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Earth & Space Science News

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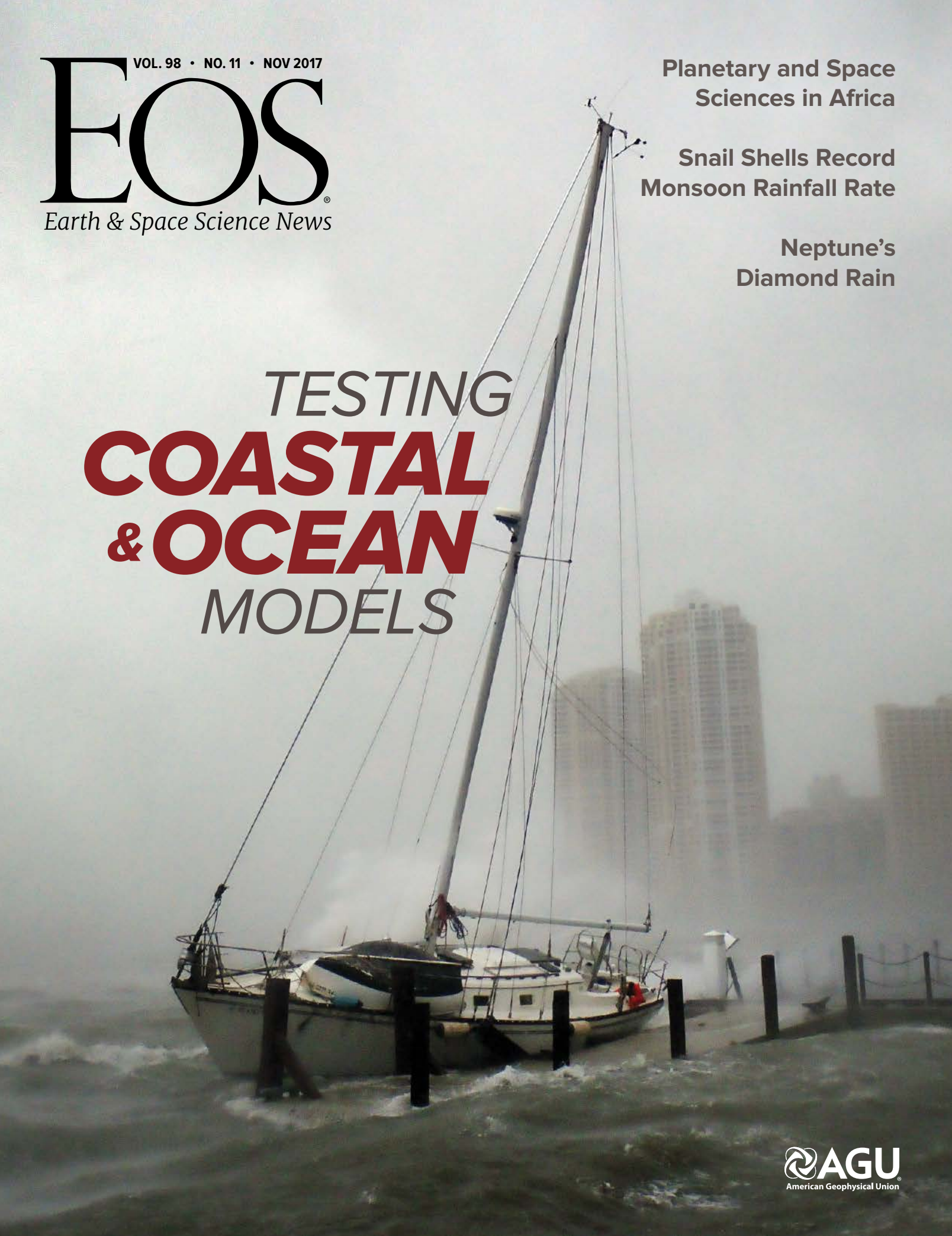

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Christine W. McEntee, Executive Director/CEO

AGU American Geophysical Union

Diamonds Really Do Rain on Neptune, Experiments Show

A very hard rain likely falls inside Uranus and Neptune.

In recent high-energy laser experiments, researchers have replicated the pressures and temperatures found deep in the atmospheres of such planets, known as ice giants. Those extreme conditions in the laboratory compressed hydrocarbon plastics, chemically similar to the methane found in ice giants, into tiny diamonds, giving an experimental boost to a long-standing theory about the characteristics of ice giant planets.

"It was a very surprising experiment," said Dominik Kraus, a researcher at Helmholtz-Zentrum Dresden-Rossendorf in Dresden, Germany. His team had expected very small signs of molecules splitting apart after being subjected to high pressures, "maybe some little hints of diamonds," he explained.

Instead, they found a very strong signal that under intense pressures, hydrocarbons inside Neptune would transform into diamonds. Kraus is lead author of a 21 August *Nature Astronomy* paper (http://bit.ly/Kraus-2017) describing the results.

Pressure Shock

In the recent tests, the experimenters first had to find a substance that was chemically similar to methane (CH_4), a molecule believed to be in about 1.5% abundance on Neptune and the planet's most common component after hydrogen and helium. They hit upon polystyrene (C_8H_8) plastic—not only is it a common material, but also it is easier to use because it's solid at room temperature, whereas methane is gas, which would need to be contained.

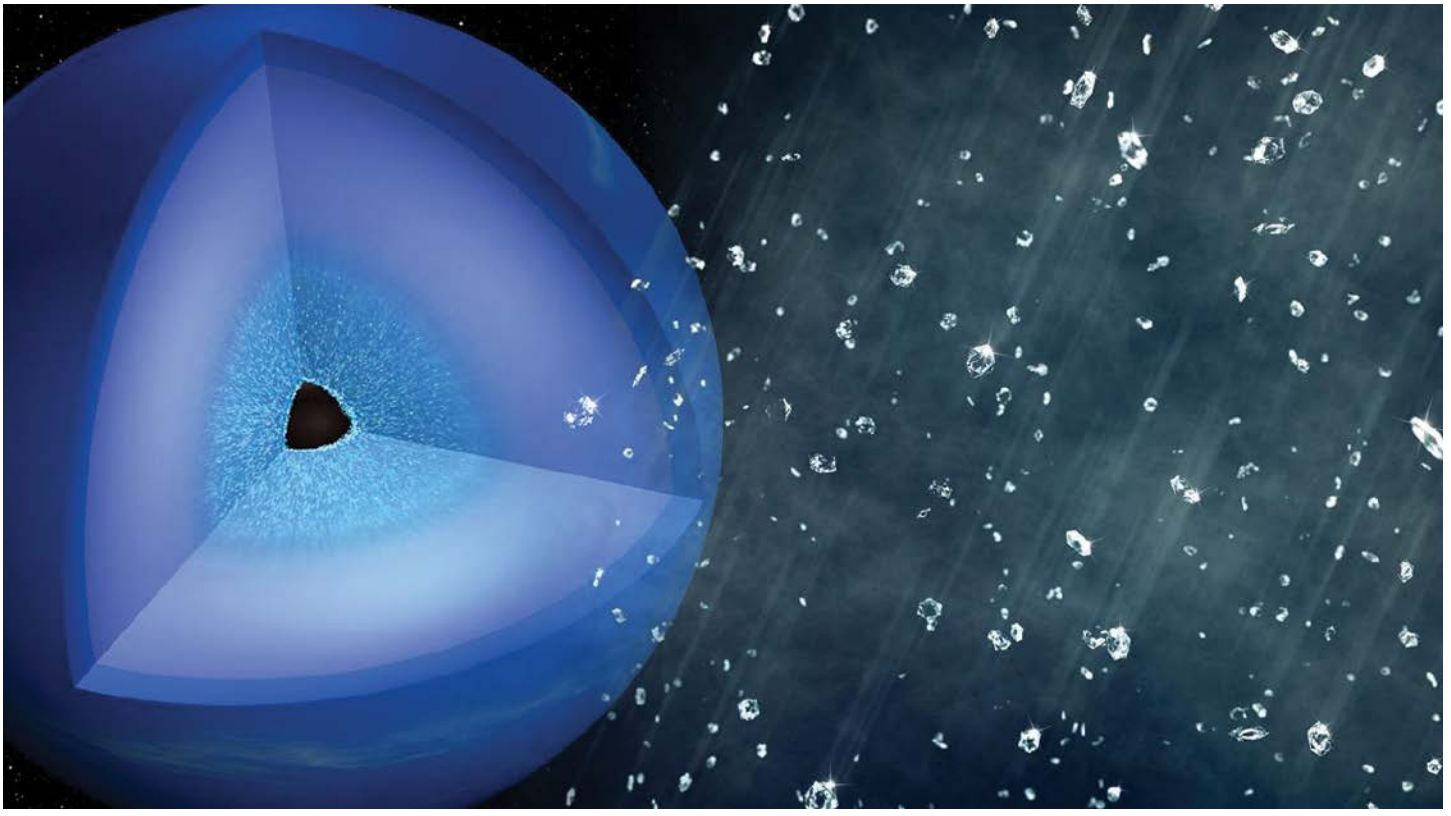
The researchers then fired two short, but intense, pulses from a high-energy X-ray laser at the polystyrene sample. The two laser bursts hitting the sample at nearly the same time exerted a pressure shock almost 1.5 million times greater than Earth's surface atmospheric pressure yet kept the temperature below the melting point of diamond.

The fleeting shock simulated conditions found around 10,000 kilometers below the surfaces of Uranus and Neptune. Then, using X-ray diffraction measurements to continually monitor the chemical nature of the sample after the laser strikes, the researchers witnessed carbon separating from hydrogen and compressing into nanometer-sized diamonds.

Carrying the experiment's analogy back to Neptune, the results indicated that hydrocarbons known to be within Neptune likely condense into a solid as one goes deeper into the planet's interior. The experiments took place at the Stanford Linear Accelerator Center (SLAC) National Accelerator Laboratory in Menlo Park, Calif.

Why Simulate Neptune's Atmosphere?

Knowing how hydrocarbons might behave deep within an ice giant's atmosphere will affect our understanding of how atmospheres transport heat and evolve over time, explained Kraus. What's more, the implications of this research extend beyond our solar system to



A cutaway of Neptune shows the theorized interior structure of the planet, including the region where the hydrocarbon atmosphere may produce diamond rain (light blue) that falls onto the core (black center). A recent experiment observed the formation of diamonds from hydrocarbons under conditions like those found in the interiors of Uranus and Neptune. Credit: Greg Stewart/SLAC National Accelerator Laboratory

exoplanets, as a large fraction of the known exoplanets are similar in size or mass to our ice giants.

The ability to model an ice giant atmosphere's density from the top down to the core is a critical part of characterizing that planet. For example, an atmosphere made mostly of hydrogen is much puffier than one with diamonds, Kraus noted.

A diamond-studded atmosphere also likely behaves very differently than one without diamonds. For example, atmospheric convection might have to overcome more hurdles, which may lead to sharp changes in chemical composition between different atmospheric layers, the researchers said. This could also inhibit heat flow.

"These experiments can be used to improve our understanding of the behavior of common materials in the universe at high pressures and temperatures, which has a direct connection to modeling planetary interiors," said Ravit Helled, a computational science and theoretical astrophysics professor at the University of Zurich in Switzerland, who was not involved in the study.

