (1988), Graduate students' experiences with and responses to sexual harassment, *J. Interpers. Violence, 3*(3), 319–325.

Rosenthal, M. N., A. M. Smidt, and J. J. Freyd (2016), Still second class: Sexual harassment of graduate students, *Psychol. Women Q., 40*(3), 364–377.

Smith, C. P., and J. J. Freyd (2014), Institutional betrayal. *Am. Psychol., 69*(6), 575–587.

Stockdale, M. S., T. K. Logan, and R. Weston (2009), Sexual harassment and posttraumatic stress disorder: Damages beyond prior abuse, *Law Human Behav., 33*(5), 405–418.

Warnke, M. B. (2016), UC harassment inquiry shows system's shortcomings, faculty say. *San Francisco Chron.,* Published on 28 March 2016. [Available at http://www.sfchronicle.com/bayarea/article/UC-harassment-inquiry-shows-system-s-7210185.php; cached at https://berkeleysexualassault.wordpress.com/2000s/#SSEAS.]

Williams, J. C., K. W. Phillips, and E. V. Hall (2014), Double jeopardy? Gender bias against women of color in science, Univ. of Calif., Hastings College of the Law, San Francisco, Calif. [Available at http://www.uchastings.edu/news/articles/2015/01/double-jeopardy-report.pdf.]

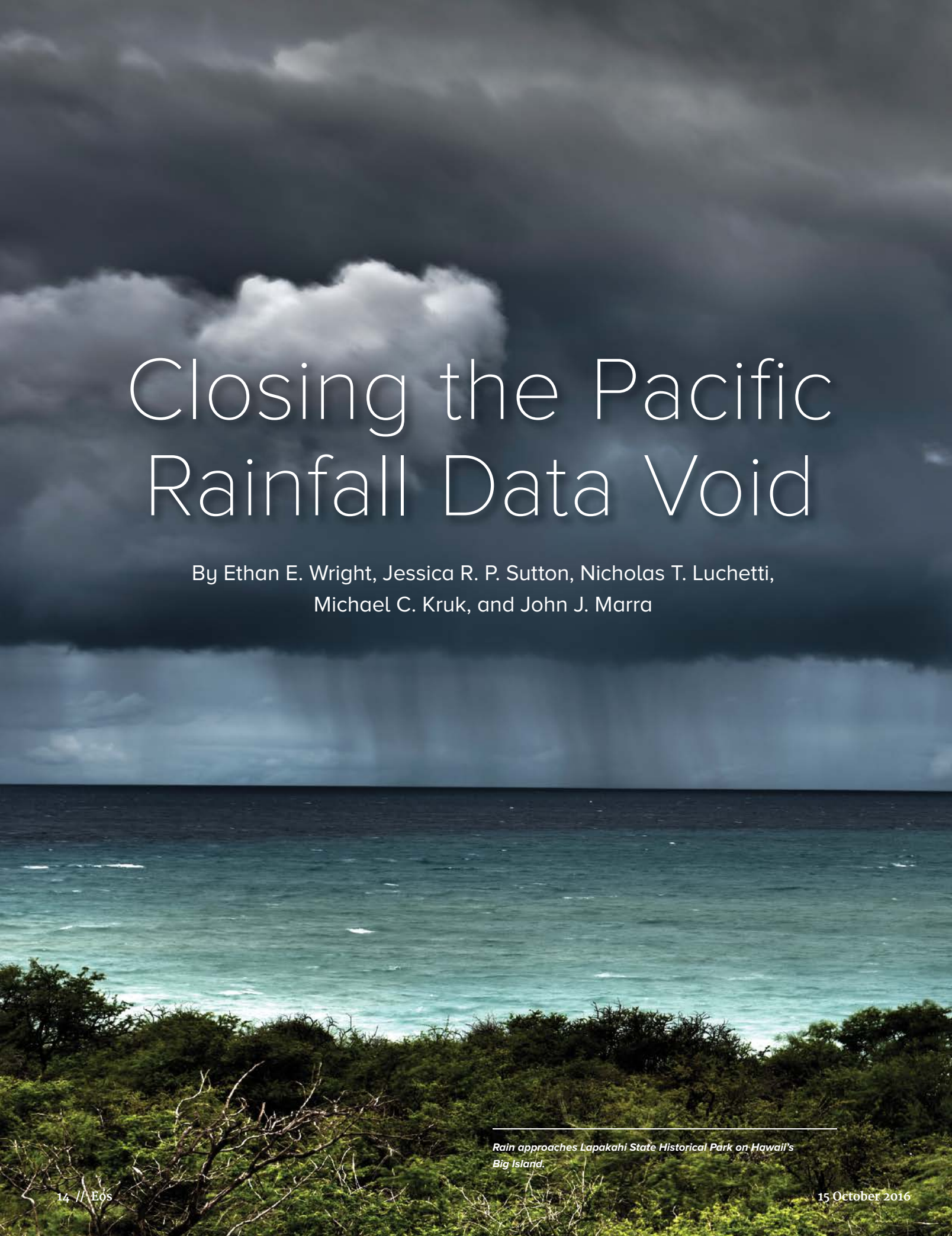
Williams, M. T. (2015), The link between racism and PTSD, *Psychol. Today.* Published on 9 September 2015. [Available at https://www.psychologytoday.com/blog/culturally-speaking/201509/the-link-between-racism-and-ptsd.]

Witze, A. (2015), Berkeley releases report on astronomer sexual-harassment case, *Nature,* doi:10.1038/nature.2015.19068. Published on 19 December 2015 and updated on 23 December 2015.

Serina Diniega, Pasadena, Calif.; email: sdiniega@gmail.com; **Joshua Tan,** Instituto de Astrofísica, Pontificia Universidad Católica de Chile, Santiago, Chile; **Matthew S. Tiscareno,** SETI Institute, Mountain View, Calif.; and **Elizabeth Wehner,** Minneapolis, Minn.

Closing the Pacific Rainfall Data Void

By Ethan E. Wright, Jessica R. P. Sutton, Nicholas T. Luchetti, Michael C. Kruk, and John J. Marra



Rain approaches Lapakahi State Historical Park on Hawaii's Big Island.

A new climatology tool uses satellite data to map precipitation in a data-sparse region of the Pacific Ocean.

David Nelson

The wide expanse of the tropical Pacific Ocean is known by many yet populated by few. Here the El Niño–Southern Oscillation (ENSO) causes fluctuating ocean temperatures that continuously alter global weather patterns, making this geographic location important in the global teleconnections of weather and climate.

During strong El Niño phases, a large-scale eastward shift of anomalous warm sea surface temperatures is accompanied by a large shift in the locations of tropical thunderstorms and hence rainfall. Following the onset of a strong El Niño, many Pacific island nations experience severe drought episodes.

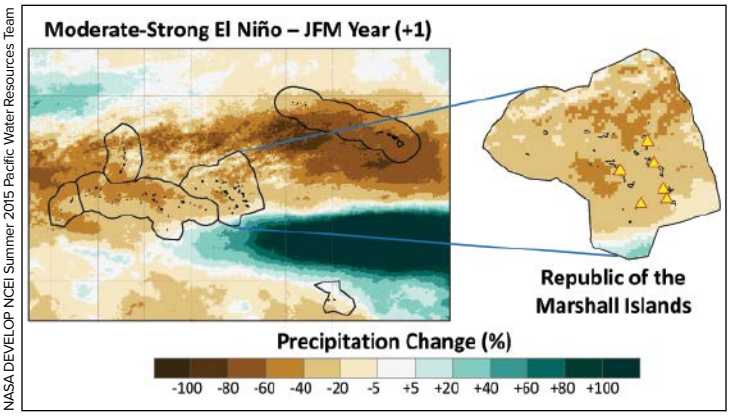


Fig. 1. Departure from normal precipitation during the 3-month season of January–February–March (JFM) from 1985 to 2014 following the onset of a moderate to strong El Niño event (≤1.5 on the Oceanic Niño Index) in the U.S. Affiliated Pacific Islands. These islands include the Republic of Palau, Federated States of Micronesia, Guam and the Commonwealth of Northern Mariana Islands, Republic of the Marshall Islands, American Samoa, and Hawaii. The inset map shows the Republic of the Marshall Islands with long-term precipitation station locations (yellow triangles).

Because many island nations are dependent on seasonal precipitation as a vital source of fresh water [*Kruk et al.*, 2015], this shift can cause prolonged water shortages.

For these reasons, local forecasters and water resource managers have asked for tools to assess the probability of wet or dry conditions for a particular area in relation to a specific phase of ENSO. A new satellite-derived visual climate record addresses this need by mapping past precipitation changes in the tropical Pacific in relation to changing phases of ENSO.

The new climate record is a useful tool for water resource managers in the U.S. Affiliated Pacific Islands (USAPI). What's more, the project highlights the importance of satellite data and their use in the analysis of long-term precipitation trends, particularly those related to ENSO.

A Spatial Problem

Different phases of ENSO have varied effects on the local climate of Pacific island nations and on the global climate as a whole. Yet effects of strong El Niño phases on local Pacific island climates are less widely known than effects on, say, the continental United States. This leaves island nations, buffeted by advancing and retreating ENSO cycles, with a heavy burden of uncertainty.

Almost all long-term monitoring stations are located on islands that are often separated by large stretches of ocean.

Developing tools required for assessing climatological variables in the tropical Pacific does not come without challenges. The vast area of the tropical Pacific, with its large spatial gaps between on-site observations, makes it difficult to visualize climate data effectively. Almost all long-term monitoring stations are located on islands that are often separated by large stretches of ocean.

To effectively evaluate climate variables in this region, other sources of data must also be examined in conjunction with in situ data. Data derived from satellites have proven indispensable in meeting these challenges.

In Search of Better Seasonal Precipitation Outlooks

The National Oceanic and Atmospheric Administration's (NOAA) Pacific ENSO Applications Climate (PEAC) Center currently provides information products based on the ENSO climate cycle for the USAPI, including products that facilitate water conservation. Forecasters issue seasonal rainfall outlooks on a monthly basis using a blend of current observations, dynamic and statistical atmospheric model output, and local expertise [*Schroeder et al.*, 2012].

Forecasters at the PEAC Center currently use a climate record of ENSO-influenced rainfall based on observations from 1955 to 1998 for 66 stations located throughout the Pacific Basin [*He et al.*, 1998]. This in situ–based record provides forecasters with knowledge of specific quantitative precipitation amounts for a given station location in relation to past phases of ENSO.

However, in addition to a lack of spatial coverage, point sources of quantitative rainfall amounts communicate only part of the story. To help facilitate actions in relation to water conservation, we need visual representation of past precipitation during ENSO phases. This visual representation could be used to educate water resource managers and Pacific Islanders about the potential ENSO-related precipitation effects on not just their local islands but the surrounding region as well.

Challenges Across the Pacific Basin

The six areas of the USAPI are shown in Figure 1, along with the USAPI's exclusive economic zones (EEZs). These zones stretch 370 kilometers from the coast into the surrounding ocean and encompass an area of more than 9 million square kilometers.

To understand precipitation trends over climatological timescales, station records must extend over at least a 30-year period. Only 11 stations in the six EEZs meet this criterion for the time period 1985–2015.

Figure 1 also shows the six in situ station locations within the Republic of the Marshall Islands EEZ that have at least a 20-year record of precipitation and at least a 75% complete record of data—meaning that at least 15 years experienced no data collection hiatuses—from 1985 to 2014. The Marshall Islands EEZ has one station per 300,000 square kilometers—an extremely low density.

In situ station density on timescales shorter than 30 years is sufficient for areas such as the Hawaiian EEZ, where numerous stations cover the highly populated islands. However, in more remote areas of the Pacific, where in situ station data are less prevalent, many long-

Grasping the full picture of precipitation patterns involves analysis of visual as well as quantitative sources.

term station locations are concentrated only near the country capitals. This leaves large gaps on a regional scale.

A Clearer Image

To meet the growing need for better spatial coverage of climate variability within seasonal dry and wet periods, we constructed a record of anomalous precipitation patterns for Hawaii and the USAPI using the publicly available Precipitation Estimation from Remotely Sensed Information using Artificial Neural Networks (PERSIANN) Climate Data Record (CDR). The PERSIANN-CDR's strength lies in its ability to depict spatial patterns of precipitation, and it has already been used successfully in other data-sparse regions [*Miao et al.*, 2015].

The record was created using the PERSIANN algorithm and GridSat-B1 infrared satellite data. The satellite data are adjusted using in situ gauge data from the Global Precipitation Climatology Project (GPCP). The PERSIANN-CDR product offers global daily coverage of precipitation from 1983 to the present at 0.25° (about 750-square-kilometer) spatial resolution [*Ashouri et al.*, 2015].

We performed a verification analysis by comparing the annual and monthly precipitation amounts calculated by PERSIANN-CDR with data from stations in the Global Historical Climatology Network (GHCN)—an integrated database of quality-controlled observations from land-based stations across the globe. Results indicate that although the PERSIANN-CDR rainfall accuracy varied with different stations, the PERSIANN-CDR accurately depicted seasonal trends of rainfall.

Using the PERSIANN-CDR, we mapped precipitation trends for an area encompassing the USAPI in relation to five defined phases of ENSO for a 30-year period from 1 January 1985 through 31 December 2014. We depicted the seasonal rainfall trends using maps that show the percentage of departure from normal for different areas within Hawaii and the USAPI. We created anomalous precipitation maps to illustrate the past response of precipitation changes in relation to a specific phase of ENSO (Figure 1).

The full downloadable atlas provides a list of specific ENSO events in each phase and the results of the verification analysis (see http://bit.ly/ENSOatlas).

A Multiple-Source Approach

Grasping the full picture of precipitation patterns involves analysis of visual as well as quantitative sources. Using both the in situ station climate records and the visual climate data products derived from the PERSIANN-CDR provides insight into past precipitation changes associated with ENSO.

To this end, we hope that this visual climate representation will be used as a reference tool to aid water resource managers in Pacific islands. Armed with this atlas, resource managers can, for example, better prepare for forecasted drought episodes by managing water use before strong El Niño phases shift precipitation patterns. In doing so, they will be building more resilient communities.