One-Two Punch Keeps Old Theory in the Ring

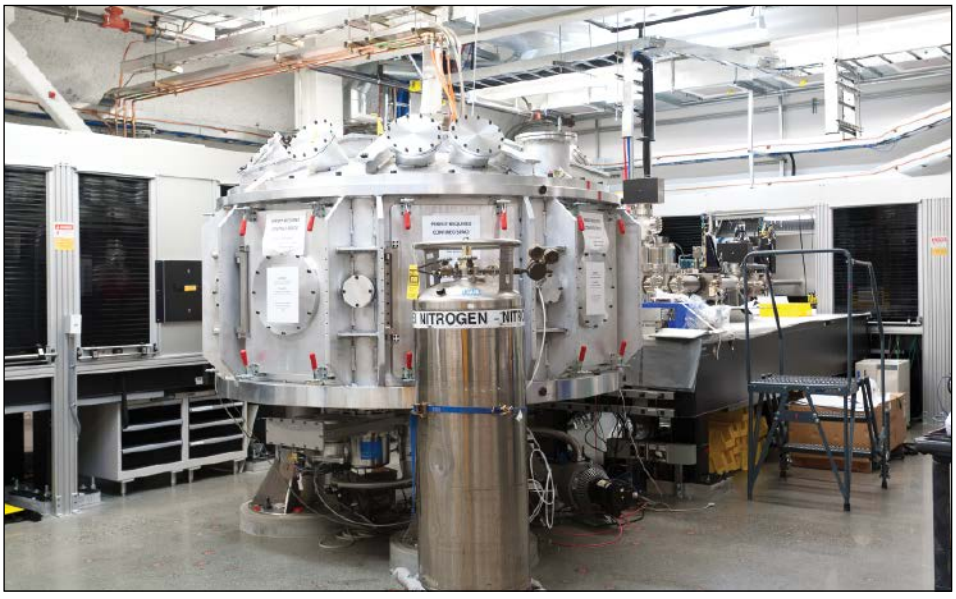
Planetary scientist Marvin Ross first proposed the idea that Uranus and Neptune could have diamond precipitation in 1981. Other research groups have tried many times since then to observe this chemical reaction in the lab but have seen only hints of hydrogen–carbon separation and diamond formation. Moreover, these changes took place at pressures and temperatures that don't match theory very well.

In contrast, the shock method used by Kraus and his team produced strong signals from the separation and diamond formation at the temperatures and pressures suggested by theory. The one-two X-ray punch was the key to the experiment's success, according to coauthor Siegfried Glenzer, professor of photon science at Stanford University and director of SLAC's High Energy Density Sciences Division.

"We saw carbon clusters forming under the presence of hydrogen, and then we saw those carbon clusters forming diamonds under high pressure," Glenzer recounted.

Kraus added that "nearly every carbon atom inside the plastic turned, within this 1 nanosecond or less, into a diamond crystal structure." He said that if the nanometer-scale diamonds could grow for longer spans of time, like they might in ice giant atmospheres, the nanodiamonds "would for sure grow to much larger size."

To see diamond formation, the sample needed to be highly compressed but not heated beyond the melting point of diamond, a tricky combination for most laser experiments, Glenzer explained. The lasers compressed the sample for only a few nanoseconds, too short a time to substantially increase the temperature. The team performed its experiment with the Matter in Extreme Conditions (MEC) instrument on SLAC's Linac Coherent Light Source (LCLS).



The Matter in Extreme Conditions instrument (central chamber) attached to SLAC National Accelerator Laboratory's Linac Coherent Light Source can replicate the pressures and temperatures found in the interiors of ice giant planets, enabling researchers to observe chemical reactions that may occur under those conditions. Credit: Matt Beardsley/ SLAC National Accelerator Laboratory

> "Hydrogen is still present, and that's important because that's what happens [in] Neptune."

SLAC's full range of experimental techniques allows scientists "to be able to assess these questions of reactivity and kinetics," said Laura Robin Benedetti, an experimental physicist at Lawrence Livermore National Laboratory in Livermore, Calif., who did not participate in the research. "It's very exciting to have new work in this field."

The Hydrogen Solution

Glenzer explained that the shock method's short timescale is important for keeping hydrogen from escaping during the diamond compression. Past experiments that observed the reactions over the course of a few seconds might have suffered from hydrogen loss, he speculated.

In the shock experiments, "hydrogen is still present, and that's important because that's what happens [in] Neptune," Glenzer said. "You have carbon under high pressure, and hydrogen is still around. And then we see the formation of diamonds." In this way, the lab simulation "is a much better approximation for what we believe is happening in Neptune."

The research group has begun conducting similar experiments with plastics of different composition to test the range of reactions that could occur, according to Kraus. He and his colleagues are particularly interested in reactions that include oxygen and helium, two elements in high abundance in not just ice giants but Jupiter-like planets as well.

"To refine our models of the interiors of the ice giant planets and also to understand their formation processes, we will need every bit of data we can get our hands on!" Benedetti told *Eos* in an email.

The team also hopes to retrieve the newly formed diamonds from the MEC chamber to analyze their structure and strength, Glenzer said. Through that, there may be a practical application to this science: Harvesting the diamond nanocrystals formed in the experiments is the researchers' first step in assessing potential applications for the diamonds in material science or industry.

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

Clues Found That Earth May Have a Thermostat Set to "Habitable"

In 1981, geologists proposed that the chemical weathering of rocks like granite can draw the greenhouse gas carbon dioxide (CO_2) out of the atmosphere and, in the process, cool Earth. As cooling progressed, chemical weathering reaction rates would decrease, more CO_2 would remain in the air, and warming of the planet would begin again. Although this sort of natural "thermostat" could help explain such puzzles as why CO_2 from volcanic eruptions does not accumulate unceasingly in the atmosphere, physical evidence for a mechanism that moderates the planet's temperature has been lacking.

New research presented on 14 August at the Goldschmidt2017 conference in Paris (http://bit.ly/pogge-von-strandmann-2017) showcased telltale chemical data from ancient rocks. The data indicate that falling temperatures during a glaciation about 445 million years ago triggered a process leading to a period of renewed warming, much like a chilly afternoon might trigger your thermostat to turn on the furnace for the night.

Combining these new findings with prior modeling studies, "for the first time we have actual empirical data for the thermostat, and therefore of the mechanism that keeps the Earth habitable," isotope geochemist Philip Pogge von Strandmann of the University College London in the United Kingdom told *Eos.*

He added, however, that finding a thermostat does not offer hope for humanity's current climate change predicament. The weathering thermostat helps warm and cool the planet on the scale of hundreds of thousands of years—too slow to help moderate the modern meteoric rise in atmospheric CO_2 caused by human activity. "While this is the process that will allow the climate to recover from man-made warming, it's too slow to help us right now," said Pogge von Strandmann, who led the new research.

Setting the Thermostat

Silicate rocks like granite react with CO_2 dissolved in rainwater, explained Lee Kump, a geochemist at Pennsylvania State University in University Park who was not involved in the new research. "Carbon dioxide in rainwater is an acid, and that acid attacks rocks and is neutralized. When it attacks silicate rocks like granites and basalts," a reaction incorporates the CO_2 into limestone, which removes the molecule from the atmosphere, he said.

"While this is the process that will allow the climate to recover from man-made warming, it's too slow to help us."

The reaction also releases isotopes of lithium from the rocks, Pogge von Strandmann explained. Although it's difficult to tease out weathering-driven deterioration of rock from other factors in the stratigraphic record, lithium isotopes offer a relatively straightforward, parallel record of how much weathering took place.

Investigating a period of ice buildup known as the Hirnantian glaciation, which happened about 445 million years ago at the end of the Ordovician period and likely triggered life's first mass extinction, Pogge von Strandmann and his team tested three stratigraphic sections for their lithium isotope content. Their analysis of two sections on Anticosti Island in Canada and a third near Moffat in Scotland revealed that less lithium weathered out of silicate rocks around the time of the glaciation.

"We found that lithium isotope ratios show a…peak around this time, and we can model that as being due to a decrease in silicate weathering during this cooling time period," Pogge von Strandmann said.

At Sixes and Sevens

The team found in strata from the cooling period less lithium-6 than usual compared with lithium-7, both of which are stable isotopes. Although, generally, "there's 12 times more lithium-7 than lithium-6 on Earth," Pogge von Strandmann said, during the cooling period the ratio increased to about 12.2 to 12.4.

That difference resulted from a rise in the formation of clays, such as illite, on land, which typically happens when less weathering is occurring, he explained. The greater abundance of clays reduced how much lithium-6 was transported to the ocean because the clays

Strata in this cliff face at Ellis Bay on Anticosti Island in Canada preserve rocks deposited during the Hirnantian glaciation. Lithium levels in rock samples collected on this island and in Scotland indicate that weathering of silicate rocks, like granite and shale, may act as a natural thermostat that stabilizes Earth's temperature. Credit: Andre Desrochers

take up and retain some of the lithium-6 from nearby rock. Consequently, streams transported less lithium-6 compared with lithium-7 to the oceans where the deposition that created the strata took place.

"Temperatures initially dropped because of decreasing CO_2 degassing from volcanoes. This caused weathering to decrease by about 4 times globally, allowing CO_2 and temperatures to recover, terminating the glaciation," Pogge von Strandmann said. This weathering "minimum," as he described it, occurred right at the end of the glaciation, which is unsurprising as long as temperature controls weathering rates.

Before the glaciation, silicate weathering sequestered about 150 megatons of CO_2 per year. "At the peak of the Hirnantian, we model a rate of 35 megatons per year—so around a 4 to 5 times decrease," Pogge von Strandmann said. Over long time spans, this change was enough to help restore warming of the planet, he added.

"For me what is compelling about this study is that it presents not just one but three records for the same time period from different parts of the world, and they all appear to show the same response," said Rachael James, a geochemist at the University of Southampton in the United Kingdom who was not involved in the work. "This hasn't been done before, for any time period, and it really gives me hope that lithium isotopes can be used to trace silicate weathering rates far back in time and consequently assess the role of weathering in setting Earth's thermostat."

Two-Way Control

Thermostats regulate temperature in both directions, not only turning up the heat when temperatures drop, as this new evidence suggests happened in the Hirnantian, but also triggering cooling when temperatures rise.

"It really gives me hope that lithium isotopes can be used to trace silicate weathering rates far back in time."

In previous work published in 2013 in *Nature Geoscience*, Pogge von Strandmann and a different team of colleagues used geochemical simulations to determine that an increase in weathering during an era of warming 93.5 million years ago known as ocean anoxic event 2 may have led to sequestering of carbon and cooling of the planet. "That gave the first half of the story," he said.

"By itself, [that's] not full evidence of the thermostat," Pogge von Strandmann acknowledged. However, "now we have evidence that weathering decreases during cooling," showing both sides of thermostat operation.

Tricky to Measure

Despite this new evidence, forces other than temperature might also control the thermostat, according to Kump. For instance, another study suggested that the number of silicate rocks exposed at a particular time on the planet's surface may exert the most influence on the rate of weathering. During the Ordovician, mountain uplift brought silicate rocks to the surface in droves. "The uplift of these mountain belts—some expressions of which are in the East Coast of the United States—led to enhanced weathering because it's like a conveyor belt bringing these rocks to the surface," Kump said. "That exposes them to this naturally acidic rain, and that stimulates weathering." Then, as atmospheric CO_2 concentrations decreased, ice sheets grew and covered the rocks, "and that reduces silicate weathering," said Kump.

Regardless of whether mountain building or temperature change is the main thermostat driver, Pogge von Strandmann explained, the main take-home from his team's work—also reported in a recent *Geochemical Perspectives Letters* paper—is that they have solid evidence that a thermostat exists at all. "But it doesn't mean that [temperature change] always is dominant," Pogge von Strandmann said (see http://bit.ly/pogge-von-strandmann-gpl-2017).

"We never actually had any real information that thermostats even existed in the past. What we've done is show that at least the thermostat does exist, and in this particular area it stabilized the climate rapidly" on a geological timescale. The team's findings, he explained, take scientists a step further toward understanding a stabilizing force that may help Earth escape from extreme climatic conditions.

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

Giant Snails' Century-Old Shells Recorded Monsoon Rainfall

The giant African land snail may help scientists retrace the rainfall history of monsoons across the Indian subcontinent. Credit: Paul Brown/Rex Features via Associated Press

The shells of a large, invasive snail in India can provide exceptionally fine-grained records of past precipitation in the region, a new study finds. By measuring isotope ratios in shells from some of these snails from as long ago as 1918, the researchers have demonstrated that they could reconstruct the subseasonal rainfall rate of past monsoon seasons.

The snails in question are of the giant African land snail species *Achatina fulica*, which can grow shells up to 20 centimeters long. "We had the opportunity to observe [the snail] growing at extraordinary rates during monsoon time," said Prosenjit Ghosh of the Indian Institute of Science in Bangalore, India.