Acknowledgments

We thank Lance Watkins, Carl Noblitt, Alejandro Ludert, Carl Schreck, Olivier Pratt, Mark Lander, Luke He, Kevin Kodama, Charles Guard, Thomas Schroeder, Maria Ngemaes, and the NASA DEVELOP National Program Office for their support, edits, and commentary that have strengthened this research. This material is based upon work supported by NASA and NOAA through contract NNL11AA00B and cooperative agreement NNX14AB60A.

References

Ashouri, H., K. Hsu, S. Sorooshian, D. K. Braithwaite, K. R. Knapp, L. D. Cecil, B. R. Nelson, and O. P. Prat (2015), PERSIANN-CDR: Daily precipitation climate data record from multisatellite observations for hydrological and climate studies, *Bull. Am. Meteorol. Soc., 96*(1), 69–83.

He, Y., A. G. Barnston, and A.C. Hilton (1998), A precipitation climatology for stations in the tropical basin; effects of ENSO, *NCEP/Clim. Predict. Cent. ATLAS 5,* Clim. Predict. Cent., College Park, Md. [Available at http://www.cpc.ncep.noaa.gov/pacdir/NINDEX22.shtml.]

Kruk, M. C., A. M. Lorrey, G. M. Griffiths, M. Lander, E. J. Gibney, H. J. Diamond, and J. J. Marra (2015), On the state of the knowledge of rainfall extremes in the western and northern Pacific basin, *Int. J. Climatol., 35*(3), 321–336.

Miao, C., H. Ashouri, K.-L. Hsu, S. Sorooshian, and Q. Duan (2015), Evaluation of the PERSIANN-CDR daily rainfall estimates in capturing the behavior of extreme precipitation events over China, *J. Hydrometeorol., 16,* 1387–1396.

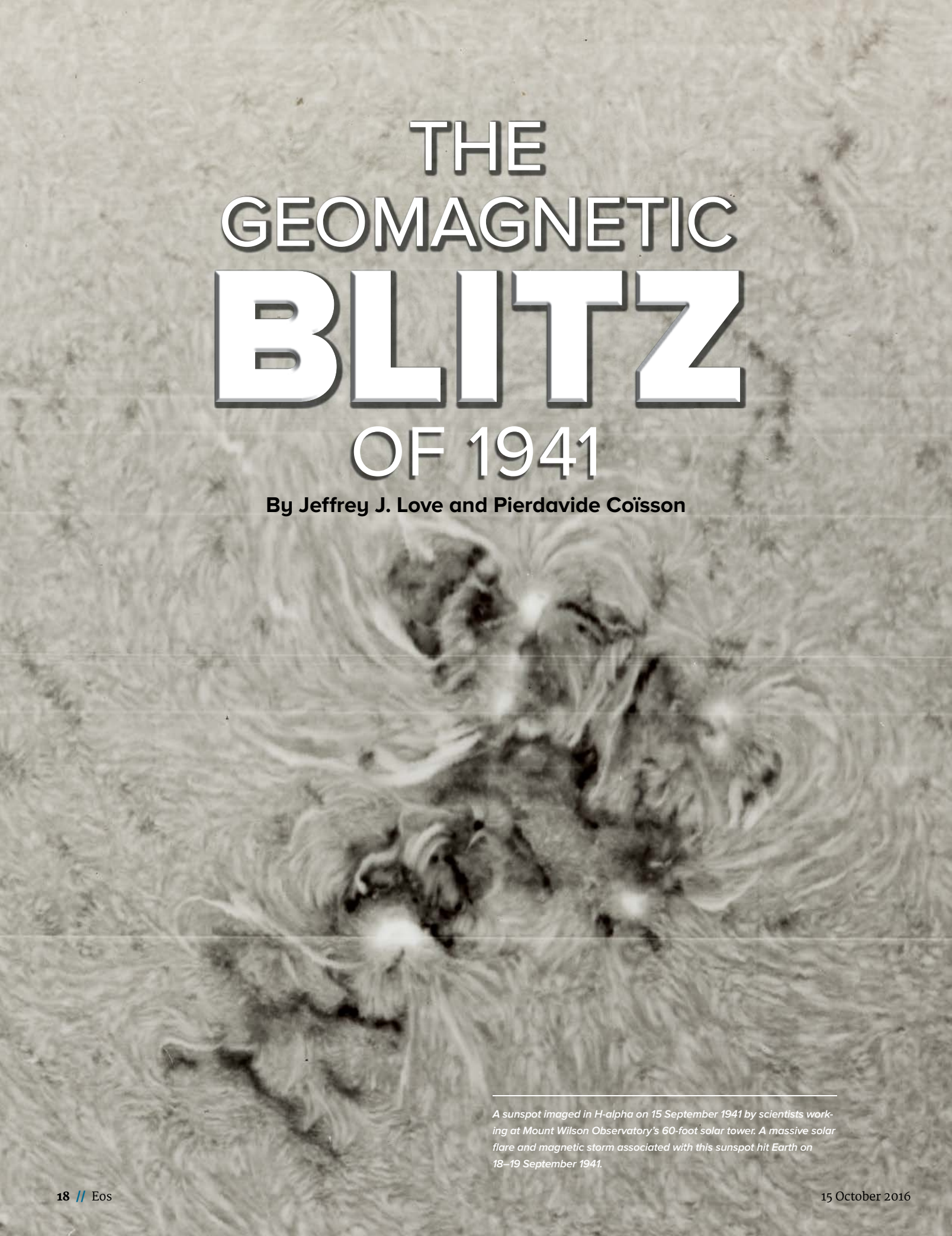
Schroeder, T. A., R. Chowdhury, M. A. Lander, C. C. Guard, C. Felkley, and D. Gifford (2012), The role of the Pacific ENSO Applications Climate Center in reducing vulnerability to climate hazards: Experience from the U.S.-Affiliated Pacific Islands, *Bull. Am. Meteorol. Soc., 93*(7), 1003–1015.

Author Information

Ethan E. Wright, Jessica R. P. Sutton, and **Nicholas T. Luchetti,** NASA DEVELOP at NOAA National Centers for Environmental Information, Asheville, N.C.; email: ewright1@unca.edu; **Michael C. Kruk,** Earth Resources Technology Inc., Asheville, N.C.; and **John J. Marra,** NOAA National Centers for Environmental Information, Honolulu, Hawaii

THE GEOMAGNETIC BLITZ OF 1941

By Jeffrey J. Love and Pierdavide Coïsson



A sunspot imaged in H-alpha on 15 September 1941 by scientists working at Mount Wilson Observatory's 60-foot solar tower. A massive solar flare and magnetic storm associated with this sunspot hit Earth on 18–19 September 1941.

Mason City Public Library

A photograph of the aurora over Mason City, Iowa, 18 September 1941.

Seventy-five years ago, on 18–19 September 1941, the Earth experienced a great magnetic storm, one of the most intense ever recorded. It arrived at a poignant moment in history, when radio and electrical technology was emerging as a central part of daily life and when much of the world was embroiled in World War II, which the United States had not yet officially entered.

Auroras danced across the night sky as voltage surged in power grid lines. A radio blackout interrupted fan enjoyment of a baseball game, and another radio program was interrupted by private phone conversations. Citizens, already on edge, wondered whether neon lights were some sort of antiaircraft signal. And far away in the North Atlantic, the illuminated night sky exposed an Allied convoy to German attack.

These effects raised awareness within the scientific community and among the public of the societal significance of the effects that the Sun and outer space can have on the Earth—what we now call space weather.

Solar–Terrestrial Interaction

On 10 September 1941, during the declining phase of solar cycle 17, astronomers saw an unusually large, low-latitude group of sunspots on the eastern limb of the Sun. The spots had formed, as they all do, with the buoyant emergence of a concentrated bundle of magnetic field lines from the Sun's interior through the photosphere. Over the course of the next week the spots grew, and the Sun's rotation brought them near the center of the solar disk as viewed from Earth [e.g., *Richardson,* 1941]. The sunspot group was large enough to be seen with the naked eye.

At 08:38 universal time (UT) on 17 September 1941, the Greenwich Observatory spectrohelioscope recorded a solar flare above this sunspot group [*Newton,* 1941]. The emitted ultraviolet and X-ray radiation abruptly enhanced the ionization of the Earth's atmosphere, causing a sharp perturbation known as a "crochet" in dayside ground-based recordings of the geomagnetic field and temporarily interfering with high-frequency radio communication. Subsequently, scientists at the Mount Wilson Observatory in California observed another solar flare at 16:26 UT [*Richardson,* 1941].

On the basis of daily sunspot reports supplied by the U.S. Naval Observatory, the Department of Terrestrial Magnetism at the Carnegie Institution of Washington formally issued a warning to radio operators that they could expect significant disturbances to ionospheric and geomagnetic conditions beginning on about 18 September [*McNish,* 1941a]. This prediction, which turned out to be accurate, is a noteworthy development in the historical development of methods for reliably forecasting space weather.

Less than 20 hours after the flare was reported by Greenwich, a magnetic storm commenced at 04:12 UT on

Carnegie Observatories/Cindy Hunt (2016 digitization)

Plain Dealer Archive/Advance Media and State Journal Register

An artistic graphic on sunspots that accompanied an informational story in Cleveland's Plain Dealer *syndicated "Uncle Ray's Corner" column, published in the* Illinois State Journal *on 21 September 1941, a few days after a geomagnetic storm produced spectacular auroral displays.*

18 September with the arrival at Earth of a coronal mass ejection. This mass ejection abruptly compressed the magnetopause and generated a magnetic impulse that was recorded by observatories around the world [*Newton,* 1941]. The magnetic superstorm that followed was complex, intense, and of long duration.

A magnetic observatory in Cheltenham, Md., operated by the U.S. Coast and Geodetic Survey registered six separate occurrences of geomagnetic storms with a *K* index of 9 (the most intense value possible). Five of these occurred consecutively over a 24-hour period. In terms of a related global index, that level of geomagnetic activity over a 24-hour period has not since been matched [e.g., *Cliver and Svalgaard,* 2004].

An Auroral Light Show

On 18–19 September 1941, the Moon was nearly new, ideal for seeing the auroral light that the magnetic storm produced in many nighttime skies. The observer in charge at the Cheltenham, Md., observatory [*Ludy,* 1941] reported a brilliant auroral display of rays and moving drapery of pink, green, and lavender. He also described an auroral corona, where light appears to stream down from directly overhead, a phenomenon rarely seen at midcontinental latitudes.

Weather Service observers reported seeing auroras in New Mexico [*Cameron,* 1941]. Letters to *Sky and Telescope* [1941] described the auroras seen around the United States. One amateur astronomer from Rhode Island [*Boss,* 1941] wrote a detailed description of the "celestial pyrotechnics," and he apparently stayed up all night watching the spectacle, until the paperboy delivered the morning newspaper with the headline "Auroral Display Watched by Thousands."

The popular press provided vivid accounts of the auroras. The *Brooklyn Eagle* [1941] described celestial "neon lights." The *Chicago Tribune* [1941a] reported that a "cosmic brush painted the Chicago sky with light" and that motorists parked on the highways had caused a traffic jam as they sought a clear view of the celestial spectacle.

According to the *Washington Post* [1941a], some people wondered if the celestial events had something to do with national defense: "Was it an anti-aircraft search battery?" These were, after all, difficult times. The United States was already being drawn into World War II [e.g., *Heinrichs,* 1988], and many citizens anticipated even greater involvement.

Auroras were also seen in Europe, but not surprising, most newspaper articles focused on wartime events. Newspapers, for example, succinctly reported that the British Royal Air Force had carried out a raid on a German supply base on the Baltic Sea [*Washington Post,* 1941b] and that the Germans had bombarded Leningrad [*Chicago Tribune,* 1941b], each under the lights of the aurora borealis.

When the magnetic storm finally subsided and the aurora faded, a *New York Times* [1941c] article described the events, in war terms that were common at the time, as an "ethereal blitz." Some readers even optimistically saw the auroral displays as a representation of hope for victory [*New York Times,* 1941d].

Electric Power System Disruptions

Storm time geomagnetic activity can induce geoelectric fields in the Earth's electrically conducting crust and lithosphere of sufficient strength to interfere with the operation of electric power grids.

Magnetic activity recorded at the Cheltenham, Md., observatory abruptly increased at about 19:45 UT on

"Was it an anti-aircraft search battery?"

18 September [*Fleming,* 1943, p. 204]. Almost simultaneously, at 19:45 and 19:50 UT, the Pennsylvania Water and Power Company recorded uncontrolled voltage variations in transmission lines connecting generating plants on the Susquehanna River with Baltimore and Washington. At the moment when the auroral brilliance was greatest, system transformers vibrated and groaned as a result of geomagnetically induced currents [*McNish,* 1941b].

Radio Silence and Spice

The *National Bureau of Standards* [1941] reported a great ionospheric disturbance starting at about 06:00 UT on 18 September, 2 hours after the sudden commencement of the magnetic storm. We might retrospectively infer that this was caused by substorm precipitation of charged particles into the Earth's auroral zone. This would have disrupted

over-the-horizon radio signals that are normally calibrated for a set level of ionospheric reflectivity.

And, sure enough, as a result of the 18–19 September storm, widespread interference was reported for radio transmissions around the world [e.g., *General Electric Review,* 1941; *Conklin,* 1941]. As part of these developments, two amusing happenings were reported in the *New York Times* [1941a, 1941b], *Newsweek* [1941], and *Time* [1941], paraphrased here.

First, on the afternoon of 18 September, the Pittsburgh Pirates hosted the Brooklyn Dodgers in a game of baseball. Red Barber, a well-known sports commentator, was calling the game for WOR Radio. In the fourth inning, with the score tied at 0–0, the broadcast lost signal for 15 minutes. By the time the broadcast resumed, the Pirates had four accumulated runs. Irate Brooklyn fans phoned the radio station to complain, but they found "little satisfaction" with the "explanation that the sun," sunspots, and the related magnetic storm were to blame for the outage. To top it off, the Dodgers went on to lose to the Pirates, 5-6.