According to Ghosh, the fast growth rate of these snails makes them "ideal candidate[s] to record high-frequency changes in the monsoon precipitation." Ghosh is lead author on the research paper, published on 7 September in *Geochemistry, Geophysics, Geosystems* (http://bit.ly/Ghosh-2017), that presents the research.

An Archive of Rain Rates at Fine Scales

Because of the rapid growth rate of the snails, which are a widespread invasive species in India, moisture-sensitive oxygen isotope ratios in growth bands in the animals' shells preserve week-to-week rainfall rates, the researchers found.

"Very few proxies give you that sort of [time] resolution in reconstructing precipitation," said coauthor Kaustubh Thirumalai of Brown University in Providence, R.I. The snail shells sample shorter time increments than do data from bands found in caves, trees, or mollusks, which have been used in prior paleoclimate research, he added.

These snail shells, which are made of calcium carbonate, could fill gaps in historical rainfall records and help scientists understand the evolution of monsoons on the Indian subcontinent, Thirumalai explained.

"Snail shells are pretty ubiquitous across the Indian subcontinent," he said. "The idea was that if we could use snails and snail shells to piece together the history of the Indian monsoon, it could be a powerful archive."

Slithering into the Past

The researchers began their new work by reconstructing the rainfall record in Kolkata, India, an area at the edge of the core monsoon zone, during the 2009 Indian summer monsoon (ISM). They collected snail shells, water samples, and instrumental records from that season.

To estimate the amount of precipitation, Ghosh's team measured a common paleoclimate proxy for temperature, humidity, and atmospheric circulation. This proxy, known as the $\delta^{18}O$ stable oxygen isotope ratio, varies in proportion to the ambient moisture.

The proxy works like this: Although water can form using either a light or a heavy oxygen isotope, snails more readily draw in water with oxygen-16 than with its heavier counterpart, oxygen-18. In times of drought, the snails end up using water with the heavy oxygen by necessity and are forced to expend extra energy incorporating heavier molecules into their shells. So dry spells correspond to higher $\delta^{18}O$ levels in the shells.

Just how sensitive is this proxy?

Very sensitive, the team discovered. The researchers found that variations in the $\delta^{18}O$ ratio in growth bands of the 2009 shells directly mirrored week-to-week fluctuations in recorded rainfall. "Because we extracted high-resolution stable isotopic profiles from these shells, we were able to match them to active spells and breaks in the monsoon," Thirumalai said.

They turned next to two shells of the same species that had been gathered in Kolkata in 1918 and archived at the Natural History Museum in London in the United Kingdom. The modern shells then served as a Rosetta stone to translate the 1918 shells, turning the $\delta^{18}O$ measurements from the historical shells into rainfall intensity during their lifetimes.

The rainfall patterns reconstructed from the 2009 snail shells have "good consistency with rainfall," said Anant Parekh of the Indian Institute of Tropical Meteorology, Pune, India, who did not participate in the project. He added that this technique "can be used to identify active and break spell[s] in the past," as was done with the 1918 shells, but that repeating the experiment with more shells and comparing them to independent records of rainfall would help verify the method's accuracy.

A Data Boon from an Invasive Pest

Ghosh and his colleagues report in their paper that by using data from fresh and archived shells, they can independently verify historical human rainfall records. Plus, in areas and time periods for which human records are sparse or inaccurate, snail shell data could fill gaps and extend the record.

What's more, the authors suggest that this new pathway for reconstructing subseasonal rainfall of past ISMs may help us understand how climate variables like the El Niño–Southern Oscillation (ENSO) and the Indian Ocean Dipole (IOD) have changed over time.

The team also plans to carry out similar experiments with snail shells collected across the Indian subcontinent. Although these snails tend to have devastating impacts on local ecosystems wherever they invade, their expansive reach could lead to mapping rainfall history across the entire Indian subcontinent.

"We know that there's a lot of spatial heterogeneity in the Indian monsoon," Thirumalai said. "Snails could potentially be a really useful tool to fill in the puzzle pieces of how rainfall changed in the past and how it changed spatially."

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

Deepwater Horizon Dispersant Cleared the Air, New Model Shows

As the crippled Deepwater Horizon oil well spewed nearly 5 million barrels of crude oil and gas into the Gulf of Mexico in 2010, cleanup crews attacked the spill with almost 2 million gallons of Corexit, a controversial brand of dispersant used to break up oil into smaller droplets.

Now new modeling of the oil's behavior as it leaked out of the well has simulated the characteristics of the spill's oil and natural gas bubbles with and without the addition of Corexit EC9500A, the main dispersant used against the spill. The research finds that the dispersant diminished the average oil droplet's volume by more than thirtyfold, which would have likely made droplets dissolve more easily and rise more slowly, allowing them to become trapped below the sea surface.

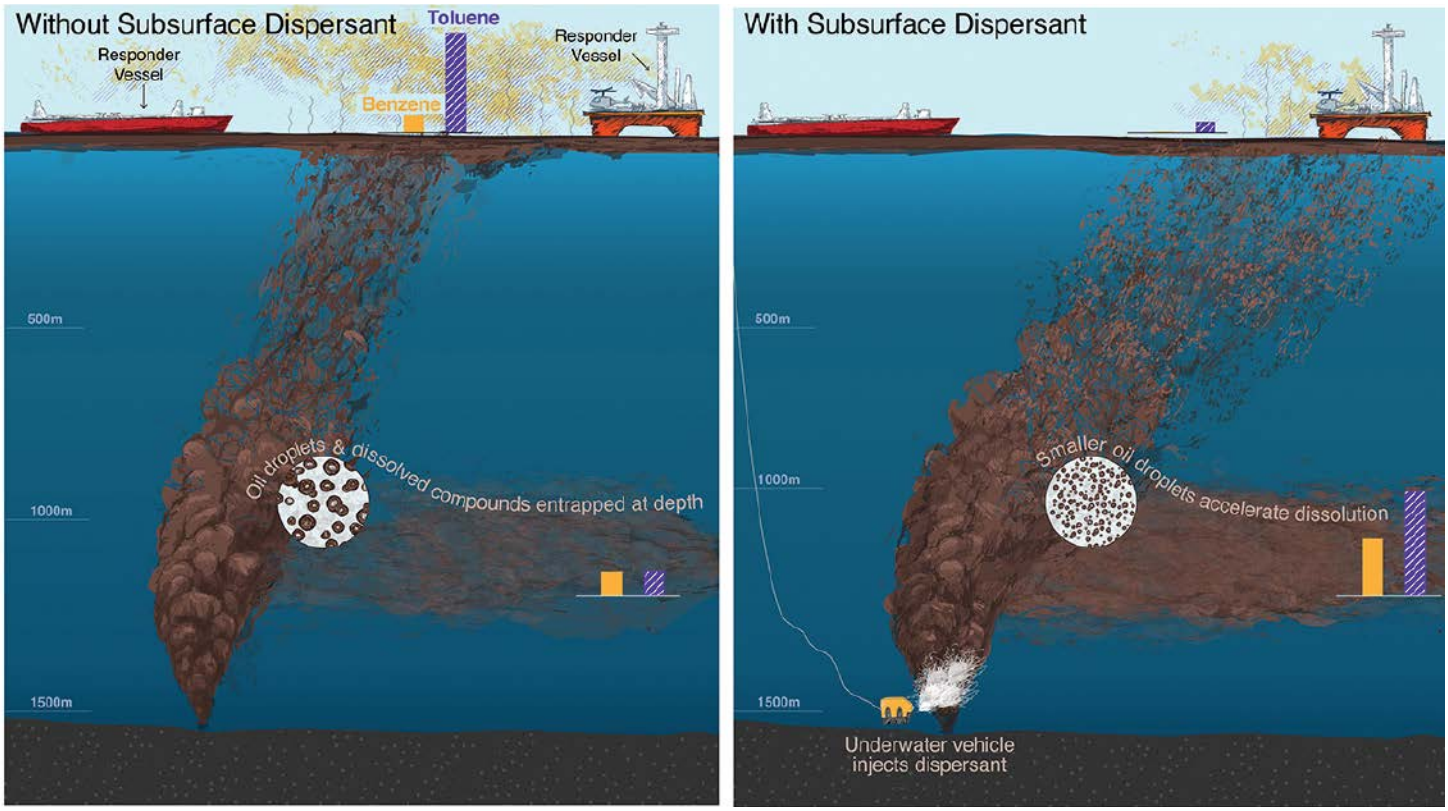
The droplets' shrinkage would have reduced the amount of volatile oil components that reached the surface of the ocean and, in turn, dramatically improved air quality for responders, the researchers report. In the model's simulations, droplet diameters decreased from approximately 4 millimeters without dispersant to 1.3 millimeters with it.

"If dispersants had not been used, then according to our model, emergency responders would have had to spend much more time worrying about health risks," said J. Samuel Arey, a senior adjunct researcher at the Swiss Federal Institute of Aquatic Science and Technology. "Anything you do that affects logistics in a negative way is going to have a huge impact" on response, he added. "Logistics is your ability to get work done. That has a direct multiplier on the scale of the disaster."

The new model indicates that dispersant use lowered the amount of volatile organic chemicals in the atmosphere by about 30%, on average. For chemicals most harmful to humans, the reduction was far steeper. The atmospheric concentration of benzene, a component of crude oil, decreased 6,000-fold, for example. That had big implications for cleanup crews working on the site.

The new study shows "how the dispersant was effective in retaining [more] of the hydrocarbons at depth than would otherwise be the case. That's really important," said Gary Andersen, a senior scientist at Lawrence Berkeley National Laboratory in Berkeley, Calif., who has also studied the effects of dispersants.

"If dispersants had not been used, then according to our model, emergency responders would have had to spend much more time worrying about health risks."



The new study model shows that the dispersant injection decreased the overall concentration of all volatile organic chemicals in the atmosphere by a modest amount. However, the dispersant reduced the amount of chemicals most harmful to humans, including benzene and toluene, by a much greater amount. Credit: Natalie Renier, Woods Hole Oceanographic Institution

Arey and his colleagues published the new work on 28 August in the *Proceedings of the National Academy of Sciences of the United States of America* (*PNAS*) (http://bit.ly/Gros-2017).

Woods Hole Oceanographic Institution researchers donned respirators to work on the top deck of R/V Endeavor *during a rapid response expedition to the Deepwater Horizon oil spill in the Gulf of Mexico in June of 2010. Credit: Dan Torres, Woods Hole Oceanographic Institution*

Dispersants at Depth

Dispersants affect oil much the way dish soap breaks up grease. The chemicals in the dispersants, which are typically used on surface slicks, lower the interfacial tension of the boundary between oil and water, which allows waves and wind to break up a slick. "As a consequence, less oil reaches the coastline because it's dispersed into the environment," Arey said. But how dispersants would behave when used at depth was still an open question in 2010.

Since then, numerous scientists have attempted to answer that question. In theory, a dispersant would have reduced the size of the oil droplets under the water's surface. Smaller droplets would rise to the surface more slowly, making them more likely to get trapped within the water. If microbes degraded the oil droplets or if the droplets were trapped, they might not reach the surface at all.

Limited underwater observations near the spill with a camera mounted on a remotely operated vehicle (ROV) captured some data on droplet sizes. Operated by a team led by the Woods Hole Oceanographic Institution in Woods Hole, Mass., the ROV looked at droplets 1–9 kilometers from the wellhead, observing sizes of 0.03–0.40 millimeter.

These sizes are consistent with the model, which simulated droplets only 200 meters from the leaking wellhead, according to the paper. The model's larger droplets would have broken up by the time they drifted kilometers from the disabled oil rig because of natural turbulence and the dispersant's effect.

However, the in situ measurements are "a relatively small set," Arey noted. Thus, many researchers have turned to lab experiments or models.

From Models to Bottles

A 2015 modeling study by scientists at the University of Western Australia in Perth and the University of Miami in Florida found that mechanical energy did most of the dispersing. In addition, regarding how much spilled oil remained at depth rather than breaching the surface, "the simulations suggest that the application of dispersant actually made only a marginal difference," the authors wrote. They estimate that only 1%–3% less oil reached the surface because of dispersants.