The next morning, radio station WAAT was broadcasting a program of Bing Crosby songs. Suddenly, during "Where the Blue of the Night (Meets the Gold of the Day)," a phone conversation between two men discussing their previous night's amours could be heard in the background. Workers at the radio station tried without success to clear up what was apparently some sort of silly mix-up of signals. Station representatives later claimed that although the conversation was "strong," it was also "not particularly objectionable."

When the men's phone conversation did finally fade, it was replaced by what was described in the language of the time as a "spicy" conversation between two young women talking about a blind date: "I fixed it for Eddie to pick up a guy for you." Before station operators could mute the conversation, the colorful "crosstalk had faded, and decorum was again supreme" on the airwaves. Communications engineers for the Radio Corporation of America attributed the trouble to sunspots and the magnetic storm.

Jack Layer, courtesy of the Harry Ransom Center, University of Texas

Aurora over Bergenfield, N.J., September 1941.

Wartime Event in the Atlantic

Far away from those innocent events in the United States, in the frigid North Atlantic Ocean east of southern Greenland, several German U-boats of the Brandenburg wolf pack were lurking. They operated there, out of reach of Iceland-based Royal Air Force maritime patrols, in search of eastbound ships that were keeping Britain supplied during the war.

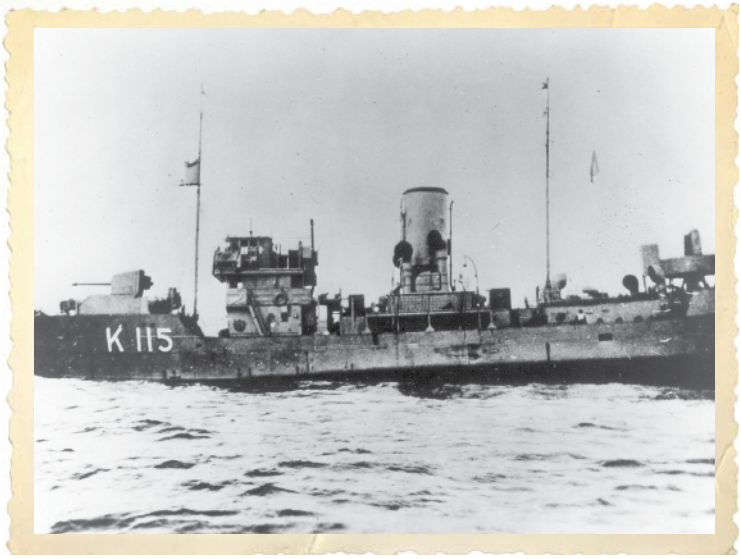
Kapitänleutnant Eitel-Friedrich Kentrat of *U-74* recorded the ensuing events in his war diary [*Morgan and Taylor,* 2011, pp. 119–123]: "September 18, 1941, visibility 4–6 nautical miles, a number of smoke plumes on the horizon, vessels seem well strung out." Kentrat had spotted *SC-44*, a Canadian convoy of cargo ships. For protection, a destroyer and small antisubmarine warships known as corvettes escorted *SC-44* along its journey.

At 22:30 UT, Kentrat issued a radio dispatch to headquarters and the other Brandenburg U-boats: "Alpha. Alpha. Enemy convoy in sight. Quadrant AD9761. Course NE, moderate speed. U-74." Unsure whether his compatriots received his message, he recorded in his diary that since 04:30 UT on 18 September, "short-wave radio reception has been very poor and it gradually cuts out altogether. We try absolutely everything but without success. I hope the other Brandenburg boats can receive me." Unbeknownst to Kentrat, his radio problems were caused by the magnetic storm and the ionospheric disturbance that followed.

As the Sun set, the sea haze lifted. Under such conditions, a wartime convoy would normally have been relatively securely hidden in the dark of night. But not this night. The sky was ablaze with the aurora borealis. Kentrat described the conditions as being "as bright as day." Ironically, in a postwar interview [*Johnston,* 2008, p. 38], a crewman on board a ship in the convoy, the *SC-44* corvette HMCS *Lévis*, recalled seeing the aurora on that evening and remarking to a fellow crewman, "What a night for a torpedoing." This bit of dark humor would turn out to be prophetic.

At 01:00 UT on 19 September, Kentrat tried several times to maneuver *U-74* into attack position on the starboard side of the convoy, only to be "driven off" each time by *SC-44*'s defending corvettes. They didn't pursue for long, but Kentrat became concerned that his own U-boat was too visible "in these conditions." (In those days, submarines were only occasionally submerged.) He decided to maneuver "to the port side of the convoy, where the Northern Lights [were] less bright."

At 03:50 UT, Kentrat radioed, "Brandenburg boats report in immediately." (He did not know at the time that the



Royal Canadian Navy/Department of National Defence, Canada

HMCS Lévis *on 19 September 1941, just before it sank.*

other U-boats had been receiving his radio messages; he just hadn't been receiving theirs.) At 05:03 UT, from the unusually long distance of 3 kilometers, Kentrat ordered four torpedoes to be fired in spread formation at the convoy. Afterward, *U-74* quickly turned around to escape, and Kentrat ordered a fifth torpedo to be fired from the stern. Monitoring the results through his periscope, Kentrat reported a direct hit, "a plume" and "green light." A torpedo had struck the stern of the *Lévis*, nearly cutting it in two. Afterward, Kentrat recorded detecting a desperate Morse code signal: "Help."

Hours later, the *Lévis* sank. Of the ship's complement, 18 died and 40 were rescued.

Modern Implications

Although the magnetic storm of 18–19 September was of only minor anecdotal consequence compared to the terrible and momentous events of World War II, its occurrence does provide us with an opportunity to reflect on the course of history and how things have and have not changed. During the war, some geophysical and astronomical observatories were temporarily closed, but others managed, sometimes against considerable challenge, to remain open and operational. The data collected during this time from war zone observatories are a lasting testament to the dedication of their workers.

In today's world, we are more dependent than ever on modern technology. For this reason, the plausible future occurrence of a space weather superstorm could have widespread impact—disrupting over-the-horizon radio communication, degrading the accuracy of global positioning systems, damaging satellite electronics and increasing their orbital drag, interfering with geophysical surveys, exposing airplane pilots and passengers to unhealthy radiation levels, and even interrupting electric power distribution for prolonged periods [e.g., *Baker et al.,* 2008; *Cannon et al.,* 2013]. Strategic planning [e.g., *National Science and Technology Council,* 2015] is helping focus resources in support of research, monitoring, assessment, prediction, mitigation, and response planning related to extreme space weather events.

Acknowledgments

We thank C. A. Finn, S. J. Hardy, J. McCarthy, E. J. Rigler, and J. L. Slate for reading a draft manuscript. We thank E. W. Cliver, W. F. Denig, and H. J. Singer for useful conversations. Part of this work was accomplished while J.J.L. was a visiting professor at the Université Paris Diderot in September 2015. This is IPGP contribution 3760.

References

Baker, D. N., et al. (2008), *Severe Space Weather Events—Understanding Societal and Economic Impacts*, 144 pp., Natl. Acad. Press, Washington, D. C.

Boss, L. J. (1941), Notes from amateurs: The aurora of September 8–19, 1941, *Pop. Astron., 49*(11), 504–505.

Brooklyn Eagle (1941), Celestial "neon lights" cut news from Europe, p. 3, 19 Sept.

Cameron, D. C. (1941), Climatological data, New Mexico section, *Climatol. Data, N. M. Sect., 45*(9), 65.

Cannon, P., et al. (2013), *Extreme Space Weather: Impacts on Engineered Systems and Infrastructure,* 68 pp., R. Acad. Eng., London.

Chicago Tribune (1941a), Cosmic brush paints Chicago sky with light, part 1, p. 1, 19 Sept.

Chicago Tribune (1941b), Northern lights add eerie glare to war in Arctic, part 1, p. 5, 21 Sept.

Cliver, E. W., and L. Svalgaard (2004), The 1859 solar-terrestrial disturbance and the current limits of extreme space weather activity, *Sol. Phys., 224*(1), 407–422, doi:10.1007/s11207-005-4980-z.

Conklin, J. (1941), UHF...The big aurora, *Radio, 263,* November, 55.

Fleming, J. A. (1943), The Sun and the Earth's magnetic field, in *Annual Report of the Smithsonian Institution, 1942,* pp. 173–208, U.S. Gov. Print. Off., Washington, D. C.

General Electric Review (1941), Dodging the aurora: High lights and side lights, *44*(10), 573.

Heinrichs, W. (1988), *Threshold of War: Franklin D. Roosevelt and American Entry into World War II,* 302 pp., Oxford Univ. Press, New York.

Johnston, M. (2008), *Corvettes Canada: Convoy Veterans of World War II Tell Their True Stories,* 272 pp., John Wiley, Mississauga, Ont., Canada.

Ludy, A. K. (1941), Cheltenham magnetic observatory, July to September 1941, *Terr. Magn. Atmos. Electr., 46*(4), 474, doi:10.1029/TE046i004p00474.

McNish, A. G. (1941a), The great geomagnetic storm of September 18–19, 1941, *Sci. Mon., 53*(5), 478–481.

McNish, A. G. (1941b), The aurora and geomagnetic storm of September 18–19, 1941, *Terr. Magn. Atmos. Electr., 46*(4), 461–463, doi:10.1029/TE046i004p00461.

Morgan, D., and B. Taylor (2011), *U-Boat Attack Logs: A Complete Record of Warship Sinkings from Original Sources, 1939–1945,* 480 pp., Seaforth, Barnsley, U. K.

National Bureau of Standards (1941), High-frequency radio transmission conditions, September, 1941, with predictions for December, 1941, *Proc. Inst. Radio Eng., 29*(10), 563–564.

National Science and Technology Council (2015), National space weather strategy, 14 pp., White House Off. of Sci. and Technol. Policy, Washington, D. C.

Newsweek (1941), Aurora sideshow, *18*(13), 18.

Newton, H. W. (1941), The great spot group and magnetic storm of September 1941, *Observatory, 64,* 161–165.

New York Times (1941a), Aurora borealis gives city a show as sun spots disorganize radio, p. 25, 19 Sept.

New York Times (1941b), Sun spots add some radio spice, sneaking private phone calls on air, p. 19, 20 Sept.

New York Times (1941c), Short wave better as 'storm' abates: Magnetic disturbance fades—Another 'blitz' feared, p. 46, 21 Sept.

New York Times (1941d), Aurora borealis: Victory sign, Mail-bag excerpts, p. 113, 28 Sept.

Richardson, R. S. (1941), The sunspot-group associated with the magnetic storm of September 18, 1941, *Terr. Magn. Atmos. Electr., 46*(4), 459–460, doi:10.1029/TE046i004p00459.

Sky and Telescope (1941), Letters, *1*(1), 14–15.

Time (1941), Magnetic uproar, *38*(13), 59.

Washington Post (1941a), Northern light show visits South, p. 1, 19 Sept.

Washington Post (1941b), Nazi cities hit as northern lights illumine raiders' goals, p. 1, 21 Sept.

Author Information

Jeffrey J. Love, Geomagnetism Program, U.S. Geological Survey, Denver, Colo.; email: jlove@usgs.gov; and **Pierdavide Coïsson,** Institut de Physique du Globe de Paris, Sorbonne Paris Cité, Paris, France; and Université Paris Diderot, Centre National de la Recherche Scientifique, Paris, France

AGU Congressional Science Fellows Take the Hill

iStock.com/Willard

U.S. Capitol Building in Washington, D. C. On 31 August, two young scientists began yearlong AGU-sponsored fellowships working in congressional offices.

AGU is excited to introduce its new Congressional Science Fellows, Karen Akerlof and Patrick Drupp. For a year that began 31 August, Akerlof, a social scientist, and Drupp, a chemical oceanographer/education specialist, have traded their research equipment for seats among the staff in a congressional office.

It's a big change but a valuable one. Past AGU Congressional Science Fellows have gone on to take permanent jobs on Capitol Hill, work for state or federal agencies, or return to academia with an improved understanding of how their science can help shape policy.

AGU has proudly supported these fellows for the past 39 years.

During their time in congressional offices, fellows often serve as resident science experts, using their broad scientific background as well as their unique expertise on critical issues such as climate, hazards, or resource management to inform and guide policy makers. Through the fellowship program, fellows are able to gain firsthand knowledge of the legislative process and explore career paths outside academia.

Promoting the Use of Science in Policy Making

Karen Akerlof

Akerlof was a research assistant professor at the Center for Climate Change Communication at George Mason University in Fairfax, Va., before being chosen as a fellow. Her work focused on applying social science research and theory to problems in science and risk communication. She earned a Ph.D. in environmental science and public policy from George Mason with a dissertation titled "Risky Business: Engaging the Public in Policy Discourse on Sea-Level Rise and Inundation."

During her time on Capitol Hill, Akerlof hopes to learn "how the national scientific research agenda is influenced by budgeting, formation of legislation, and federal agency oversight." In turn, she says, she wants to use the fellowship as an opportunity "to bridge between the physical and social sciences" using her science communication, climate science research, and social science research background.

Drupp comes from the National Oceanic and Atmospheric Administration (NOAA), where he was an education program specialist. His work focused on improving educational programs within NOAA. He has a Ph.D. in chemical oceanography from the University of Hawai'i, where he completed his dissertation titled "Observations and Modeling of the CO_2-Carbonic Acid System of Hawaiian Coral Reefs: Implications of Future Ocean Acidification and Climate Change."

Patrick Drupp

Drupp said he will bring a "personal approach to science" to make "sometimes daunting topics much more approachable for nonscientists." He aspires to "help produce solid, scientifically sound, and sustainable marine policy, as well as make scientific education a priority in both formal and informal settings."

Apply for a Congressional Science Fellowship

To learn about applying for an AGU Congressional Science Fellowship, visit the AGU Science Policy website (see http://bit.ly/AGU-sci-policy-CSFs). Applications for the 2017–2018 term will open on 1 November 2016 and close on 1 February 2017.

By **Elizabeth Landau,** Public Affairs Manager, AGU

Applications for the 2017–2018 term will open on 1 November 2016 and close on 1 February 2017.

Mysterious Anomaly Interrupts Stratospheric Wind Pattern

NASA/JSC Gateway to Astronaut Photography of Earth

Earth's stratosphere lies just above the red-orange troposphere in this photo snapped by International Space Station astronauts in 2011. Late last year, unusual wind behavior interrupted a reliable stratospheric wind pattern known as the quasi-biennial oscillation.

The weather we experience on Earth typically occurs in the troposphere, the lowest layer of the atmosphere. But the stratosphere, which envelops the planet just above the troposphere, is home to winds of its own. In a new study, *Newman et al.* report an anomalous interruption in an otherwise reliable stratospheric wind pattern known as the quasi-biennial oscillation.

Each cycle of the quasi-biennial oscillation begins with strong westerly winds that flow through the stratosphere in a belt around the equator. Over the course of about 1 year, these winds gradually weaken and descend in altitude to the lower stratosphere as easterly winds replace them. These easterly winds slowly sink and weaken too, as westerly winds return. The cycle repeats roughly once every 28 months.

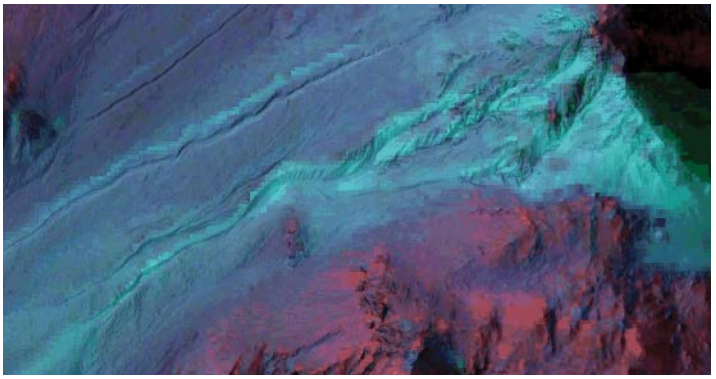
Since 1953, scientists have observed equatorial winds by instruments known as radiosondes, which are carried skyward by weather balloons. The quasi-biennial oscillation was discovered in the early 1960s. Although the timing of each cycle has sometimes varied by a few months, the pattern as a whole has remained uninterrupted—until now.

Using radiosonde data from several equatorial locations around the world, the scientists discovered that the quasi-biennial oscillation began to deviate from its usual pattern in late 2015. At that time, westerly winds were descending in altitude and should have continued to sink and weaken as easterlies replaced them.

Instead, the westerly winds shifted upward and seemed to cut off the descent of high-altitude easterlies before they could begin their usual dominance. Additional easterly winds developed at lower altitudes in the stratosphere, beneath the rising westerlies. However, by June, the westerlies appeared to have resumed their normal descent.

The researchers plan to continue analyzing wind and temperature data to determine what caused this anomaly and what its implications may be. Their investigation will include an exploration of possible connections with the 2015–2016 El Niño and climate change. (*Geophysical Research Letters*, doi:10.1002/2016GL070373, 2016) **—Sarah Stanley, Freelance Writer**

How Do Gullies Form on Mars?



HiRISE/CRISM NASA/JPL/Univ. of Arizona/JHUAPL

Gullies on Mars look a lot like water-carved channels on Earth, but new evidence supports a hypothesis that they are likely not formed by liquid water. As seen in this view of Hale crater's eastern rim (35.7°S, 323.4°E), unaltered mafic material (light blue) from the crater rim is carved and transported downslope along the gully channels. No hydrated minerals are observed within the gullies, indicating limited to no interaction of the mafic material with liquid water.

Networks of narrow channels cut into steep slopes in several regions on Mars. These gullies look much like some water-carved channels that form on Earth, but liquid water would be unstable in the Martian atmosphere, so researchers have proposed alternative gully-forming mechanisms. New research by *Núñez et al.* shows that seasonal frost-driven processes may serve a primary role in forming the Red Planet's gullies.

Using data from NASA's Mars Reconnaissance Orbiter, the researchers analyzed more than 100 gullies in the northern and southern hemispheres of Mars. They examined images captured by the spacecraft's Compact Reconnaissance Imaging Spectrometer for Mars (CRISM), the High Resolution Imaging Science Experiment (HiRISE), and the Context Camera (CTX).

The images revealed that the mineral composition of sediments deposited in and downhill from the mouth of Martian gullies matched "upstream" rock. This suggests that gully formation processes did transport materials downhill. However, the scientists found no mineral evidence that the deposits had interacted with liquid water. This evidence might include any one of the hydrated minerals that can form in the presence of water—sulfates like gypsum, carbonates like calcite, or clays, for example.

In middle- to high-latitude gullies, the researchers instead observed seasonal accumulation of carbon dioxide and water frost. These findings are consistent with the idea that carbon dioxide sublimation could destabilize rocky materials and cause gas-lubricated debris flows, driving gully formation.

Since scientists first discovered Martian gullies in 2000, some of these channels have undergone visible changes. The team studied the deposits of multiple gullies in detail and found no evidence for long-term interaction with liquid water, such as clays or sulfates. Although the observations do not rule out the possibility that liquid water may have contributed to the formation of some of these features, they favor a frost-driven mechanism for the formation of Martian gullies. (*Geophysical Research Letters*, doi:10.1002/2016GL068956, 2016) **—Sarah Stanley, Freelance Writer**

Characterizing the Faults Beneath Germany

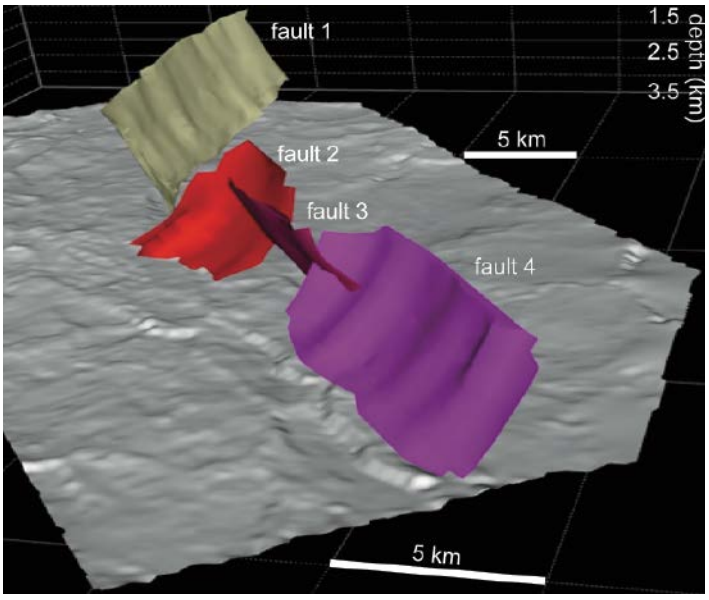
As Europe flexed down under the weight of the Alps, a foreland basin formed: the German Alpine Molasse, which today extends from Switzerland in the west to the Czech Republic in the east. Within this basin, geologists have found large faults that displace sediments. Although they are parallel to faults within the underlying carbonate platform, the two groups of faults are not physically connected, raising the question of how such faults could independently develop.

Luckily, the basin has been under intense scrutiny for decades. First, oil and gas companies scoured the region for any available resources; more recently, speculation that a newly discovered, deep aquifer could be used as a geothermal reservoir fueled further exploration. However, to characterize the potential reservoir, researchers needed to better understand the fault kinematics.

Here *von Hartmann et al.* performed a new structural analysis of a small section of the Molasse Basin—just 120 square kilometers—using data collected in 1987. The team imaged four prominent master faults that were parallel to the structures within the underlying carbonate platform. They found that the Molasse sediments were hundreds of meters above those in the carbonate platform—definitively showing that the two fault types are not connected, as previous research suggested.

Instead, the new analysis proposes that the faults grew both upward and downward from the middle of the Molasse sediments—showing for the first time how such faults could have formed independently.

The team built a model of the Molasse that proposes that as the foreland basin formed 30 million years ago, only a distinct portion of the Molasse came under extensional stress, allowing normal faults to form above while the carbonate platform below was under compression. (*Tectonics*, doi:10.1002/2016TC004176, 2016) **—Shannon Hall, Freelance Writer**



von Hartmann et al. [2016]

Four large faults cutting the sediments above the carbonate basement of the German Molasse Basin. A recent study reveals new aspects of foreland basin development.

Incorporating 3-D Cloud Effects into Weather and Climate Models

Clouds have a significant but complicated effect on Earth's climate. They shield the planet from incoming solar radiation, reflecting sunlight back into space. Clouds also insulate Earth like a blanket, emitting infrared radiation down to the surface while blocking radiation emitted by the surface from escaping to space.

Despite their obvious importance for weather and climate, the complexity of cloud shapes, their ephemeral nature, and the extreme variability in how they form and how long they last make modeling clouds and their interaction with radiation very difficult. Historically, radiation schemes in weather and climate models have ignored the flow of radiation through cloud sides because the only schemes that could accurately capture these three-dimensional (3-D) effects were much too computationally costly for use in global models.

In a step toward less computationally costly methods, *Schäfer et al.* present a radiation scheme called the Speedy Algorithm for Radiative Transfer Through Cloud Sides (SPARTACUS). The researchers used an isolated, homogeneous, isothermal, cubic cloud as a benchmark to develop the scheme's ability to capture infrared radiation emitted from clouds.

Theoretically, 3-D effects within this reference cloud are expected to increase the cloud radiative effect by a factor of 3. SPARTACUS was able to capture this effect as long as the movement of energy throughout the cloud was accounted for. The authors parameterized the energy fluxes at cloud sides and presented an empirical adjustment to roughly account for the fact that in cloud clusters, neighboring clouds can absorb emitted radiation from each other, influencing the overall cloud radiative effect.

In a companion paper, *Hogan et al.* further explore the modifications necessary to incorporate SPARTACUS into weather and climate models. To ensure that the SPARTACUS scheme incorporated 3-D effects, the authors modified two-stream equations, which usually assume radiation to flow just up and down, to include horizontal radiative movement as well.

The study revealed that the 3-D radiative effects significantly influence how cumulus clouds affect Earth's energy budget, but there is still room for improvement in the treatment of cloud clustering. According to the authors, more observations of cloud geometry and clustering in the real world will help researchers determine the effect of 3-D radiative transfer on the solar and infrared radiation on a global scale. (*Journal of Geophysical Research*, doi:10.1002/2016JD024875, doi:10.1002/2016JD024876, 2016) **—Kate Wheeling, Freelance Writer**

Deciphering the Bay of Bengal's Tectonic Origins

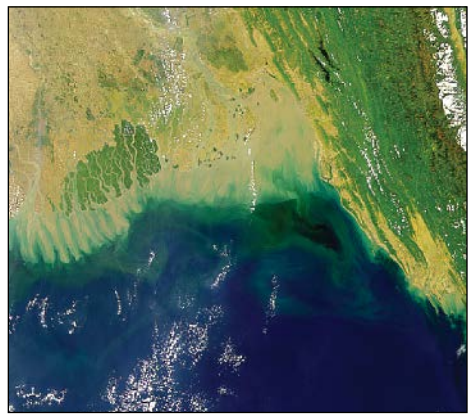
Although researchers have long understood that the tectonic evolution of the Bay of Bengal, located east of India, is intertwined with the opening of the Indian Ocean, the specifics of these events have yet to be unraveled. Because the standard methods of resolving the age and origin of the underlying crust—the crucial information needed to solve this puzzle—have so far yielded ambiguous results, *Talwani et al.* have combined new, multidisciplinary data sets to obtain a better understanding of the region's tectonic history.

Using magnetic data from several tracks in the bay's Western Basin, the team identified a series of magnetic anomalies and used these to date the Western Basin's crust as Early Cretaceous in age. Next, by correlating these anomalies with conjugate ones in the western Enderby Basin, located off of East Antarctica, the researchers established that seafloor spreading between Antarctica and India began 132 million years ago and occurred in a northwest–southeast direction.

Additional gravity, seismic, and petrologic data suggest that the next step in the region's tectonic evolution occurred about 120 million years ago, when the arrival of a hot spot near India reorganized seafloor spreading. This event, conclude the researchers, opened a new spreading center along a line that now joins two volcanic provinces, called the Rajmahal and Sylhet traps, which are located in India on opposite sides of northern Bangladesh. Although these provinces were previously believed to be the products of separate eruptions, the data in this study suggest that both composed a single spreading center about 118 million years ago.

Collectively, the results indicate that this former spreading center forms the boundary between oceanic and continental crust in this region and that oceanic crust underlies Bangladesh and the eastern Bay of Bengal. Unlike most of the planet's ocean-continent boundaries, this one is unusual in that it is located on shore, several hundred kilometers inland, because of the large volume of sediments shed following the uplift of the Himalayas.