Using another model last year, Jeremy Testa, a researcher at the University of Maryland Center for Environmental Science in Solomons, reported droplet sizes similar to those simulated in the new paper by Arey and his coauthors.

In experiments reported in June, also in *PNAS*, Andersen and his colleagues recreated the presumed conditions of the Deepwater Horizon spill in bottles, rotating the bottles so that the oil droplets didn't become slicks. They found that the dispersant did not inhibit microbial work. Microbes degraded most of the oil from the spill "in a matter of weeks or months," Andersen said. A lot of the work was done by a newfound organism now thought to be part of the genus *Bermanella*.

"I come down strongly in favor of using dispersants, much more so now than ever," Andersen added. "Dispersants are really important in trying to retain as much [oil as] possible in the lower depths, where there's greater potential for microbial degradation."

> "To the extent that we can shed light on the benefits of these intervention technologies, [we can] continue to inform the policy around emergency preparedness."

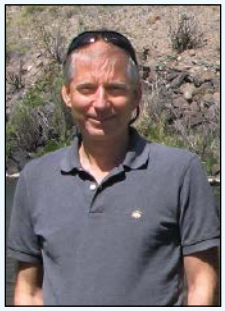
Informing Oil Spill Response

The model used in the August *PNAS* study allowed the scientists "to fill in everything that happened from the wellhead to the sea surface and describe in detail what was happening at the wellhead itself," according to Arey. He said that he hopes studies like his can be used to help plan for future oil spill management.

"We still rely heavily on fossil fuel reserves," he said. "To the extent that we can shed light on the benefits of these intervention technologies, [we can] continue to inform the policy around emergency preparedness."

By **Rachel Kaufman** (email: rk@readwriterachel.com; @rkaufman), Freelance Science Journalist

Timothy A. Cohn (1957–2017)


Sarah S. Humphrey

Timothy A. Cohn.

Timothy A. Cohn, U.S. Geological Survey (USGS) statistical hydrologist and expert on flood risks, water quality, and hydrologic trends, died at his home in Reston, Va., surrounded by his loved ones on 20 February 2017, a few days short of his sixtieth birthday.

During his 30 years with USGS, Tim developed innovative tools to help scientists, engineers, and policy makers better understand water quality and streamflow (especially floods) in a manner that informs and protects Americans. His tools and concepts are used by federal agencies and are incorporated into software used worldwide.

Tim was a hydrologist with a great gift for mathematics and statistics, and he never lost sight of the importance of hydrologic science to sound public policy. He shared his ideas and insights freely with many colleagues at USGS and other agencies of government and with his university colleagues. For his outstanding contributions to USGS, Tim was awarded the Department of the Interior's Distinguished Service Award.

Tim's influence extended beyond those tools. To be with Tim was ennobling. His friend and colleague Bill Hooke, in a 20 February blog post, said that Tim was "skeptical of shortcuts and premature judgments."

He continued, "To dialog with him…was always an education. To leave was to leave with a stronger determination to be more thorough, to do higher-quality work, be more self-critical" (see http://bit.ly/hooke-blog).

Tim always exhibited curiosity and followed through by learning about a diverse range of topics, including the medical science involved in his treatments for mantle cell lymphoma, the disease that ultimately took his life. Hooke went on to say of Tim, "He had a great sense of humor but never employed it at anyone else's expense. To be around Tim was to experience dignity and respect."

Tim was born in Boston, Mass., on 26 February 1957. He grew up in Cambridge, dropping out of high school to go to Colombia and work on Ingetec's Chivor Hydroelectric Project, an experience that kindled a lifelong love of science and water. He then earned a B.A. in mathematics from Swarthmore College (Swarthmore, Pa.) and an M.S. and Ph.D. in water resource systems engineering from Cornell University (Ithaca, N.Y.), where he developed an enduring collaboration with his major professor, Jery Stedinger.

Lasting Contributions to Hydrology

Tim made lasting contributions to three major topics in hydrology. First, he developed an unbiased and accurate method for estimating how much pollution flows down a river in a given year on the basis of very limited data and highly nonlinear relationships. The rivers flowing into Chesapeake Bay were his test bed, and his methods have been incorporated into the most commonly used statistical software designed to address this issue. He made the method properly handle "censored data" (data values reported as less than some limit of detection), and he developed the means to assess the accuracy of the estimates that the method produced.

The second topic was his examination of the role of long-term persistence (the tendency of data values to stay above or below their mean value for long periods) in hydrologic records that results in the appearance of trendlike behavior. With his USGS colleague Harry Lins, Tim published "Nature's style: Naturally trendy," which illustrates how readily long-term persistence in hydrologic records at timescales of decades to centuries can be mistaken for trends. It is an important cautionary tale for all scientists who aim to characterize the signature of human actions on natural phenomena such as streamflow (http://bit.ly/cohn-lins-2005).

Probably his most notable contributions were in the area of flood hazard estimation. Working with Jery Stedinger and others, he developed a set of mathematical tools for analysis of long-term flood records that are partly based on instrumental records but also contain historical, geological, or botanical evidence of large floods in the distant past. He also developed a much improved approach for eliminating the influence of "low outliers" (years with no real flood events) from the analysis of flood frequency. As was typical for Tim's work, he stressed the importance of quantifying the uncertainty, and he reminded practitioners of just how little we actually know. The analysis methods he developed are at the core of the new interagency manual for flood frequency analysis, the first update of official flood frequency methods for the federal agencies in more than 40 years.

A Keen Interest in Science for Public Good

Alongside this record of technical accomplishment, Tim was keenly interested in the public policy aspects of his science. He served as an AGU-sponsored Congressional Science Fellow in the office of Sen. Bill Bradley (D-N.J.), and he was president of the AGU Societal Impacts and Policy Sciences focus group. While he served as the USGS science advisor for hazards, Tim took a leadership role in a series of workshops promoting collaboration between the government and the private sector to reduce disaster loss (sponsored by the National Science and Technology Council's interagency Subcommittee on Natural Disaster Reduction). This activity resulted in the volume *Living with Earth's Extremes*, which Tim coedited with Kathleen Gohn and Bill Hooke (see http://bit.ly/live-w-extremes).

Tim also served on several National Academy of Sciences studies related to floods and risk reduction. He was a tireless contributor to the science community through his service on the Board of Governors and Executive Committee of the American Institute of Physics and his role as an associate editor of AGU's journal *Water Resources Research*.

Enthusiasm for Life

Tim's enthusiasms extended well beyond his work. He was an avid distance runner. He once said, "Ultramarathons are more fun than marathons. You don't just run. You talk. You stop for meals. You're in community." He served as president of Reston Runners and also was a board member of Reston Association, working to improve the Virginia community he lived in for more than 30 years.

Tim is survived by his wife, Sarah S. Humphrey; his children, Alexander Cohn and Hannah Cohn; his mother, Barbara P. Norfleet; two brothers; three nephews; and a niece. He is also survived by many grateful hydrologists who knew the joy of interacting with him and many more who have benefited from his research.

By **Robert M. Hirsch** (email: rhirsch@usgs.gov), U.S. Geological Survey, Reston, Va.

A New Platform for Managing Soil Carbon and Soil Health

International Soil Carbon Network Workshop
Stanford, California, 27 February to 3 March 2017

Soil organic matter and its carbon content (SOM-C) are key indicators of soil health, ecosystem productivity, and resilience. However, the scientific data sets, tools, and terminology used to describe and analyze processes related to SOM-C differ between managed and unmanaged lands. Carbon cycling studies typically focus on unmanaged systems that are vulnerable to climatic changes (e.g., northern peatlands and permafrost soils), whereas soil health studies are related to actively managed lands (e.g., grazing land, cropland, and forestry). Because the goals and needs of scientists and land managers are converging toward enhancing SOM-C stocks and soil health, the need for an interdisciplinary collaboration has emerged.

Early this year, the Stanford School of Earth, Energy and Environmental Sciences hosted the International Soil Carbon Network (ISCN). This organization led a workshop that focused on defining future research priorities in SOM-C science. The workshop aimed to accomplish the following:

- identify key data sets needed to improve our understanding of SOM-C stabilization and destabilization mechanisms
- set up infrastructure to access currently disparate data sets relevant to critical soil processes
- improve the connection between soil carbon cycle science and land management practices
- flesh out the structure of a new platform that will allow the exchange of ideas, data, tools, and expertise between scientists, landowners and managers, and the general public

Fourteen scientists attended the workshop, and six guest speakers also participated in some discussions. Workshop participants visited a grazing land, part of the Marin Carbon Project, that represents a successful "carbon farming" partnership between scientists and landowners. This partnership involves large-scale compost application experiments on grasslands to enhance carbon sequestration in soils.

Our workshop discussions resulted in the drafting of a paper synthesizing current knowledge and gaps and outlining proposals for improved collaboration in soil carbon research. Elements for continued discussion and research include the underrepresentation of SOM-C process data in repositories relative to the scientific literature and the need for a robust and modular modeling platform for developing process-based models that would move field data and localized experiments into a larger Earth system framework.

To address the data repositories issue, a data rescue and curation project (see http://bit.ly/ISCN-hackathon) will be launched in late 2017 at the AGU Fall Meeting to recover data from repositories and the literature. The resulting data sets will be centralized in ISCN's new data platform. A new modeling platform will be developed in collaboration with other existing ones to enable model parameterization, hypothesis testing, and model intercomparisons. At the meeting, we also proposed increased interoperability between ISCN and partner networks (e.g., the International Soil Reference and Information Centre (ISRIC), U.S. Geological Survey, U.S. Department of Agriculture, FLUXNET) to improve the platform. As of this June, ISCN now has a formal data-sharing agreement with ISRIC.

Overall, workshop participants recognized the need to identify vulnerabilities and opportunities for linking SOM-C science and the societal mandate to manage soils and ecosystems for productivity and carbon sequestration in future decades. We outlined a path to gain support for the ISCN vision of a collective soil data platform from stakeholders and partners through engagement in coming years.

More ISCN-related events scheduled for the 2017 AGU Fall Meeting are available from the ISCN website (see http://bit.ly/ISCN-FM2017).

Acknowledgments
The workshop was organized by Jennifer Harden (lead) and Gustaf Hugelius (colead). We thank our guest speakers Rob Jackson and Margaret Torn; breakout coleads Andres Ahlström, Kate Maher, and Alex Konings; and field trip leaders Whendee Silver and John Wick. Sintana Vergara and Jennifer Harden helped write this report; Kathe Todd-Brown and Rodrigo Vargas provided feedback.

By **Julie Loisel** (email: julieloisel@tamu.edu), Department of Geography, Texas A&M University, College Station; **Avni Malhotra,** Environmental Sciences Division and Climate Change Science Institute, Oak Ridge National Laboratory, Oak Ridge, Tenn.; and **Claire Phillips,** Forage Seed and Cereal Research Unit, Agricultural Research Service, U.S. Department of Agriculture, Corvallis, Ore.

International Soil Carbon Network Workshop participants visited this rangeland, a part of the Marin Carbon Project in California. This grazing area provides an example of a successful partnership among landowners, land managers, and scientists. These stakeholders have identified potential soil carbon stabilization opportunities that are scientifically sound, financially feasible, and scalable. Credit: Avni Malhotra.

Strengthening the Observational Basis for Carbon Science, Policy

Sustained Observations for Carbon Cycle Science and Decision Support Workshop
Boulder, Colorado, 13–14 April 2016

Charles David Keeling began making ongoing atmospheric carbon dioxide measurements at Mauna Loa Observatory in Hawaii, shown here, in 1958. Sustained carbon observations have led to profound scientific discoveries and support for policy decisions. Attendees at a 2016 workshop addressed interagency cooperation and the U.S. role in an international carbon observing system. Credit: Forrest M. Mims III, Mauna Loa Observatory

Sustained observations provide the foundation for understanding Earth's carbon budget on timescales ranging from seasonal to several decades. To track variations in carbon stocks in the atmosphere, ocean, and terrestrial biosphere—as well as fluxes between these reservoirs—data records must be of sufficient quality, density, and duration. Such data are needed to verify emissions inventories and carbon storage estimates.