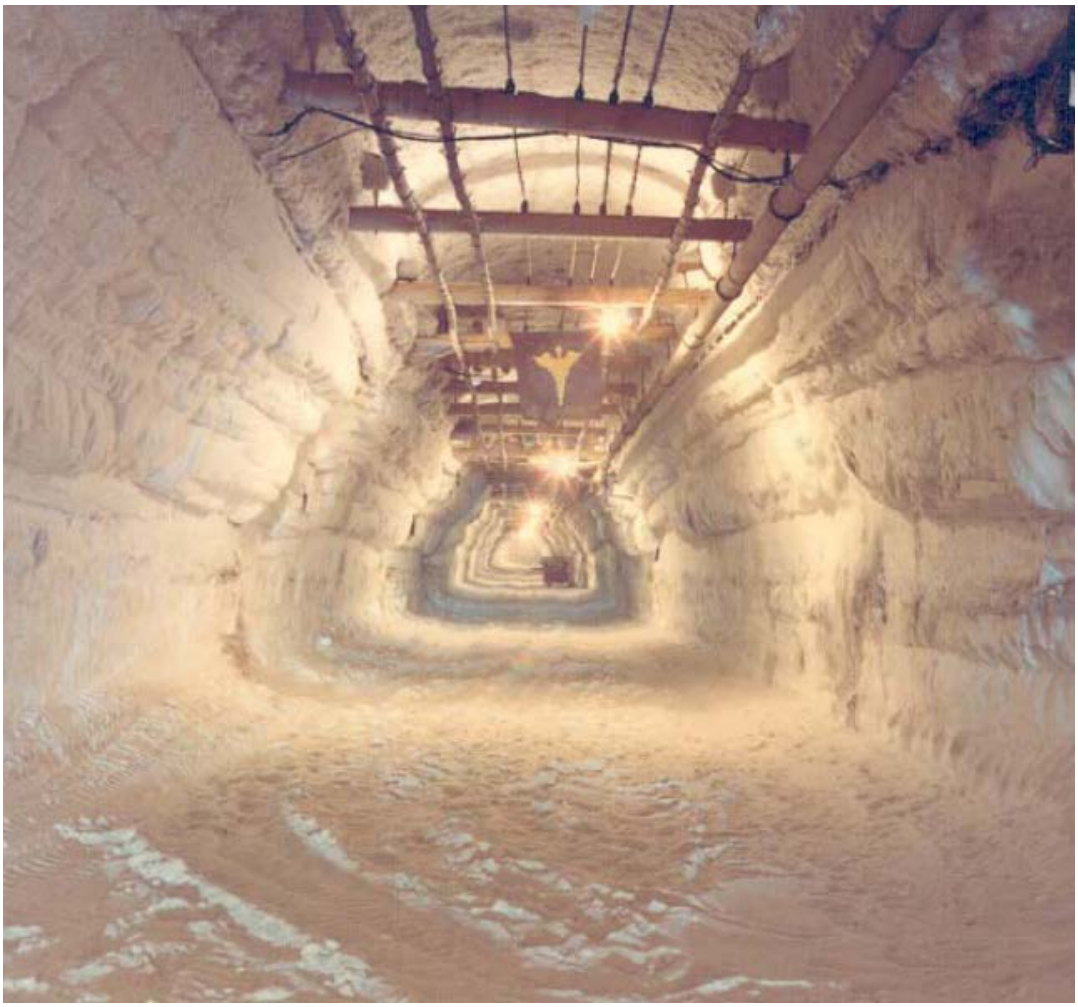
Despite the progress made in this study, many questions remain, according to the researchers. Additional studies, including a seismic refraction survey, will be necessary to further refine the details regarding this region's complex tectonic evolution. (*Journal of Geophysical Research: Solid Earth*, doi:10.1002/2015JB012734, 2016) **—Terri Cook, Freelance Writer**



NASA

A satellite view of the northern Bay of Bengal. New analysis of the seafloor underlying the bay paints a complex picture of how it formed.

Melting Ice Could Reveal Toxic Cold War Era Waste in Greenland



U.S. Army

A view inside the main 400-meter access trench to Camp Century in 1964. More than twelve 150-meter-long side trenches radiated out from the main trench.

In 1959, during the height of the Cold War, the U.S. Army Corps of Engineers built Camp Century, a military base in northwestern Greenland encased completely within the Greenland Ice Sheet. The camp's official purpose was to test construction techniques in the Arctic and conduct scientific research, but it doubled as a top secret site for testing the feasibility of deploying nuclear missiles that could reach the Soviet Union in case of nuclear war.

Greenland is a Danish territory, and although the United States had Denmark's approval to build Camp Century, the missile launch program, known as Project Iceworm, was kept secret from the Danish government. Several years after the camp became operational, however, Project Iceworm was rejected by the Joint Chiefs of Staff, and the camp was decommissioned in 1967. The Army Corps of Engineers removed the nuclear reactor that powered the camp but left the camp's infrastructure and waste behind, under the assumption they would be frozen and buried forever by perpetual snowfall.

But in the decades since Camp Century was abandoned, climate change has warmed the Arctic more than any other region on Earth. Here *Colgan et al.* take an inventory of the wastes at Camp Century and run climate model simulations to determine whether the waste will stay put in a warming Arctic. The team analyzed historical Army Corps of Engineers documents to determine where the wastes are located, how deep under the ice sheet they are buried, and how much the ice sheet has moved since the 1950s.

The team estimates that the site contains 200,000 liters of diesel fuel, enough for a car to circle the globe 80 times. Considering the building materials used in the Arctic at the time, the authors speculate that the site also contains polychlorinated biphenyls (PCBs), which are pollutants toxic to human health. They also estimate that the site has 240,000 liters of wastewater, including sewage, along with an unknown volume of low-level radioactive coolant from the nuclear generator.

Looking at existing business-as-usual climate projections, the team determined that as early as 2090, the portion of the ice sheet covering Camp Century could transition from net snowfall to net melt. Melting of the ice would guarantee that the camp's infrastructure and waste, which represent a significant environmental hazard, would remobilize, according to the authors.

If that happens, pollutants could be transported to the ocean, where they could disrupt marine ecosystems. The authors do not advocate starting remediation activities at Camp Century now, however. The waste is buried tens of meters below the ice, and any cleanup activities would be costly and technically challenging, according to the researchers, but the new study does raise questions about who is responsible for cleaning up the waste when it is exposed.

Although Camp Century was a U.S. base, it is on Danish soil, and while Greenland is a Danish territory, it is now self-governing. According to the authors, the implications of climate change on such politically ambiguous abandoned wastes have never been considered before. (*Geophysical Research Letters*, doi:10.1002/2016GL069688, 2016)

—Lauren Lipuma, Contributing Writer

ATMOSPHERIC SCIENCES

Postdoctoral Research Scientist

The Department of Applied Physics and Applied Mathematics at The Fu Foundation School of Engineering and Applied Science of Columbia University in the City of New York invites applications for a Postdoctoral Research Scientist position in the area of modeling atmospheric chemistry and aerosol processes over a wide range of oxidation-reduction states and their interactions with the climates of Solar System rocky planets and rocky exoplanets in a three-dimensional general circulation model. This is a full-time position for a 2-year period.

The successful candidate will participate in a groundbreaking NASA research initiative, the Nexus for Exoplanet System Science (NExSS; https://nexss.info), with an interdisciplinary team of scientists from the Goddard Institute for Space Studies (GISS), the Goddard Space Flight Center, Columbia University, and other institutions. The broad goals of the team's research are to address questions about the habitability of the past climates of Earth, Mars, and Venus, to use these insights to assess the habitability of exoplanet climates, and to inform the design of future spacecraft missions for detecting and characterizing habitable exoplanets. The candidate will be expected to perform original research, present the results of the research at scientific meetings, and publish first-author papers in peer-reviewed journals. The candidate will be resident at NASA GISS, located in New York City near the Morningside Campus of Columbia University.

BIOGEOSCIENCES

Stream and Watershed Biogeochemist

The Stroud Water Research Center is searching for a Stream and Watershed Biogeochemist (open rank/level) with interest and expertise in any of the following topics: aquatic and terrestrial biogeochemical dynamics; carbon, nitrogen, and/or phosphorus cycling in streams and watersheds; stream and watershed hydrogeochemistry; stream and watershed pollutant dynamics; emerging contaminants in aquatic ecosystems; in-situ technologies for sensing/monitoring the physical-chemical dynamics in streams and watersheds. The individual will establish a permanent research program focused on Stream and River Biogeochemistry or other closely related discipline described herein. The ideal candidate will possess a strong background in some combination of the following skillsets: biogeochemistry, hydrogeochemistry; stream and watershed ecology; ecosystem modeling/nutrient or chemical modeling in streams/watersheds; lab management (management of technical staff and analytical equipment); grant writing and proven success in securing extramural funding; demonstration of strong collaborative approach to research; general understanding of research project budgeting and budget management.

QUALIFICATIONS

The candidate must possess a Ph.D. relating to any of the core disciplines listed herein. The ideal candidate should 1) have core competencies in stream and river biogeochemistry, a strong understanding of physical-chemical-biological interactions in the context of nutrient cycling or pollution chemistry-ecology; 2) possess a strong understanding of ecosystem and freshwater science and be able to integrate biogeochemistry and ecosystem processes; 3) possess a strong publication record; 4) be able to secure external funding for research in their primary discipline; 5) have a proven ability to work collaboratively with a multidisciplinary team; 6) be knowledgeable about the emerging technologies within their discipline. Postdoctoral or several years (+2 yrs) of postgraduate experience is required. The preferred candidate will be at a point in their career that is equivalent to an Associate or higher Research Scientist/Professor, but exceptional early career scientists are encouraged to apply.

RESEARCH ENVIRONMENT AND EXPECTATIONS

The successful candidate is expected to build and manage a science section that may include technical staff, graduate students and postdoctoral candidates. The Stroud Center strives to maintain and enhance a strong collaborative environment with a research focus on how stream ecosystems function, from molecules to organisms to watershed and global scale processes. Thus, the Center offers rich collaborative opportunities with other staff at the Stroud Center that includes expertise in the following disciplines: fluvial geomorphology, hydrology, molecular microbiology, aquatic entomology, stream ecology, watershed restoration science, and environmental education. The candidate's experience with sensor networks or incorporating watershed-scale, high temporal and spatial resolution data from in-situ devices to enhance understanding of biogeochemical processes are also a plus. The candidate will also be asked to manage at least one technical staff member that will help curate analytical instrumentation in well-equipped chemistry labs that include: Dionex Ion Chromatograph, Gas Chromatograph, High Pressure Liquid Chromatograph, Total Organic Carbon analyzers, Isotope Ratio Mass Spectrometers, and In-Situ Spectrophotometers (S::CAN), among other instrumentation.

GEOCHEMISTRY

Assistant Professor of Geology

The Geology Department at Washington and Lee University, Lexington, VA seeks applications for a tenure-

track assistant professor in environmental geochemistry starting in fall 2017. PhD required at the time of appointment. Courses taught by the successful candidate will include hydrology, geochemistry, and environmental field methods at the majors level, and physical geology at the introductory level. We seek a dynamic, creative teacher/scholar, dedicated to diverse teaching approaches, enthusiastic about teaching intensive field-based geology courses, and able to develop a strong research program including collaboration with undergraduates. W&L and the Geology Department value excellence in scholarship, meaningful engagement in professional activities, sustainability, and the development of a campus climate that supports equality and diversity among its faculty, staff, and students. W&L is a nationally ranked, highly selective liberal arts college. The Department (geology.wlu.edu) has excellent facilities and resources, makes great use of the Appalachians in field courses and labs, and belongs to the Keck Geology Consortium. Applications should include: curriculum vitae; teaching statement including teaching interests/experience; research statement; and contact information for 3 referees. Apply via email to wilsons@wlu.edu. Please address to Lisa Greer, Chair, Geology Department, Washington and Lee University. Initial review of applications will begin Sept. 1; we will be available to meet with potential candidates at the fall GSA meeting in Denver. Review will continue until the position is filled. The University is an Equal Opportunity Employer.

Assistant Professor

About the Position: Applications are invited for a tenure track Assistant Professor position in Stable Isotope Geochemistry in the Geology Department at WWU in Bellingham, WA, with an expected start date of September 2017. We encourage applications from candidates from underrepresented backgrounds who are interested in this faculty position.

Position Responsibilities: The ideal candidate will enhance our existing strengths in geoscience teaching and research by developing new courses and research avenues in stable isotope geochemistry applied to any of a diverse range of geoscience problems. Areas of interest include, but are not limited to paleoclimatology/paleolimnology/paleoceanography/paleoecology, fluid flow and fluid-rock interactions, applications of stable isotopes to (bio)geochemical processes and (bio)mineralization. The applicant will be expected to successfully contribute to the department's course and curricular offerings, establish a successful research program that includes BS and MS students and securing external funding for support of major research instrumentation, work with department faculty and staff to develop connections to WWU departments and programs in marine and environmental sciences and allied fields. The faculty member will be expected to participate in service activities, including departmental committees and student advising.

Required Qualifications:

• Earned doctorate by hire date in the geosciences with an emphasis and experience in stable isotope geochemistry.

• Record of or potential for high quality undergraduate teaching

• Commitment to establishing a vigorous research program involving graduate and/or undergraduate students

• Ability to establish an externally-supported research program

• Demonstrated commitment to working effectively with a diverse student body

Preferred Qualifications:

• Post-doctoral research experience in the geosciences.

• Experience teaching in a BS and/or graduate program

• Ability and interest to work with other interdisciplinary programs in materials science, marine and environmental science

• Experience or demonstrated ability managing geochemistry research lab

Application Instructions: Applications must include (1) a detailed cover letter that addresses the required and preferred qualifications and describes the applicant's background and interest in joining the department, (2) a statement outlining the candidate's plans and approaches for teaching and course development at WWU, including a statement on how the applicant's background and experiences (academic and non-academic) have prepared them to effectively teach increasingly diverse students and work effectively with diverse colleagues, (3) a detailed research statement including plans for laboratory development and undergraduate/graduate student involvement in future research projects, (4) a full curriculum vitae including the names, addresses, e-mail addresses, and telephone numbers of three professional references, and (5) undergraduate and graduate transcripts. Submit all application material to the WWU Electronic Application System for Employment (https://jobs.wwu.edu/JobPosting.aspx?JPID=7158).

Inquiries may be addressed to Prof. Brady Foreman at (360) 650-2546 or Brady.Foreman@wwu.edu. WWU is an AA/EO employer. For disability accommodation call (360) 650-3774. Review of applications begins December 19, 2016; position open until filled.

Tenure Track Position

The Department of Geosciences at the University of Massachusetts invites applications for a tenure track position in Aqueous and Environmental Geochemistry at the Assistant Professor level starting Fall 2017. We are seeking talented applicants qualified for an assistant professor position. Under exceptional circumstances, highly qualified candidates at other ranks may receive consideration. A Ph.D. in Geosciences or related field is required at the time of appointment and post-doctoral experience is preferred.

The successful candidate will have research interests within the broad area covered by the position title. These areas might include critical zone and near-surface weathering, processes that occur at solid-water interface, including biological interactions, or chemical, physical and biological processes controlling the transport of dissolved species. It is hoped that the candidate will have interests in isotope or trace element geochemistry and the application of geochemical tools to a broad range of scientific questions.

Research within the Department of Geosciences revolves around four main clusters: Global Change and Surface Processes; Water; Dynamic Earth; and Geography, Society and the Environment. It is expected that successful candidate will develop a rigorous externally funded research program and contribute to one or more of these research themes. Candidates who have experience in integrating geochemical tools with quantitative approaches to solving problems in natural systems are especially encouraged. Field-oriented research that could be incorporated into both undergraduate and graduate courses will be an asset. Teaching will involve participation in a large-enrollment introductory course in addition to appropriate advanced undergraduate and graduate courses.

Applicants must submit a cover letter, CV, research statement, teaching statement, and contact information for three referees familiar with their research and teaching efforts to http://umass.interviewexchange.com/jobofferdetails.jsp?JOBID=76620. For more information, visit the Department of Geosciences website (www.geo.umass.edu) or contact the Search Committee Chair (search@geo.umass.edu). Review of applicants will begin 1 November 2016 and continue until the ideal candidate is identified.

The university is committed to active recruitment of a diverse faculty and student body. The University of Massachusetts Amherst is an Affirmative Action/Equal Opportunity Employer of women, minorities, protected veterans, and individuals with disabilities and encourages applications from these and other protected group members. Because broad diversity is essential to an inclusive climate and critical to the University's goals of achieving excellence in all areas, we will holistically assess the many qualifications of each applicant and favorably consider an individual's record working with students and colleagues with broadly diverse perspectives, experiences, and backgrounds in edu-

Cornell Geochemistry Faculty Position

Cornell is a community of scholars, known for intellectual rigor and engaged in deep and broad research, teaching tomorrow's thought leaders to think otherwise, care for others, and create and disseminate knowledge with a public purpose.

Cornell University's Department of Earth and Atmospheric Sciences seeks to fill a tenure track faculty position in geochemistry with emphasis on magmatic and/or metamorphic processes. This is expected to be one in a series of faculty renewal hires. Areas of interest include, but are not limited to subduction-related processes; formation, evolution and recycling of the oceanic and/or continental crust; fluid-rock interactions at hydrothermal, metamorphic and magmatic conditions; and volatile recycling. Approaches can be theoretical, observational and experimental. The successful candidate will be expected to contribute intellectually to our broad program in solid earth processes, and to interact with other research programs and units at Cornell. Applicants must hold a doctorate in an appropriate field, have a demonstrated ability to conduct outstanding research, and show promise for attracting external research support. The successful candidate will be a committed educator, enthusiastic about teaching and supervising student research at all levels. We anticipate filling the position at the Assistant Professor level, but applications for Associate level will be considered; salary and rank will be commensurate with qualifications and experience.

Cornell has a Dual Career program. We strongly encourage women and underrepresented minorities to apply. Applicants should submit: a cover letter addressed to search committee chair, Dr. Geoff Abers, a curriculum vita, research statement, teaching statement, and complete contact information for three references. Statements should include teaching experience and interests, leadership efforts, and contributions to diversity.

All materials must be submitted on-line at **https://academicjobsonline.org/ajo/jobs/8080**; inquiries only to abers@cornell.edu. Review of applications will begin November 20, 2016.

Cornell University is an innovative Ivy League university and a great place to work. Our inclusive community of scholars, students and staff impart an uncommon sense of larger purpose and contribute creative ideas to further the university's mission of teaching, discovery and engagement. Located in Ithaca, NY, Cornell's far-flung global presence includes the medical college's campuses on the Upper East Side of Manhattan and in Doha, Qatar, as well as the new CornellNYC Tech campus to be built on Roosevelt Island in the heart of New York City.

Diversity and Inclusion are a part of Cornell University's heritage. We're an employer and educator recognized for valuing AA/EEO, Protected Veterans, and Individuals with Disabilities.

cational, research or other work activities. We will also favorably consider experience overcoming or helping others overcome barriers to an academic degree and career.

W. O. Crosby Postdoctoral Fellowship

The Department of Earth, Atmospheric and Planetary Sciences at the Massachusetts Institute of Technology (MIT) invites applications for the W. O. Crosby Postdoctoral Fellowship. The two-year fellowship supports exceptional early-career scientists with research interests in the fields of geology, geochemistry, or geobiology. Crosby Fellows pursue independent research but are encouraged to collaborate with one or more researchers in the department. A faculty mentor hosts each fellow. Prospective fellows are strongly encouraged to contact members of the department to discuss possible collaborations. The fellowship includes an annual stipend of $64,000, full coverage of premiums for affiliate health, dental and vision insurance, and an allowance of $5,000 per year for research and relocation expenses. The start date of the fellowship is flexible, but should ideally fall between June 1, 2017, and January 31, 2018. Applicants must have obtained a Ph.D. by the start date, but not more than three years before the start date.

Applications are due by December 1, 2016, and must include a curriculum vitae with a list of publications, a two-page plan of research to be conducted during the fellowship, and three reference letters.

A description of the application process is at http://eapsweb.mit.edu/crosby

MIT is an equal employment opportunity employer. All qualified applicants will receive consideration for employment and will not be discriminated against on the basis of race, color, sex, sexual orientation, gender identity, religion, disability, age, genetic information, veteran status, ancestry, or national or ethnic origin.

GLOBAL ENVIRONMENTAL CHANGE

ASSISTANT PROFESSOR

The Department of Geography at Dartmouth College seeks an ASSISTANT PROFESSOR with a specialty in climate science, biogeochemical cycling, and/or earth systems modeling. We welcome applications from candidates with an established record of excellence in teaching and research to augment and complement the department's strengths in physical/environmental geography. Candidates should hold a Ph.D. or be in the final stages of a Ph.D. program. Application review will begin November 15th and will continue until the position is filled.

Dartmouth College is an equal opportunity/affirmative action employer with a strong commitment to diversity and inclusion. We prohibit discrimination on the basis of race, color, religion, sex, age, national origin, sexual orientation, gender identity or expression, disability, veteran status, marital status, or any other legally protected status. Applications by members of all underrepresented groups are encouraged. Please submit a letter of application, C.V., writing samples, and contact information for three referees. Inquiries should be directed to Search Committee Chair Frank Magilligan.

HYDROLOGY

Tenure-Track Faculty – Director of the Center for Hydrologic Studies

The Department of Civil, Construction, and Environmental Engineering at The University of Alabama invites applications for the Directorship of a new Center proposed to be in the area for Hydrologic Studies. Candidates will be considered for appointment at the rank of Associate or Full Professor commensurate with experience and qualifications.

The Director of the Center for Hydrologic Studies would lead research efforts focusing on water quantity challenges that impact human lives, specifically flood and drought events. Candidates with collaborative research experiences with computer science and remote sensing would be preferred. The candidate is expected to engage with researchers across the UA campus to develop multi-disciplinary research targeting opportunities with the NOAA National Water Center (currently located on the campus of the University of Alabama), the US Army Corps of Engineers (located in nearby Vicksburg, MS), the National Science Foundation and other federal and state agencies. The development of multi-institutional proposals, working with universities both nationally and internationally is also expected. The Director position is part of a University of Alabama water initiative in which multiple faculty positions are being hired in engineering and sciences. The Director would manage and lead a group of outstanding faculty that provide expertise in water quantity. The preferred candidate would exhibit experiences in multiple areas of hydrologic research including computational hydrology, statistically based modeling, paleo-hydrology, data mining and management of "big" data, and/or integration of remote sensed data.

The department benefits from the College and University's expansion in enrollment and facilities including completion of the $300 MM Engineering and Science Complex in 2013. These buildings provide nearly one million ft.^{2} of state-of-the-art research and instructional space.

Applicants must have an earned doctorate (Ph.D.) in civil engineering or a closely related field. Application packages must be submitted electronically and should consist of a cover letter, CV, statements of research and teaching interests, and contact information for at least three references. Applications will be accepted and reviewed continuously until the positions are filled with a possible start date as early as January 2017. Apply online at http://facultyjobs.ua.edu (Requisition #0810343). Questions about the positions can be directed to Dr. W. Edward Back (eback@eng.ua.edu).

The University of Alabama is an Equal Employment/Equal Educational Opportunity Institution. All qualified applicants will receive consideration for employment without regard to race, color, religion, national origin, sex, sexual orientation, age, genetic information, disability, or protected veteran status, and will not be discriminated against because of their protected status.

Tenure-Track Faculty – Director of the Center for Water and the Environment

The Department of Civil, Construction, and Environmental Engineering at The University of Alabama invites applications for the Directorship of a new proposed Center for Water and the Environment. Candidates will be considered for appointment at the rank of Associate or Full Professor commensurate with experience and qualifications.

The Director of the proposed new center would lead research efforts focusing on water quality challenges that impact society and the environment. The candidate is expected to engage with researchers across the UA campus to develop multi-disciplinary research targeting opportunities with appropriate funding organizations. The Director position is part of a University of Alabama water initiative in which multiple faculty positions are being hired in engineering and sciences. The Director would manage and lead a group of outstanding faculty that provide expertise in water quality addressing the challenge of sustainable management of water for health and human development. The preferred candidate would exhibit experiences in multiple areas of research such as global water health and development, environmental sustainability, drinking water and wastewater treatment, and chemical/biological processes influencing the environmental health conditions for urban populations.

The department benefits from the College and University's expansion in enrollment and facilities including completion of the $300 MM Engineering and Science Complex in 2013. These buildings provide nearly one million ft.^{2} of state-of-the-art research and instructional space.

Applicants must have an earned doctorate (Ph.D.) in civil engineering or a closely related field. Application packages must be submitted electronically and should consist of a cover let-

ter, CV, statements of research and teaching interests, and contact information for at least three references. Applications will be accepted and reviewed continuously until the positions are filled with a possible start date as early as January 2017. Apply online at http://facultyjobs.ua.edu (Requisition #0810344). Questions about the positions can be directed to Dr. W. Edward Back (eback@eng.ua.edu).

The University of Alabama is an Equal Employment/Equal Educational Opportunity Institution. All qualified applicants will receive consideration for employment without regard to race, color, religion, national origin, sex, sexual orientation, age, genetic information, disability, or protected veteran status, and will not be discriminated against because of their protected status.

INTERDISCIPLINARY

Assistant/Associate Professor of Invertebrate Paleontology

The Department of Biodiversity, Earth & Environmental Science at Drexel University seeks applicants for a tenure-track assistant or associate professor appointment in invertebrate paleontology. Areas of interest include, but are not limited to, Systematic and Evolutionary Biology, Paleoecology, Climatology and Conservation Paleobiology, with the aim of deploying paleontological data to understand patterns of global change. The successful candidate will develop a research program in their subject area; will teach courses in Invertebrate Paleontology and Stratigraphy, and other potential courses; and will be Curator of the Invertebrate Paleontology collection at Drexel's Academy of Natural Sciences. The ability to collaborate with other research groups at the university, such as Environmental Biogeochemistry and Environmental Engineering, is a plus. Drexel University emphasizes experiential learning and field-oriented candidates are encouraged to apply.

Candidates must have a Ph.D. in Geology, Invertebrate Paleontology or a related field, a record of scientific achievement, a strong interest in undergraduate and graduate teaching, and must be able to develop a high-quality, externally-funded research program. For the Associate level, the candidate must demonstrate extramural funding.

Qualified candidates should submit a cover letter, CV, a summary of research experience, a statement of teaching philosophy, and a list of three or more references with postal address, email address, and telephone number.

Applicants should apply online at drexeljobs.com (Position # 7849). Review of applications will begin December 1st, 2016 and will continue until the position is filled. Inquires may be sent to Dr. Gary Rosenberg, Search Committee Chair at gr347@drexel.edu.

Drexel University is an Equal Opportunity/Affirmative Action Employer and is proactively committed to diversity and inclusion in all of its policies, practices and services. We are especially interested in qualified candidates who can contribute to the varied diversity and excellence of the academic community, and all of its complements.

Assistant Professor

Department of Earth and Environmental Sciences at California State University East Bay invites applications for an assistant professor tenure-track position in Environmental Geoscience to begin in Fall 2016. The successful candidate will be broadly trained in geoscience, with a specialization related to surficial processes and sustainability, such as the effects of landslides and mass wasting, sea level rise, urban riparian landscape restoration, etc. The person filling this position should be qualified to teach a range of undergraduate courses in the department's Geology and/or Environmental Science programs, and courses in the candidate's area of expertise. Candidates with expertise and advanced degrees in Earth science, environmental science, geomorphology, civil/environmental engineering, etc. are strongly encouraged to apply. Applicants should have a Ph.D., outstanding teaching skills, and a commitment to pursue an active research and teaching program in partnership with other faculty engaged in sustainability issues at CSUEB. Review of applications will begin November 1, 2016, and the position will be considered open until filled (applications after November 1 will be accepted). Please see the full position announcement at: https://apply.interfolio.com/35239. CSUEB is an Equal Opportunity Employer.

Questions? Please contact Mike Massey at mike.massey@csueastbay.edu.

Endowed Chair

The Department of Earth, Atmospheric, and Planetary Sciences at Purdue University invite applications for the Steven and Karen Brand Chair in unconventional energy resources. Candidates with a core expertise in unconventional energy with a strong and consistent track record of applying this expertise to unconventional petroleum resources will be considered. Candidates with expertise including, but not limited to, unconventional exploration and production, tight reservoir characterization, geophysics and seismic data analysis, subsurface integration, hydraulic fracture mechanics, pore/fluid interactions, water and environmental issues, and enhanced oil and gas recovery are encouraged to apply. Excellence in and/or commitment to

Assistant/Associate/Full Professors - Physical and Biological Oceanography, Marine Geophysics/Geology, and Ocean Engineering

South University of Science and Technology of China

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

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

To apply submit a cover letter, complete vitae with list of publications, and three names of references via http://talent.sustc.edu.cn/en/, or to Dr. Y. John Chen, Chair Professor at School of Oceanography, South University of Science and Technology of China, No 1088, Xueyuan Rd., Xili, Nanshan District, Shenzhen, Guangdong, China 518055.