One group, the U.S. Carbon Cycle Science Program (CCSP), has already coordinated sustained observations among various government agencies to a significant degree. In April 2016, the Carbon Cycle Interagency Working Group, via the CCSP, sponsored a workshop hosted by the National Oceanic and Atmospheric Administration's (NOAA) Earth System Research Laboratory. Sixty-one participants attended the workshop, including university, government, and private-sector researchers and agency program managers.

Participants explored targeted efforts to address gaps and enhance links among agencies, with consideration of the U.S. role in an international carbon observing system. Presentations highlighted important discoveries from long-term data records. Attendees discussed challenges to sustained data collection, such as the difficulties of securing funding for time series measurements and implementing new technologies to improve capability. One presentation described efforts by the U.S. Group on Earth Observations to coordinate Earth observations and engage with stakeholders.

The workshop identified research areas that are ripe for translation to decision support services. Over the past 2 decades, U.S. science agencies have sponsored a vigorous program of carbon research, resulting in a wide variety of data products and data synthesis techniques with potential to inform stakeholders and carbon management efforts.

For example, the U.S. Environmental Protection Agency produces an annual U.S. Greenhouse Gas Inventory to meet U.S. commitments under the United Nations Framework Convention on Climate Change. Likewise, data assimilation and integration efforts such as NOAA's CarbonTracker, NASA's Carbon Monitoring System, and the Global Carbon Project enable ongoing evaluation of inventories and process models. In addition to identifying these endeavors, participants discussed opportunities to expand and coordinate programs that support critical long-term observations from observatories on the ground and aboard aircraft and satellites.

Although much work is still needed to develop long-term monitoring networks, recent investments in technology have already enabled the deployment of autonomous sensor networks and satellite measurement systems with unprecedented capability.

Two sensor networks funded by the National Science Foundation, the Ocean Observatories Initiative and the National Ecological Observatory Network, currently provide or will soon provide infrastructure to leverage new technologies and generate rich data sets to advance carbon cycle science. These platforms, along with vessels of opportunity such as oceangoing ships, commercial aircraft, and profiling floats, can be further equipped with chemical sensors.

For remote sensing, NASA's Orbiting Carbon Observatory-2 is the first U.S. satellite mission designed to measure air column carbon dioxide. Workshop participants noted that the further expansion of a successful space-based carbon monitoring program will require rigorous algorithms and "ground truth" verification. Presentations highlighted the value of model-informed observing system design and described recent examples.

Workshop participants also considered other topics at the intersection of research and decision support services, including understanding ecological and oceanic carbon storage impacts of ocean acidification, monitoring of biomass stocks with emphasis on vulnerable carbon reservoirs, rapid detection of leaks from oil and gas facilities, and quantification of urban emissions to inform local-scale mitigation efforts.

Workshop organizers willncontinue to engage with the carbon cycle community to produce a scientific strategy document for sustained carbon cycle observations. This effort will augment the 2011 U.S. Carbon Cycle Science Plan (see http://bit.ly/USCCSP-2011) and inform the Second State of the Carbon Cycle Report (see bit.ly/SOCCR-2).

By **Arlyn Andrews** (email: arlyn.andrews@noaa.gov), Earth System Research Laboratory, National Oceanic and Atmospheric Administration, Boulder, Colo.

Mapping the Topographic Fingerprints of Humanity Across Earth

Since geologic time began, Earth's surface has been evolving through natural processes of tectonic uplift, volcanism, erosion, and the movement of sediment. Now a new force of global change is altering Earth's surface and morphology in unprecedented ways: humanity.

Human activities are leaving their fingerprints across Earth (Figure 1), driven by increasing populations, technological capacities, and societal demands [e.g., *Ellis,* 2015; *Brown et al.,* 2017; *Waters et al.,* 2016]. We have altered flood patterns, created barriers to runoff and erosion, funneled sedimentation into specific areas, flattened mountains, piled hills, dredged land from the sea, and even triggered seismic activity [*Tarolli and Sofia,* 2016]. These and other changes can pose broad threats to the sustainability of human societies and environments.

If increasingly globalized societies are to make better land management decisions, the geosciences must globally evaluate how humans are reshaping Earth's surface. A comprehensive mapping of human topographic signatures on a planet-wide scale is required if we are to understand, model, and forecast the geological hazards of the future.

Understanding and addressing the causes and consequences of anthropogenic landform modifications are a worldwide challenge. But this challenge also poses an opportunity to better manage environmental resources and protect environmental values [*DeFries et al.,* 2012].

The Challenge of Three Dimensions

"If life happens in three dimensions, why doesn't science?" This question, posed more than a decade ago in *Nature* [*Butler,* 2006], resonates when assessing human reshaping of Earth's landscapes.

Landforms are shaped in three dimensions by natural processes and societal demands [e.g., *Sidle and Ziegler,* 2012; *Guthrie,* 2015]; societies in turn are shaped by the landscapes they alter. Understanding and modeling these interacting forces across Earth are not small challenges.

For example, observing and modeling the direct effects of some of the most widespread forms of human topographic modification, such as soil tillage and terracing [*Tarolli et al.,* 2014], are possible only with very fine spatial resolutions (i.e., ≤1 meter). Yet these features are common all over the world. High-resolution three-dimensional topographic data at global scales are needed to observe and appraise them.

The Need for a Unified, Global Topographic Data Set

High-resolution terrain data such as lidar [*Tarolli,* 2014], aerial photogrammetry [*Eltner et al.,* 2016], and satellite observations [*Famiglietti et al.,* 2015] are increasingly available to the scientific community. These data sets are also becoming available to land planners and the public, as governments, academic institutions, and others in the remote sensing community seize the opportunity for high-resolution topographic data sharing (Figure 2) [*Wulder and Coops,* 2014; *Verburg et al.,* 2015].

Thanks to these geodata, anthropogenic signatures are widely observable across the globe, under vegetation cover (Figure 2a), at very fine spatial scales (e.g., agricultural prac-

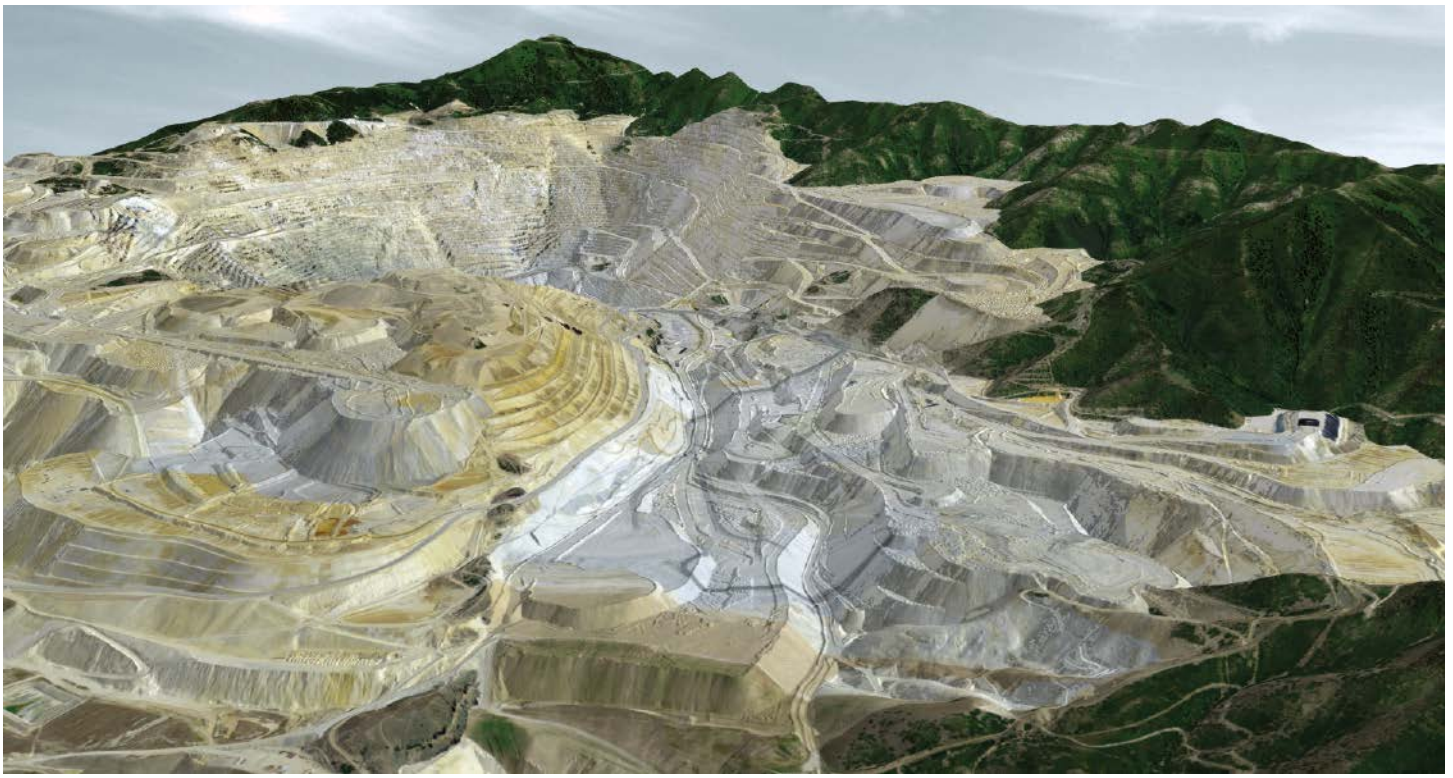


Fig. 1. Three-dimensional view of Bingham Canyon Mine in Utah, a human-made topographic signature, based on a free, open-access high-resolution data set. Credit: Data from Utah AGRC

tices and plowing; Figure 2b) and large spatial scales (e.g., major open-pit mines; Figure 3), and far from contemporary human settlements (Figure 2c). So the potential to assess the global topographic fingerprints of humanity using high-resolution terrain data is a tantalizing prospect.

However, despite a growing number of local projects at fine scales, a global data set remains nonetheless elusive. This lack of global data is largely the result of technical challenges to sharing very large data sets and issues of data ownership and permissions.

But once a global database exists, advances in the technical capacity to handle and analyze large data sets could be utilized to map anthropogenic signatures in detail (e.g., using a close-range terrestrial laser scanner) and across larger areas (e.g., using satellite data). Together with geomorphic analyses, the potential is clear for an innovative, transformative, and global-scale assessment of the extent to which humans shape Earth's landscapes.

For example, fine-scale analysis of terrain data can detect specific anthropogenic configurations in the organization of surface features (Figure 3b) [*Sofia et al.,* 2014], revealing modifications that humans make across landscapes (Figure 3c). Such fine-scale geomorphic changes are generally invisible to coarser scales of observation and analysis, making it appear that natural landforms and natural hydrological and sedimentary processes are unaltered. Failure to observe such changes misrepresents the true extent and form of human modifications of terrain, with huge consequences when inaccurate data are used to assess risks to society from runoff, landslides, and other geologic hazards [*Tarolli,* 2014].

Topography for Society

A global map of the topographic signatures of humanity would create an unparalleled opportunity to change scientific and public perspectives on the human role in reshaping Earth's land surface. A worldwide inventory of anthropogenic geomorphologies would enable geoscientists to assess the extent to which human societies have reshaped geomorphic processes globally and provide a tool for monitoring these changes over time.

Such monitoring would facilitate unprecedented insights into the dynamics and sensitivity of landscapes and their responses to human forcings at global scale. In turn, these insights would help cities, resource managers, and the public better understand and mediate their social and environmental actions.

As we move deeper into the Anthropocene, a comprehensive mapping of human topographic signatures will be increasingly necessary to understand, model, and forecast the geological hazards of the future. These hazards will likely be manifold.