Faculty Positions in Environmental Science and Engineering
South University of Science and Technology in Shenzhen, China

The South University of Science and Technology (known as SUSTC or SUSTech) (http://www.sustc.edu.cn/en) is a public university founded in the Shenzhen Special Economic Zone of China. It is intended to be a top-tier international university that excels in interdisciplinary research, nurturing innovative talents and delivering new knowledge to the world. SUSTC is conducting a global search for talented faculty who are also innovators and trailblazers. Founded since 2015, the School of Environmental Science and Engineering at SUSTC aspires to become a center of excellence for cutting-edge and multidisciplinary environmental research. We invite applications for tenure-track and tenured faculty positions in broadly defined environmental science and engineering. Research areas include but are not limited to: hydrology and water resource engineering, water pollution and treatment, atmospheric chemistry, air pollution control, solid waste utilization, ecosystem assessment, environmental remote sensing, and global change. Positions are immediately available at all ranks. Highly competitive salaries and start-up packages will be provided. The successful candidates will have great opportunities to advance environmental research in China as the country faces up to enormous challenges in achieving environmental sustainability.

Applicants should have a Ph.D. degree in a water, air, or earth system related discipline. Candidates must have a proven track record of high-quality scientific publications and must have excellent communications skills. Those interested are invited to apply by submitting the following material electronically to iese@sustc.edu.cn: 1) Curriculum Vitae (with a complete list of publications); 2) Statement of research interests; 3) Statement of teaching philosophy; 4) Selected reprints of three recent papers; and 5) Names and contact information of five references. Review of applications will begin immediately and continue until the positions are filled.

multi-disciplinary research and teaching is a requirement. It is expected that the candidate hired would significantly enhance Purdue's visibility and impact in this key area; increase opportunities for industry collaboration and grant funding; and inspire and train the next generation of leaders in the field.

This is an open-rank search; senior or mid-career scientists with academic, national laboratory, and industry background are all encouraged to apply. Applicant must hold a doctorate in an appropriate field; salary and rank are commensurate with qualifications and experience. The Department of Earth, Atmospheric, and Planetary Sciences, and the College of Science at Purdue embrace diversity and seek candidates who will have experience working with diverse groups.

The department, in collaboration with other departments, has expertise in solid earth geophysics and crustal seismology, fracture mechanics, fluid flow in porous media, hydrogeology, clay mineralogy and surface chemistry, and basin analysis. The department has a long tradition of training students for careers in the petroleum industry and is part of a new multidisciplinary initiative at Purdue University aimed at addressing the energy needs of the country and is affiliated with the newly established Enhanced Oil Recovery Laboratory located in Discovery Park. Faculty members have a long history of working closely with and providing leadership to various Purdue University Discovery Park Centers (www.purdue.edu/DP). The successful applicant will conduct research, will advise graduate students, will teach undergraduate and graduate level courses, and will perform service. The successful applicant will be expected to work across these existing areas of Purdue expertise and build on them with a focus on unconventional resources. Applicants should have a vision for the design and execution of a cross-functional program that achieves the intended mission as described above.

Interested applicants should visit https://hiring.science.purdue.edu; submit a curriculum vitae, a research statement, a vision statement, a teaching statement, and complete contact information for at least 3 references. Review of applications will begin October 31, 2016, and continue until the position is filled. Questions related to this position should be sent to Ken Ridgway, Chair of the Search Committee, email ridge@purdue.edu. Applications will be accepted until the position is filled.

Purdue University is a dynamic, growing university and a great place to work. Our inclusive community of scholars, students and staff impart an uncommon sense of larger purpose and contribute creative ideas to further the university's mission of teaching, discovery and engagement.

Purdue University is an EOE/AA employer. Purdue University is committed to maintaining a community which recognizes and values the inherent worth and dignity of every person. In pursuit of its goal of academic excellence, the University seeks to develop and nurture diversity. All qualified applicants for employment will receive consideration without regard to race, religion, color, sex, national origin or ancestry, genetic information, marital status, parental status, sexual orientation, gender identity and expression, disability or status as a veteran.

Faculty Position in Data Science

As part of Rice University's recently announced $150 million investment in research excellence, Rice intends to hire multiple faculty members whose research focus is in data science. We seek two distinct kinds of specialists: (1) data scientists who can make fundamental contributions to the theory, algorithms, and systems aspects of data science, and (2) scholars who work on emerging applications of data science to problems in health and medicine, urban analytics, and high-volume or high-velocity data-intensive science. A successful candidate might have demonstrated capacity in either of these specialties, or in both of them.

The Data Science initiative seeks candidates at all ranks, for employment as early as July 1, 2017. All new hires will have an appointment in one or more relevant department. Assistant Professors will have a single primary department that will be responsible for their mentoring and promotion. At higher ranks, appointments across multiple departments are desirable.

Individual departments at Rice also have active faculty searches this year. Those searches are distinct from the Data Science search and may include research areas beyond those included in the Data Science search. Interested candidates should consider applying to both the Data Science search and any appropriate departmental search.

Applicants to the Data Science search should submit the following: (1) cover letter; (2) curriculum vitae; (3) research statement which describes how the candidate's work fits with Rice's data science initiative (not to exceed three pages including figures); (4) teaching statement; and (5) the names, professional affiliations, and email addresses of three references. For full details and to apply, please visit: https://jobs.rice.edu/postings/8141. These positions require a PhD, or PhD requirements fulfilled by November 1 of the year employment commences. Applications will be evaluated beginning on October 1, 2016 and will continue to be accepted until all positions are filled. Recommendation of candidates or questions regarding this opportunity can be directed to Cin-Ty Lee at ctlee@rice.edu.

Rice University, located in Houston, Texas, is a private, coeducational, nonsectarian university that aspires to path-breaking research, unsurpassed teaching, and contributions to the betterment of our world. Rice fulfills this mission by cultivating a diverse community of learning and discovery that produces leaders across the spectrum of human endeavor. From its beginning in 1912, Rice has been dedicated to excellence in all regards.

Rice University is an Equal Opportunity Employer with commitment to diversity at all levels, and considers for employment qualified applicants without regard to race, color, religion, age, sex, sexual orientation, gender identity, national or ethnic origin, genetic information, disability or protected veteran status.

Faculty position

The University of North Dakota is seeking qualified applicants for a tenure-track/tenured faculty position within the Department of Atmospheric Sciences. The successful candidate will be expected to teach undergraduate and graduate courses and develop a program of externally-funded support.

Please send a curriculum vitae, statement of professional goals and the names and addresses of at least three professional references to: Prof. Michael Poellot, Chair of Search Committee, Atmospheric Sciences, Clifford Hall Room 400, 4149 University Avenue Stop 9006, Grand Forks, ND 58202-9006. Phone: 701-777-3180; Fax: 701-777-5032; E-mail: poellot@aero.und.edu.

Additional information can be found at: http://www.atmos.und.edu.

Graduate Assistantships

With broad expertise in geosciences and particular strengths in Geochemistry, IUPUI's Earth Sciences department provides opportunities for graduate training and research in downtown Indianapolis. We offer an M.S. in Geology and Ph.D. in Applied Earth Sciences. The Ph.D. program provides opportunities for advanced interdisciplinary research at the interface of earth sciences, public health, and geospatial analysis, and will prepare graduates for solving important interdisciplinary problems of the 21st century. Our interdisciplinary program welcomes individuals from diverse backgrounds in Geology, Environmental Science, Chemistry, Biology, Physics, Engineering, Medical or Mathematics. Applicants will be considered for our Mirsky Fellowship, along with other teaching and research assistantships available in the department for Fall 2016. The department has 13 full time faculty with active research programs in topics including aqueous and microbial geochemistry, stable isotopes, paleoclimatology and global change, medical geology, surface and hard rock geology, planetary geology,

UNIVERSITY OF MARYLAND

University of Maryland, College Park

Director: Earth System Science Interdisciplinary Center (ESSIC)

Leading a significantly expanded vision for ESSIC, the Director will leverage excellence across the campus relevant to the Earth system to build co-operative partnerships with the natural sciences and departments in a wide range of colleges, including but not limited to Agriculture and Natural Resources, Engineering, Public Health, and Public Policy. S/he will be a scientist of the highest quality in any of the disciplines essential to understanding the Earth system and must be a recognized player in the Earth system community, with a strong record of strategic leadership and a demonstrated ability to work collaboratively and successfully, nationally and internationally, inside and beyond academia. ESSIC has 11 academic faculty and 150 research scientists, with an annual research income of approximately $35M, and the Director must have a strong commitment to faculty and staff development. Appointed for a five year (renewable) term reporting to the Dean of the College of Computer, Mathematical and Natural Sciences s/he will also hold a tenured Full Professorship in an appropriate department on the campus. Ph.D. or equivalent required.

Applicants should submit as a SINGLE document a Curriculum Vitae including publications, a description of how their research and their experience qualify them for this position and the names and contact information for five referees. For more detail see http://essic.umd.edu

Please apply at: http://go.umd.edu/essicdir

The position will remain open until filled, but for best consideration applications should be received by December 31, 2016. Inquiries may be sent to: Professor Steve Halperin at shalper@umd.edu.

The University of Maryland, College Park, is an equal opportunity/affirmative action employer.

remote sensing, biogeosciences, geomorphology and hydrology. Several new state-of-the-art geochemistry labs have been built and equipped with stable isotope ratio mass spectrometers, cavity ring down spectrometers, GC-MS, ICP-MS, ICP-OES, electrochemical equipment, chromatographs (IC, HPLC, GC), spectroscopes, XRD, multisensor core scanner, and a full suite of wet chemical, solid state, and biological lab and field equipment. Assistantships include salary, tuition remission, and health insurance. Indianapolis is a very affordable, livable, and vibrant city with a wealth of outdoor, cultural, and sporting activities. Visit http://earthsciences.iupui.edu/ and http://earthsciences.iupui.edu/graduate/degrees for additional information on our department and graduate degrees, respectively.

Project Leader positions in Climate Research

The new IBS Center for Climate Physics (ICCP) (scheduled to open on January 1st, 2017, upon final approval of Korean government) at Pusan National University, Busan, South Korea, is seeking to recruit Project Leaders in the following fields:

1) Past-to-future transient climate modeling

2) Paleo climate dynamics (large-scale processes and modeling)

3) Polar processes (ice-sheet-ocean-sea ice-atmosphere dynamics)

The successful applicants, with at least 6 years of postdoctoral experience, will lead and supervise a small research team (1-2 research fellows) to conduct innovative, cutting-edge research leading to high-impact publications in international refereed journals. The project leaders will closely interact with the ICCP director and other research groups within the center. Travel and workshop funds will be available and access to a new supercomputer will be established in 2017/18.

Applicants should be emerging leaders in their field and have a PhD or equivalent in physical oceanography, atmospheric science, climate dynamics (or related). Applicants should have an outstanding publication record, a high level of independence and proven leadership skills and experience.

The positions are fixed term (initially 3 years) with possibility for renewal of up to ten years. The salary range will be: $70,000-80,000 (including social benefits). The closing date for the application is 15th of October 2016.

Application procedure:

Please submit a cover letter, statement of your research visions, curriculum vitae, the name of 5 references, and three publications to Ms. Ji Kim (jikim0204@pusan.ac.kr), Please indicate in your application, which project leader position you are applying for.

Research fellow positions in climate research

TEmployer: IBS Center for Climate Physics

Location, Pusan National University, Busan, South Korea

Discipline: Climate Dynamics, climate modeling, physical oceanography, biogeochemistry, ice-sheet processes, human migration/ecosystem modeling

Career Level: Education Level: PhD

Job type: Research Fellow

Career Level: Postdoctoral Fellow, Assistant Researcher

Salary: 50-65 million KRW/year (~$45,000-58,500) + incentives

Term: Full Time, 3 year, with possibility for renewal

Closing Date: 15th October 2016

Start data of position: February 1st, 2017 or later

The new IBS Center for Climate Physics (ICCP) (scheduled to open on January 1st, 2017 upon final approval of Korean government) at Pusan National University in Busan, South Korea, is seeking to recruit Research Fellows in the following fields:

1) Tropical Climate Dynamics: past, present, future

2) Past-to-future transient climate Modeling

3) Polar processes (ice-sheet-ocean-sea ice-atmosphere dynamics)

4) Marine Biogeochemistry (large-scale processes and modeling)

5) Climate changes and human migration and evolution

Applicants should be cutting-edge scientists, have a PhD or equivalent in physical oceanography, atmospheric science, climate dynamics (or related). Applicants should have a strong publication record and a high level of independence and creativity.

Application procedure:

Please submit a cover letter, statement of your research visions, curriculum vitae, the name of 3 references, and three publications to Ms. Ji Kim (jikim0204@pusan.ac.kr), Please indicate in your application, which of the 5 research fields you are mostly interested in.

Research Scientist Position Available

The Crustal Geophysics and Geochemistry Science Center (CGGSC) has an open position for a capable, established research scientist able to join and enhance our team of remote sensing experts. The CGGSC invites applications for a permanent Research Geophysicist/Physical Scientist/Geologist position that is supported by the Mineral Resources Program. We seek candidates that combine a broad expertise in remote sensing, with an emphasis on the use of imaging spectroscopy techniques (laboratory, theoretical and field), that may be applied to such topics as mineral resource and disaster/hazard assessments, geoenvironmental and planetary investigations, and human health issues.

The position will be filled at the GS-14 level (salary is $107,272 to $139,457 per annum). The successful candidate will have a demonstrated publication record and will have developed, or show the potential to devise and lead a nationally recognized research program in earth sciences. Detailed vacancy requirements and applications procedures for the Research Scientist position can be found at www.usajobs.gov under vacancy announcement #DEN-2016-0481. This recruitment will open on October 1, 2016 and applications must be submitted by midnight MST on October 31, 2016 in order to be considered.

The U.S. Geological Survey is an Affirmative Action/Equal Opportunity employer that values diversity. Women, persons with disabilities, and members of other under-represented groups are encouraged to apply. Additional details of the CGGSC (research scientists, support staff, and facilities) and the U.S. Geological Survey's Mineral Resources Program may be viewed at our web pages http://crustal.cr.usgs.gov/index.html and http://minerals.usgs.gov/.

Tenure-Track Assistant Professor Position

The University of Alabama (UA) Department of Geological Sciences invites applications for a tenure-track faculty position in integrated hydroclimate modeling, beginning August 2017. The position will be filled at the Assistant Professor level. Candidates must have a strong record of research and a Ph.D. by the time of appointment in hydro-climate systems science, water-atmospheric science, and/or a closely related field, preferably with specialization in integrated modeling of atmospheric processes and hydrologic response, as they impact water management, availability, dis-

tribution, and sustainability. The candidate's research would ideally aim to understand and model the movement of water between the atmosphere, land surface, soil, and/or subsurface reservoirs, and how changes in future climate affect water resources and/or environment from regional to global scales. The successful candidate will be expected to establish a strong, externally-funded research program and to attract high-quality Ph.D. and M.S. graduate students. The candidate will also be expected to teach introductory courses related to their field and undergraduate and graduate courses in hydroclimate sciences and modeling, water resources, and water-atmosphere interactions, advise graduate students, and contribute to the Department's research program in water resources and environmental geology. Existing working relationships and collaboration with entities such as NOAA, NASA, USGS, NCAR, DOE, and/or NSF is seen as positive. Opportunities for research collaboration also exist with the NOAA National Water Center, the Environmental Institute, the Geological Survey of Alabama, the Center for Sedimentary Basin Studies, the Center for Freshwater Studies, and the Water Policy and Law Institute, all located on The University of Alabama campus. The Department has a broad range of resources and existing facilities, including modeling and computational resources, field and laboratory equipment, and chemical and stable isotope analytical facilities. Questions should be directed to Dr. Geoff Tick (gtick@ua.edu), Chair of the Integrated Hydroclimate Modeler Search Committee. Applicants should submit a cover letter, curriculum vitae, research statement, teaching statement, and names and contact information for at least three referees through the UA Jobs Website at: facultyjobs.ua.edu. Review of applications will begin December 1, 2016, and continue until the position is filled. The University of Alabama is an equal opportunity/affirmative action employer and actively seeks diversity in its employees.

Wiess Post-Doctoral Research Fellowship

The Department of Earth Science at Rice University is inviting applications for the Wiess Post-Doctoral Research Fellowship in the broad fields of Earth, atmospheric, and planetary sciences.

Applicants must have a Ph.D. awarded within three years of the time of appointment.

The research fellowship will be supported by the Department of Earth Science for two years pending satisfactory progress in their first year. The fellowship covers an annual stipend of $60,000 with a benefits package and an additional annual discretionary research allowance of $3,500.

Applicants are requested to develop a proposal of research to be undertaken during the fellowship period. The principal selection criteria are scientific excellence and a clearly expressed research plan to address questions at the forefront of Earth science, broadly defined. Applicants are encouraged to explore possible research synergies with faculty in the Department of Earth Science (http://earthscience.rice.edu), but the proposed research should encompass independent research ideas and explore new directions beyond the applicant's Ph.D. Preference will be given to candidates whose proposals demonstrate independence and originality, and also the potential for collaboration with one or more faculty in the Department of Earth Science.

Candidates are required to submit:

1. A cover letter addressed to the search committee chair
2. A research proposal of no more than 3 pages (single-spaced) including figures
3. A current CV, including a list of publications

All documents should be submitted as a single PDF file by 15 November, 2016, to the chair of the fellowship search committee (esci-postdoc@rice.edu). In addition, three letters of reference should be submitted separately by each referee to the chair of the fellowship chair committee (esci-postdoc@rice.edu) by 15 November, 2016.

The highest ranked candidates will be invited to visit Rice in early 2017. Following acceptance, the appointment may begin anytime before January 1st 2018. For further information or questions contact the chair of the search committee at esci-postdoc@rice.edu.

Rice University, located in Houston, Texas, is a private, coeducational, nonsectarian university that aspires to path-breaking research, unsurpassed teaching, and contributions to the betterment of our world. Rice fulfills this mission by cultivating a diverse community of learning and discovery that produces leaders across the spectrum of human endeavor.

Rice University is an Equal Opportunity Employer with commitment to diversity at all levels, and considers for employment qualified applicants without regard to race, color, religion, age, sex, sexual orientation, gender identity, national or ethnic origin, genetic information, disability or protected veteran status.

PALEOCEANOGRAPHY

Assistant Professor

The Colby College Department of Geology invites applications for a tenure-track position in marine geology/geochemistry at the level of Assistant Professor to begin September 1, 2017. This position is part of a cluster hire in support of Colby's new Environmental Science initiative. Colby requires strong,

Yachay Tech, Ecuador
School of Geological Sciences and Engineering
Faculty positions available

The School of Geological Sciences and Engineering at Yachay Tech invites applications for tenure track assistant professors in the following fields: geophysics, sedimentology, structural geology, economic geology, hydrology and hydrogeology, climate and oceanography.

Yachay Tech faculty will develop active research programs, direct PhD students, involve undergraduate students in collaborative research projects, and teach (in English) undergraduate and graduate courses in their fields of specialty.

To apply, please send a letter of interest, curriculum vita, statements of research and teaching interests, and names and contact information for three references to Maria del Carmen Alvarado (malvarado@yachaytech.edu.ec), assistant to the Dean. Employment will begin in March 2017 with classes beginning in April 2017.

Yachay Tech is a public, research-intensive university, located in the Inter-Andean valley of Ecuador about two hours north of Quito. Since opening in March 2014, the undergraduate student population has grown to a total of approximately 1000 undergraduates. We anticipate initiating a doctoral program this September 2016.

innovative teaching at all levels of the undergraduate curriculum and an active research program involving undergraduate collaborators. Ideal candidates for this position also will: (1) teach a 200-level, low-temperature-geochemistry or biogeochemistry course in addition to other courses in the Geology Department; (2) present ambitious research plans focusing on the marine/coastal record of environmental change over 100–1,000,000-year timescales; and (3) strengthen collaborations between Colby College and the Bigelow Laboratory for Ocean Sciences on the coast of Maine (www.bigelow.org). There also are opportunities for collaborations with scientists at Colby and other nearby institutions including the University of Maine Climate Change Institute, Bowdoin College, and Bates College. A Ph.D. is required at the time of appointment. The search committee is especially interested in candidates with diverse perspectives and backgrounds, and candidates who have a record of success advising and mentoring individuals from groups under-represented in higher education.

Tenure-track faculty at Colby receive competitive startup packages and are eligible for a pre-tenure sabbatical. Female U.S. citizens are eligible for a Clare Booth Luce Endowed Chair that provides additional research funding throughout their pre-tenure probationary period. Colby faculty are afforded professional travel funding, and can apply for divisional research grants and summer research-assistant funding on a competitive basis. More information about the resources and instrumentation available at Colby and collaborating institutions can be found at: http://www.colby.edu/geologydept and http://www.colby.edu/environmentalstudies.

Complete applications will include a brief cover letter, curriculum vitae, statements of teaching philosophy and research interests, three letters of recommendation, and reprints of recent journal articles. Please submit all materials via Interfolio at: apply.interfolio.com/37632. Applications received by November 30, 2016 will receive full consideration, but applications will be reviewed until the position is filled. Inquiries may also be directed to Marinegeo@colby.edu.

Colby is a private, coeducational liberal arts college that admits students and makes employment decisions on the basis of the individual's qualifications to contribute to Colby's educational objectives and institutional needs. Colby College does not discriminate on the basis of race, color, gender, sexual orientation, gender identity or expression, disability, religion, ancestry or national origin, age, marital status, genetic information, or veteran's status in employment or in our educational programs. Colby is an Equal Opportunity employer, committed to excellence through diversity, and encourages applications from qualified persons of color, women, persons with disabilities, military veterans and members of other under-represented groups. Colby complies with Title IX, which prohibits discrimination on the basis of sex in an institution's education programs and activities. Questions regarding Title IX may be referred to Colby's Title IX coordinator or to the federal Office of Civil Rights.

For more information about the College, please visit our website: www.colby.edu.

PLANETARY SCIENCES

Faculty position

The Department of Earth & Planetary Sciences at The University of Tennessee seeks to fill a faculty position in mineralogy/ petrology/geochemistry with emphasis in planetary geoscience at the rank of Assistant Professor. The position begins August 1, 2017. The University of Tennessee, Knoxville, is a Research I University and the flagship campus of the UT system. The Department (http://eps.utk.edu) focuses on geology and has an active emphasis on planetary research, including the study of terrestrial analogs, through its Planetary Geosciences Institute (http://web.utk.edu/~pgi). Requirements for the position are: Ph.D. in geology or a related field, and demonstrated research experience in planetary/terrestrial geoscience.

The successful candidate is expected to conduct a robust, funded program of planetary/terrestrial research, mentor graduate students, effectively teach courses in mineralogy and/or petrology at the undergraduate and graduate levels, and collaborate in department research dealing with mineralogy, petrology, geochemistry, and solar system exploration. Salary and benefits are competitive and commensurate with experience. The Knoxville campus of the University of Tennessee is seeking candidates who have the ability to contribute in meaningful ways to the diversity and intercultural goals of the University.

To apply, please email the following to jmoersch@utk.edu, with the subject line "Planetary faculty application": C.V., cover letter describing research and teaching experience and plans, and names of 4 references with contact information. Applications received by November 15, 2016, are ensured review, but earlier submission is encouraged. The position will remain open until filled. Questions about the position should be directed to J. Moersch.

The University of Tennessee is an EEO/AA/Title VI/Section 504/ADA/ADEA institution in the provision of its education and employment programs and services. All qualified applicants will receive equal consideration for employment without regard to race, color, national origin, religion, sex, pregnancy, marital status, sexual orientation, gender identity, age, physical or mental disability, or covered veteran status.

Postcards from the Field

Dear Everyone,

Here we are diving in the cool waters of the sinkholes in Thunder Bay National Marine Sanctuary, Lake Huron, in July 2016 (http://bit.ly/thunder_bay). In this photo, National Oceanic and Atmospheric Administration (NOAA) archaeologist John Bright is grabbing cores of cyanobacterial mats that cover the lake floor as part of a collaborative research project with several academic institutions trying to understand life in these low-oxygen, high-sulfur ecosystems. Could modern-day microbial mats like this have oxygenated our planet during life's turbulent childhood?

—Phil Hartmeyer, Maritime Archaeologist, Thunder Bay National Marine Sanctuary, NOAA (www.thunderbay.noaa.gov)

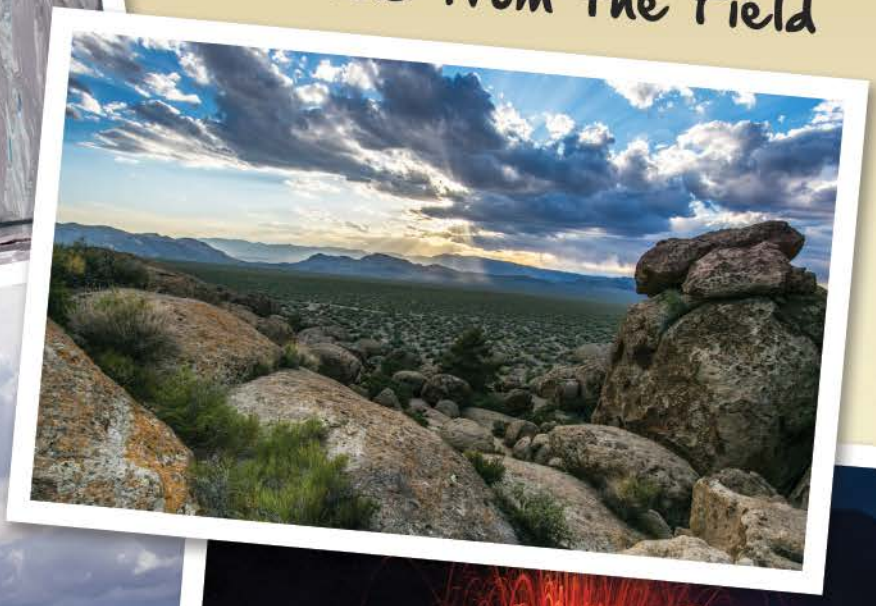
View more postcards at *http://americangeophysicalunion.tumblr.com/tagged/postcards-from-the-field.*

SHARING SCIENCE

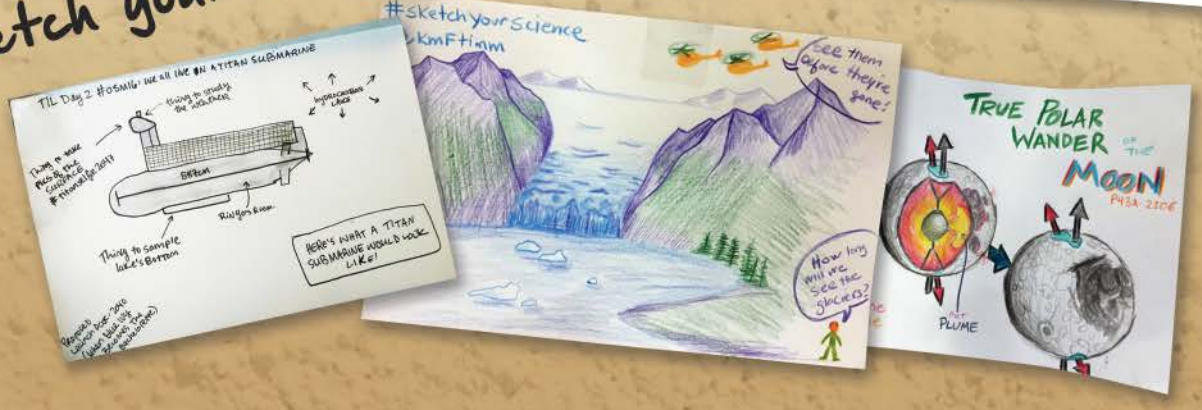
Learn, Engage, Be Inspired!

Two Great Ways to Share Your Science with AGU

Postcards from the Field



Sketch your Science



View postcards and sketches as well as submission guidelines at

americangeophysicalunion.tumblr.com

AGU

Provides Free Global Access to Research Presented at Fall Meeting

Sessions organized by channels, including:

- Climate
- Data & Rising Technologies
- Earth Processes
- Extreme Events & Hazards
- Geohealth
- Planetary Discovery
- Science & Society
- Union

Register or log in at:

AGUondemand.agu.org

Channel names are subject to change. The final program and AGU On-Demand channel listings will be published 3 October.