For example, landscapes across the world face altered flooding regimes in densely populated floodplains, erosion rates associated with road networks, altered runoff and erosion due to agricultural practices, and sediment release and seismic activity from mining [*Tarolli and Sofia,* 2016]. Modifications in land use (e.g., urbanization and changes in agricultural practices) alter water infiltration and runoff production, increasing flooding risks in floodplains. Increases in road density cause land degradation and erosion, especially when roads are poorly planned and constructed without well-designed drainage systems, leading to destabilized hillslopes and landslides. Erosion from agricultural fields can exceed rates of soil production, causing soil degradation and reducing crop yields, water quality, and food production. Mining areas, even years after reclamation, can induce seismicity, landslides, soil erosion, and terrain collapse, damaging environments and surface structures.

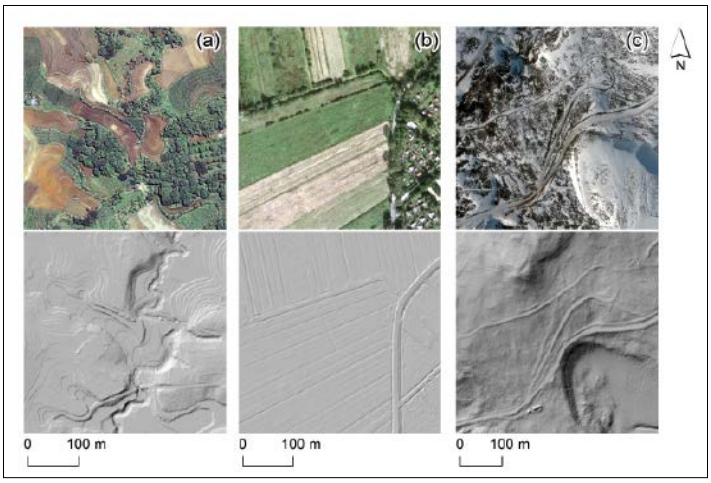


*Fig. 2. High-resolution geodata reveal the topographic fingerprints of humanity: (a) terraces in the Philippines, (b) agricultural practices in Germany, and (c) roads in Antarctica. The bottom images are lidar images of the same landscapes. Credit: Data from University of the Philippines TCAGP/Freie und Hansestadt Hamburg/*Noh and Howat *[2015]. Top row: © Google, DigitalGlobe*

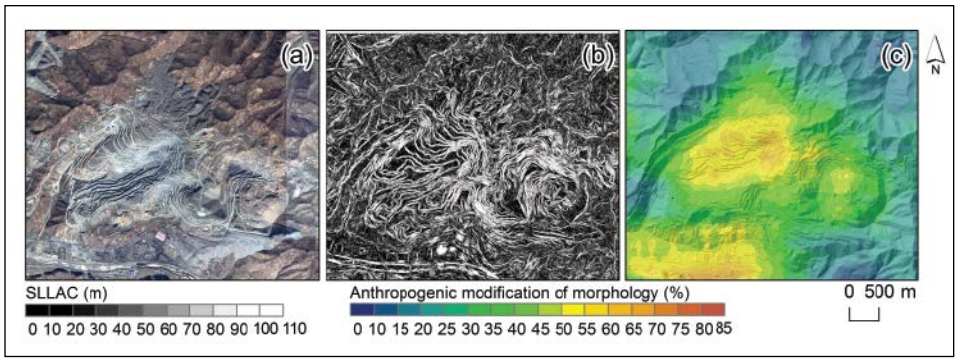


*Fig. 3. This potential detection of anthropogenic topographic signatures has been derived from satellite data. (a) This satellite image shows an open-pit mine in North Korea. (b) This image has been processed in an autocorrelation analysis, a measure of the organization of the topography (slope local length of autocorrelation, SLLAC [*Sofia et al.*, 2014]). The variation in the natural landscape is noisy (e.g., top right corner), whereas anthropogenic structures are more organized and leave a clear topographic signature. (c) The degree of landscape organization can be empirically related to the amount of human-made alterations to the terrain, as demonstrated by* Sofia et al. *[2014]. Credit: Data from CNES© Distribution Airbus DS*

Without accurate data on anthropogenic topography, communities will find it difficult to develop and implement strategies and practices aimed at reducing or mitigating the social and environmental impacts of anthropogenic geomorphic change.

Earth Science Community's Perspective Needed

Technological advances in Earth observation have made possible what might have been inconceivable just a few years ago. A global map and inventory of human topographic signatures in three dimensions at high spatial resolution can now become a reality.

Collecting and broadening access to high spatial resolution (meter to submeter scale),

Earth science–oriented topography data acquired with lidar and other technologies would promote scientific discovery while fostering international interactions and knowledge exchange across the Earth science community. At the same time, enlarging the search for humanity's topographical fingerprints to the full spectrum of environmental and cultural settings across Earth's surface will require a more generalized methodology for discovering and assessing these signatures.

These two parallel needs are where scientific efforts should focus. It is time for the Earth science community to come together and bring the topographic fingerprints of humanity to the eyes and minds of the current and future stewards, shapers, curators, and managers of Earth's land surface.

Acknowledgments

Data sets for Figure 1 are from Utah Automated Geographic Reference Center (AGRC), Geospatial Information Office. Data sets for Figures 2a–2c are from the University of the Philippines Training Center for Applied Geodesy and Photogrammetry (TCAGP), *Noh and Howat* [2015], and Freie und Hansestadt Hamburg (from 2014), respectively. Data sets for Figure 3 are from Centre National d'Études Spatiales (CNES), France, Distribution Airbus DS.

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THE STATE OF PLANETARY AND SPACE SCIENCES IN AFRICA

By David Baratoux, Hasnaa Chennaoui-Aoudjehane, Roger Gibson, Atmane Lamali, Wolf Uwe Reimold, Marian Selorm Sapah, Moulley Charaf Chabou, John Bosco Habarulema, Mark W. Jessell, Aberra Mogessie, Zouhair Benkhaldoun, Elyvin Nkhonjera, Ndivhuwo Cecilia Mukosi, Maram Kaire, Pierre Rochette, Amanda Sickafoose, Jesús Martínez-Frías, Axel Hofmann, Luigi Folco, Angelo Pio Rossi, Gayane Faye, Katrien Kolenberg, Kelali Tekle, Djelloul Belhai, Meriem Elyajouri, Christian Koeberl, and Mamdouh M. Abdeen

Africa has an enormous potential to provide insights into planetary and space sciences, but it has remained largely untapped. Fostering a new generation of scientists promises far-reaching benefits.

The scientific and societal value of exploring our solar system and studying the meteorites that fall to Earth is widely accepted in today's scientific community. However, not all regions of the world have been able to assert themselves in this endeavor. Africa in particular is underrepresented in planetary and space sciences (see page 21).

Planetary and space science (PSS) research groups are now emerging in Africa (see Figure 1), but they remain scattered and underfunded. Here we review PSS programs in Africa and pinpoint ways to further elevate PSS.

PSS is a vast domain of research, so we have focused on the exploration of the solar system, the study of planetary material (meteorites), and global-scale processes affecting planets (e.g., impact cratering).

PSS in Southern Africa

Southern Africa has a strong PSS presence and the most advanced facilities on the continent, including the South African National Space Agency and the South African Astronomical Observatory (founded in 1820). The world's largest radio telescope project, the iconic Square Kilometre Array (SKA), is currently being built in the deserts of Australia and South Africa.

The SKA has strong government support, but the planetary sciences have no dedicated academic or research programs in southern Africa. Isolated groups work on specific

A view of the night sky from Egypt's Katameya Observatory, which has the largest telescope in the Arab world. Credit: Islam Hassan, CC BY-SA 2.0 (http://bit.ly/ccbysa2-0)

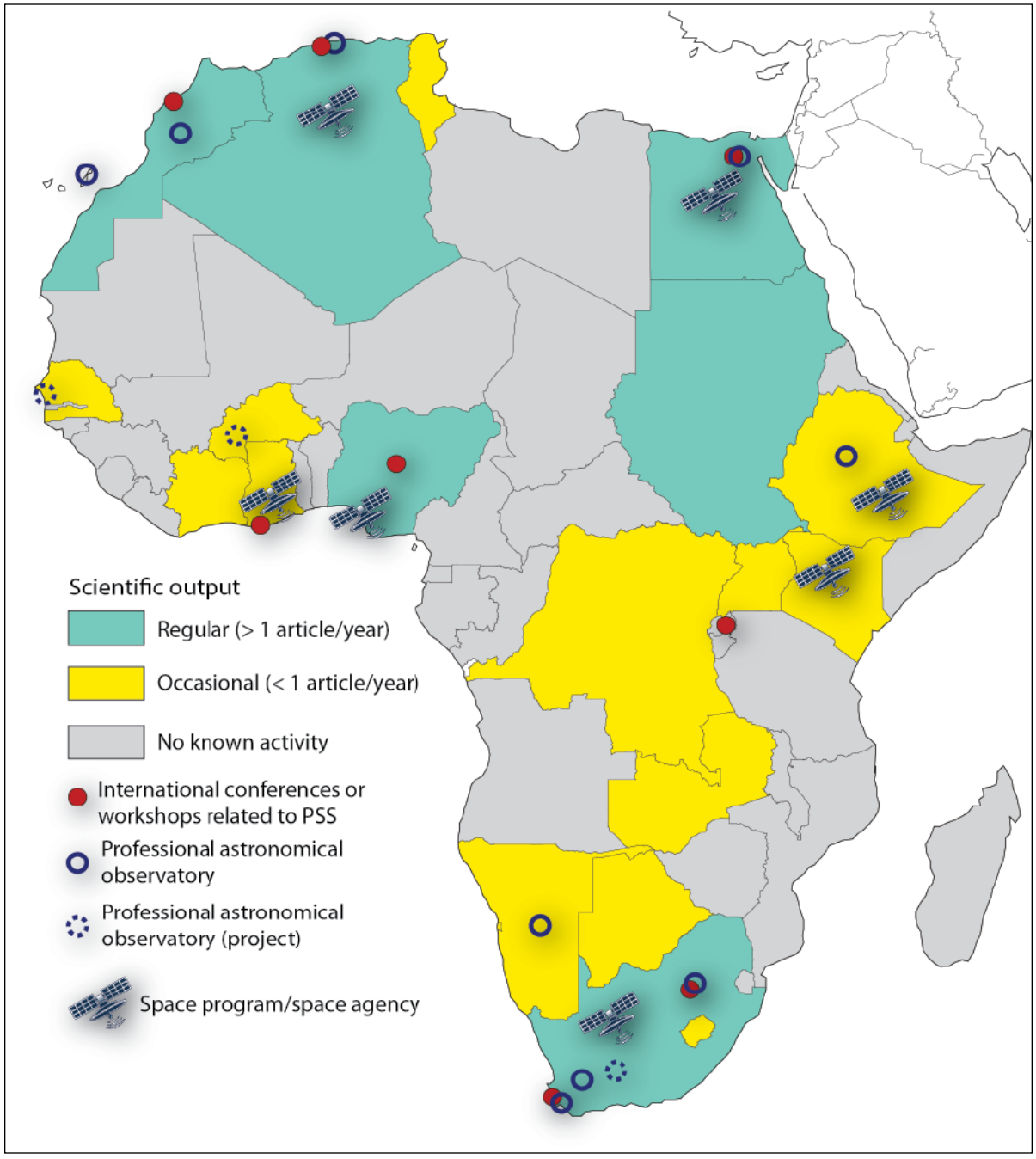


Fig. 1. Map illustrating the emerging activities in planetary and space sciences in Africa. Color codes represent results from a preliminary scan of published journals. The use of "project" here means that plans are in place to build facilities. Credit: David Baratoux

projects, such as meteorite and impact cratering studies, stellar occultations, asteroid detection and characterization, and lunar laser ranging.

Efforts in North Africa

In North Africa, Morocco has gained visibility in meteoritics and impact studies [e.g., *Chennaoui Aoudjehane et al.*, 2016] with the organization of international conferences, outreach programs (e.g., Space Bus Morocco), and frequent radio and TV appearances. The Ibn Battuta Center in Marrakesh is testing instruments and subsystems related to Martian exploration. In addition, a group of astronomers at Cadi Ayyad University (Marrakesh) has established the first astronomical observatory in the Atlas Mountains of Morocco [*Benkhaldoun et al.*, 2005].

The Algerian state has also endeavored to promote PSS through higher education reforms and development of its research infrastructure. Ongoing research is focused mainly on meteorites and impact craters and involves international collaboration [e.g., *Lamali et al.*, 2016;

A group of researchers mounts a device called the Sutherland High-speed Optical Camera (SHOC) on the 74-inch (~188-centimeter) telescope at the South African Astronomical Observatory near Sutherland, South Africa. The instrument observes stellar occultations by small bodies in the outer solar system. The project is fully funded by the South African government. Credit: Amanda Sickafoose

Sahoui et al., 2016]. Professional–amateur collaborations are common in Algeria [*Mimouni*, 2011]; events to foster such collaborations include, among other things, preparatory training courses and astronomical observations of recent asteroid occultations.

In addition, the Arabian Geosciences Union launched a section on planetary science and astrobiology in 2015 for PSS scientists across northern Africa and the Middle East.

East Africa PSS Programs

Remote sensing techniques are the cornerstone of PSS; knowledge of these techniques allows researchers to develop skills that are widely applicable in Earth, environmental, and atmospheric sciences. Recognizing this, Egypt has established a National Authority for Remote Sensing and Space Sciences (NARSS), which focuses on acquiring technical knowledge and capabilities to build small research and remote sensing satellites. NARSS also addresses environmental management and resource exploration.

Currently, the Egyptian government is establishing the Egyptian Space Agency in collaboration with China. The National Research Institute of Astronomy and Geophysics in Egypt operates the Katameya Observatory, which has the largest telescope in the Arab world. The institute also is planning to build an observatory on top of Mount Sinai.

The Egyptian Geological Museum in Cairo houses a small meteorite collection, including a specimen of the Nakhla Martian meteorite, which fell to Egypt in 1911. The exhibition is open to the public. In addition, Egypt has started a program for promoting science, technology, engineering, and mathematics (STEM) by establishing 11 STEM schools distributed across the country.

Ethiopia's vision for its space program is to focus its priorities toward serving local needs such as communication and agriculture. Ethiopia is home to the privately funded Entoto Observatory and Research Center, which is located on top of 3200-meter-high Mount Entoto, near Addis Ababa.

Kenya is taking advantage of its equatorial position to efficiently launch satellites. Its capital Nairobi also hosts a regional SERVIR facility for eastern and southern Africa; SERVIR is a joint venture by NASA and the U.S. Agency for International Development that supports satellite-based

A Landsat view of the Aouelloul impact crater in Mauritania. The crater is 390 meters in diameter and formed when a meteorite struck 3 million years ago. Mauritania and other West African countries hold several confirmed or potential impact structures that are awaiting initial or more detailed field studies. Credit: USGS/NASA

Earth monitoring and modeling in developing nations around the world.

PSS in West Africa

In West Africa, Nigeria's National Space Research and Development Agency (NASRDA) focuses on environmental management, resource exploration, communication, and defense projects.

The Ghana Space Science and Technology Centre, with current projects in radio astronomy, was established in 2012. This summer, Ghana launched its first satellite (Ghana-Sat-1) into space from the International Space Station.

The University of Ghana in Accra offers courses in geochemistry, including one that focuses on cosmochemistry. A network of international collaborations among Ghana, Europe, and North America was established around the time of the International Continental Scientific Drilling Program project at the Bosumtwi impact crater in Ghana in 2004. This collaboration resulted in several local scientists receiving advanced degrees overseas before returning to Ghana, and the program stimulated Ghanaian ecotourism [e.g., *Boamah and Koeberl*, 2007].

The Senegalese Association for the Promotion of Astronomy is very active in public outreach and has its own Space Bus program. PSS is virtually nonexistent in central Africa, but basic planetary sciences may be taught locally at the undergraduate level.

A Look to the Future

Recent strides in fostering PSS across Africa illustrate the key role played by a few dedicated individuals, particularly when they are supported by political will favoring the training and academic recruitment of a knowledgeable young generation. Such political will anticipates a return on investment: In Africa, as in the rest of the world, government investment in research and education is motivated by projected social and economic benefits.

Wider sharing of knowledge may have positive impacts on the private sector; facilitated access to space-based geostrategic data may attract investment in mineral resources as well as infrastructure development. Increasing innovation and patents with economic spin-offs requires an increasing number of professionals with engineering skills. The wider use of satellite data can assist in finding solutions to environmental, agricultural, and health issues (e.g., desertification, deforesta-

Continued on page 23

Africa Initiative for Planetary and Space Sciences

Imagine a group of academic subjects that could help Africa to inspire youngsters, spur innovation, develop local economies, solve pressing problems, and even foster regional peaceful coexistence. Can such a panacea exist?

We strongly feel that it can. The subjects? Planetary and space sciences (PSS). In many areas of the world, investment in planetary and space science kick-started a wave of technological development and interest in science that propelled countries forward. A survey of almost 800 researchers who published in *Nature* between 2005 and 2008 revealed that half of them were inspired by the Apollo missions to pursue science—and not just astronomy or planetary sciences [*Monastersky,* 2009].

To elevate planetary and space science across the entire African continent, we propose the Africa Initiative for Planetary and Space Sciences (AFIPS; https://africapss.org/), an idea that stemmed from a panel discussion during the planetary science sessions of the 35th International Geological Congress (IGC) in Cape Town, South Africa, in 2016. Here we list a series of recommendations for expanding and structuring PSS across Africa.

Why Focus on PSS in Africa?

Unlike their counterparts in North America, Europe, and Asia, African nations do not have large, dedicated PSS programs that have international visibility. If scientific output can be measured in publications, Africa produces less than 1% of the world output in PSS, despite having more than 15% of the world's population (see Figure 1 at http://bit.ly/Eos-AfricaInitiativePSS).

What factors cause this low rate? Most glaringly, several countries lack a critical mass of requisite experts in science, technology, engineering, and mathematics (STEM) subjects. In addition, there's a widespread misperception that funding fundamental science costs society a lot but has little or only long-term societal impact. Such thinking limits national or international investment in PSS in African countries, from primary school through university research.

But overcoming this obstacle offers many opportunities. PSS teams often involve physicists, chemists, geologists, biologists, and engineers working on a common problem. This multidisciplinary aspect serves as a template for tackling pressing issues in our modern world.

What's more, expanding PSS may help to address several of the United Nations' Sustainable Development Goals that have already captured the interest of African governments: quality education, economic growth, reducing inequalities, climate, and peace.

PSS focuses on universal questions, such as the origin of life and the evolution and habitability of planets. Facts gained through science also help to fight against obscurantist tendencies. The subjects inspire people to think of the world as a single planet, not as a collection of countries. This favors international and intra-African cultural exchanges, which may contribute to peace alongside economic and social development.

What Does Africa Need to Foster PSS Education?

Students at most African high schools are not exposed to basic knowledge in astronomy and space science. We recommend a continent-wide effort to enhance teaching programs to fill these gaps.

Next, undergraduate students should be familiarized with the origin of Earth and other planets. The introduction to PSS should be the occasion to learn about the scientific value of the African impact cratering record and the wealth of scientific information gleaned from the numerous meteorites collected on the African continent.

Basic courses should include stimulating practical work, such as the analysis of planetary data and the examination of meteorites. Such practical courses require the creation and curation of meteorite collections in African museums.

From these courses should emerge opportunities to study space exploration techniques and become familiar with sensors used to analyze the surface and interior of planets. Pathways to research programs offered by major space agencies should also be cultivated.

To consolidate resources, the few African universities that already have emerging PSS groups are encouraged to commit to close interaction with key neighboring and overseas partners (universities and funding and space agencies). African students commonly move between countries and universities with diverse curricula, and these PSS programs may attract highly motivated students from neighboring countries.

Filling This Need: The Africa Initiative for Planetary and Space Sciences

We propose initial investment for a 5-year program that prioritizes M.Sc. and Ph.D. scholarships, temporary study-abroad fellowships for M.Sc. and Ph.D. candidates, and visits of junior (volunteering Ph.D. students) and senior researchers to Africa for transfer of knowledge. After a fourth-year review, the program could be renewed for another 5 years, with the longer-term goal of building a 20-year plan.

Initially, students receiving fellowships should be selected in countries with emerging groups in PSS, and the research topics should be defined in relation to local expertise and scientific priorities. The program must be advertised to ensure that the local population and political authorities are able to grasp the outcomes of new groups of pioneering academics who will be moving Africa ahead.

The definition of research projects under this new effort should be based on local expertise and strengths.

Tapping into Africa's Wealth of Geological History

The African geological record offers fertile ground for understanding processes on other planets. AFIPS could tap into this record.

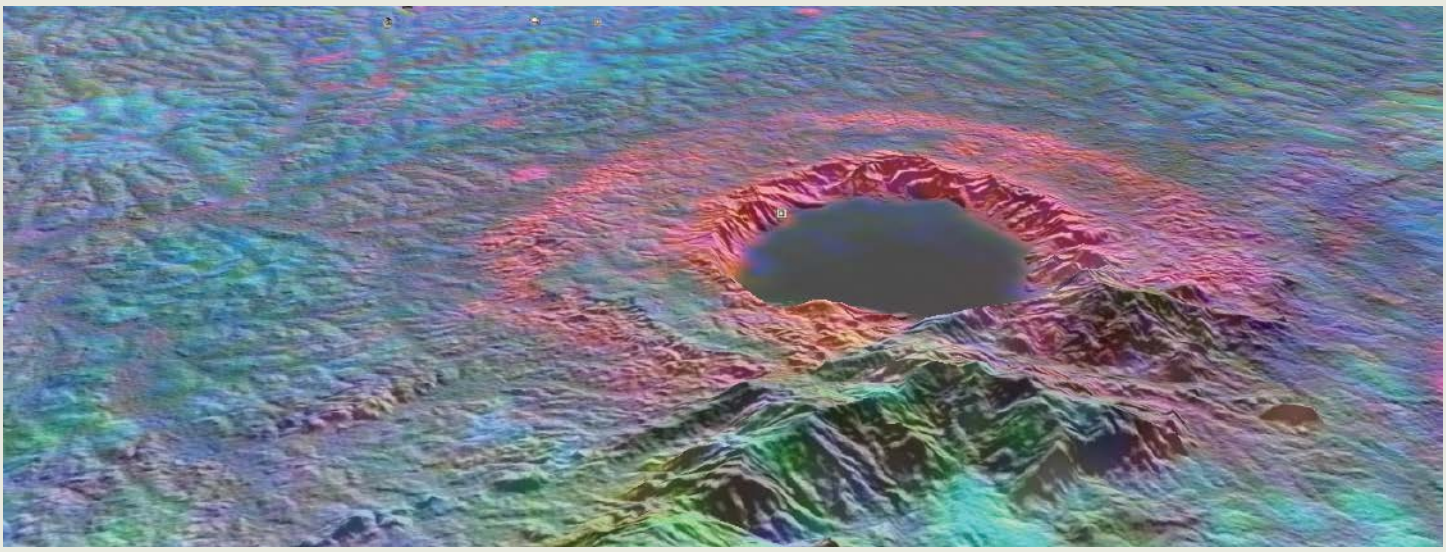
For example, planetary scientists have explored dry lakes in the Egyptian Western Desert to understand alteration signatures in the arid environment of Mars. Other planetary analogues include large meteorite impact structures, such as the Vredefort Dome in South Africa and the Bosumtwi impact crater in Ghana, and the active volcanoes and hydrothermal systems of the East African Rift. African deserts, in particular, the Sahara, are among the best places in the world to collect meteorites

The African geological record extends for more than 3.5 billion years, with cratonic nuclei distributed throughout the continent, offering clues to understanding the coupled evolution of the interior, surface, atmosphere, and life on a habitable planet.

Science for Society

A key thread for AFIPS will be to harness PSS to help society. This involves not only pure research but also applied studies and conservation efforts.

Africa hosts 20 confirmed meteorite impact structures, including the largest and oldest on Earth (Vredefort, 2.02 billion years old). These structures, and specific sites therein, must be



False-color aerial view of Ghana's Bosumtwi impact structure showing surface enrichments of potassium (red), thorium (green), and uranium (blue) superimposed on a shaded relief image. The crater is about 10.5 kilometers in diameter and formed when a meteorite struck about 1 million years ago. Researchers hope to use geologic features like Bosumtwi to inspire the public and industries to become invested in PSS. Credit: David Baratoux/Geological Survey Department of Ghana

protected. AFIPS could be structured to show leadership in their conservation.

We also hope that through AFIPS, more African nations could take advantage of the clear night sky for observation of meteorite falls and of the dry conditions over a significant part of the continent for the preservation of ancient falls. We strongly feel that the curation of African meteorites in African museums for educational purposes will foster sustainable scientific and economic (tourism) development on local and regional levels, as well as contribute to education of the wider public.

We recommend that a regulatory framework be coordinated at the regional scale for efficient preservation of meteorites for scientific studies. It is our hope that through education efforts related to AFIPS, such coordination can be fostered.

Projects with implications for pressing issues (e.g., climate change and space environment) or a connection with industry will also be targeted by AFIPS. For instance, the study of shock deformation effects in natural impactites may serve the space industry, as it is related to the effects of impacts on man-made systems by micrometeorites.

Forging Partnerships

Academic staff training in PSS is a long-term effort. Here the Africa Initiative could mirror project frameworks of other science efforts in Africa. For example, Africa Array, a research and training program dedicated to continent-wide geophysics training that is run jointly by African and North American partners, is midway through a 20-year plan. The Africa Initiative requires a similar timescale.

Our initiative will build on the grassroots networks of African researchers, for example, the African Network of Earth Science Institutions, the African Academy of Sciences, the Geological Society of Africa, the West African Exploration Initiative (WAXI; see *Jessell et al.* [2016]), and the Young Earth Scientists Network.

African networks may partner with geoscience societies. For instance, Europlanet, an organization with substantial experience in engaging policy makers and European citizens with planetary science, is already working with African partners to create a coordinated outreach strategy for activities related to the Danakil region in Ethiopia (as a planetary analogue site). Efforts in the Africa Initiative could follow this and other similar examples.

African institutions must be made more aware of the resources readily available to them. These include data released by NASA and European Space Agency planetary missions along with tools and tutorials on how to process the data. The rise of open-access journals offers African researchers greater access to the scientific literature, which will help future researchers on the continent.

Endorsing the Africa Initiative for Planetary and Space Sciences

It is our conviction that the exclusion of one fifth of the world's population from taking part in the fascinating discoveries about our solar system impoverishes global science. The identified benefits for African society as a whole justify investment in continent-wide research and education programs in PSS. This call is also timely considering the 31 January 2016 adoption by the African Union of the African Space Policy and Strategy, which raises awareness of the central role of space science and technology in Africa's socioeconomic development.

We declare our commitment to the development and expansion of PSS in Africa. Our effort will be focused on fund-raising and elaboration of international collaborative programs, coordination at the institutional level, training M.Sc. and Ph.D. students, organization of workshops and PSS sessions at Africa-based conferences, communication, and public outreach. Already, 19 international organizations, including AGU, and 257 scientists around the world have endorsed the initiative.

We will attempt to mobilize domestic resources for the implementation of this policy and strategy. We are looking for a broader endorsement from the international PSS community and from key stakeholders on the African continent. Individuals and national or international organizations who would like to support this initiative are invited to sign up on our website: https://africapss.org/.

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Editor's Note: The authors of this sidebar are those who wrote the feature article "The State of Planetary and Space Sciences in Africa" (see page 16).

Continued from page 20

tion, farming by satellite, and identification of factors controlling the spread of disease).

The knowledge gained and resources developed by current PSS efforts in Africa are only the beginning. As PSS grows in Africa, so too will its capacity to address the multiple challenges that this continent is facing for sustainable and inclusive economic growth.

Space Bus programs, such as this one in Senegal, promote planetary and space sciences to the general public. The bus follows an itinerary across the country and stops in several cities. At stops, interested people can gather to hear interactive talks and engage in hands-on activities related to telescopes, planets, and space exploration. Credit: Maram Kaire

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For complete versions of this article and the related sidebar (pages 21–22) on Eos.org, see
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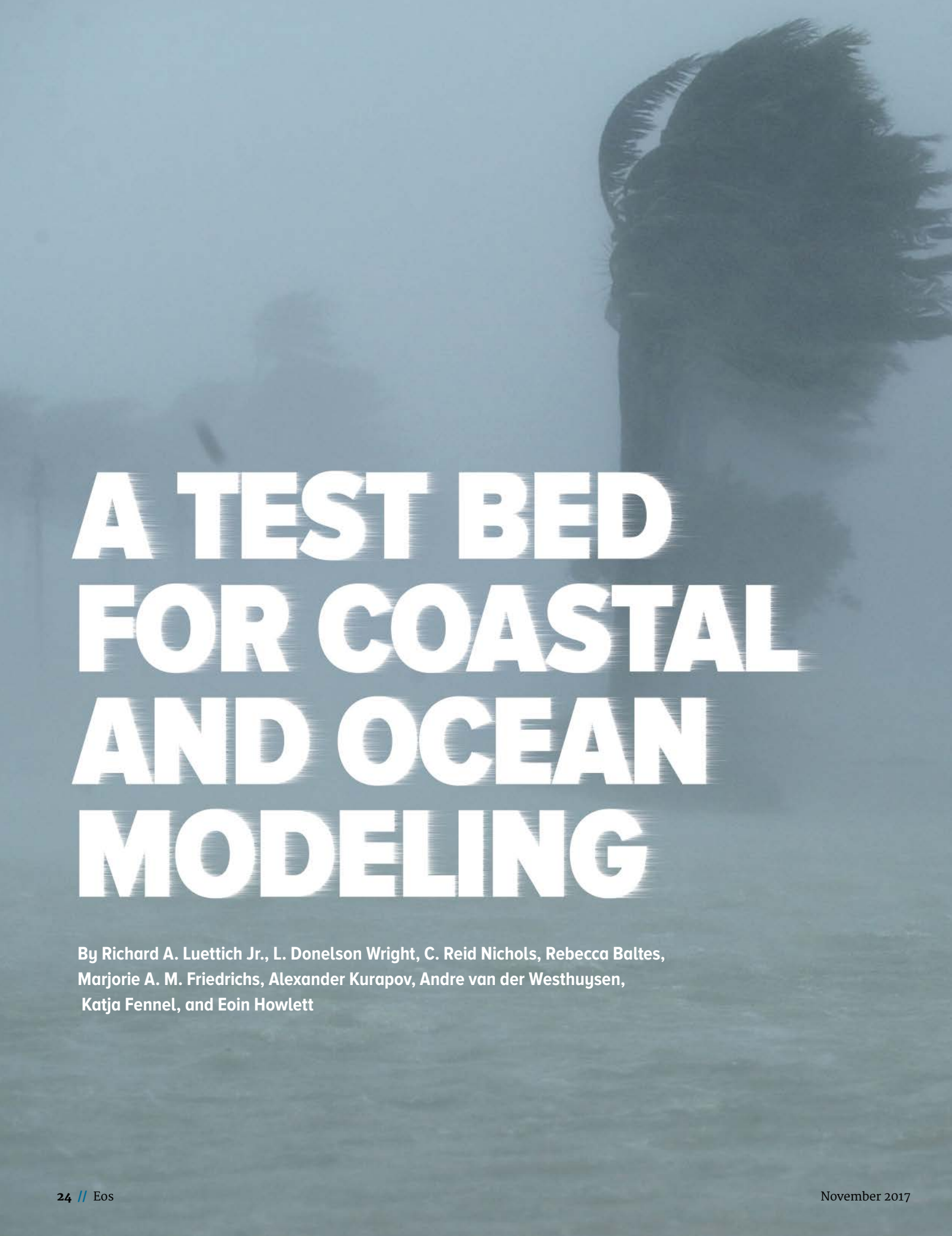


A TEST BED FOR COASTAL AND OCEAN MODELING

By Richard A. Luettich Jr., L. Donelson Wright, C. Reid Nichols, Rebecca Baltes, Marjorie A. M. Friedrichs, Alexander Kurapov, Andre van der Westhuysen, Katja Fennel, and Eoin Howlett

An ocean modeling program is improving our ability to predict circulation along the U.S. West Coast, dead zones and other coastal ecosystem responses, and storm surges in coastal and island environments.

From forecasting the incidence of oxygen-depleted "dead zones" in the Chesapeake Bay and northern Gulf of Mexico to predicting circulation along the U.S. West Coast and storm surges in the Caribbean, coastal and ocean modeling offers tools that can help save lives, protect property, and sustain marine resources.

The Coastal and Ocean Modeling Testbed (COMT; https://ioos.us/comt) supports this effort by conducting targeted research and development aimed at speeding up the process by which scientific and technical advances from the coastal and ocean modeling research community are transitioned into improved operational ocean products and services.

The COMT program, led by the Southeastern Universities Research Association (SURA), is part of the National Oceanic and Atmospheric Administration's (NOAA)

Hurricane Irma's storm surge floods a street in Fort Lauderdale, Fla. A multi-agency project evaluates the performance of coastal and ocean models, testing their ability to predict phenomena including storm surges and coastal inundation. Credit: Chip Somodevilla/Getty Images News/Getty Images

Table 1. Coastal and Ocean Modeling Testbed Collaborators and Partners

UNIVERSITY COLLABORATORS	GOVERNMENT COLLABORATORS	INDUSTRY/NONGOVERNMENTAL ORGANIZATION COLLABORATORS	PARTNERS
Dalhousie University	Center for Operational Oceanographic Products and Services, NOAA	Remote Sensing Solutions	IOOS regional associations for Southern California, Central and Northern California, Pacific Northwest, Mid-Atlantic, Gulf of Mexico, and Caribbean
Louisiana State University	Environmental Modeling Center, NOAA	RPS Applied Science Associates	Chesapeake Bay Program Office, U.S. Environmental Protection Agency
Oregon State University	National Hurricane Center, NOAA	Southeastern Universities Research Association	National Environmental Satellite, Data, and Information Service, NOAA
Texas A&M University	U.S. Integrated Ocean Observing System, NOAA		National Ocean Service, NOAA
University of California, San Diego	Naval Research Laboratory, U.S. Navy		National Weather Service, NOAA
University of California, Santa Cruz	Coastal and Hydraulics Laboratory, U.S. Army Corps of Engineers		U.S. Geological Survey
University of Maryland	Gulf Ecology Division, U.S. Environmental Protection Agency		
University of Maine			
University of North Carolina			
University of Notre Dame			
University of Puerto Rico			
University of Washington			
Virginia Institute of Marine Science, College of William and Mary			
Woods Hole Oceanographic Institution			

Integrated Ocean Observing System (IOOS) effort. Projects supported through COMT are designed to assess the performance of existing models, create new model code and tools as necessary, inform and train users, and build a repository of evaluation data sets to expand and improve the modeling capabilities of operational partners and the broader coastal and ocean modeling community.

The first COMT program began in 2010 and was completed in 2013. A description of the program from its inception and a compilation of scientific results are available in a special issue of the *Journal of Geophysical Research: Oceans* [*Luettich et al.*, 2013].

The current COMT program began in 2013 and includes participants from academia, the private sector, and government agencies (Table 1). Here we highlight progress in five ongoing COMT projects.

Chesapeake Bay Oxygen Depletion

Changes in levels of dissolved oxygen have a significant effect on the health of the Chesapeake Bay, an estuary located in the mid-Atlantic region of the U.S. East Coast. Excessively low oxygen levels can stress or kill fish and other animals, creating dead zones within the bay.

COMT's Chesapeake Bay project seeks to improve models of dissolved oxygen concentration in the estuary, taking into consideration a variety of contributing factors. The study is designed to provide a better understanding of the uncertainty inherent in predictions of such properties as salinity, temperature, chlorophyll content, and nutrient concentration and how this uncertainty contributes to the predictability of dissolved oxygen levels.

The project team compared the regulatory model used by Chesapeake Bay program managers with research models currently being used by the scientific community and found that the regulatory model performed as well as many of the scientific models. This result gives program managers and academic scientists more confidence in the regulatory model.

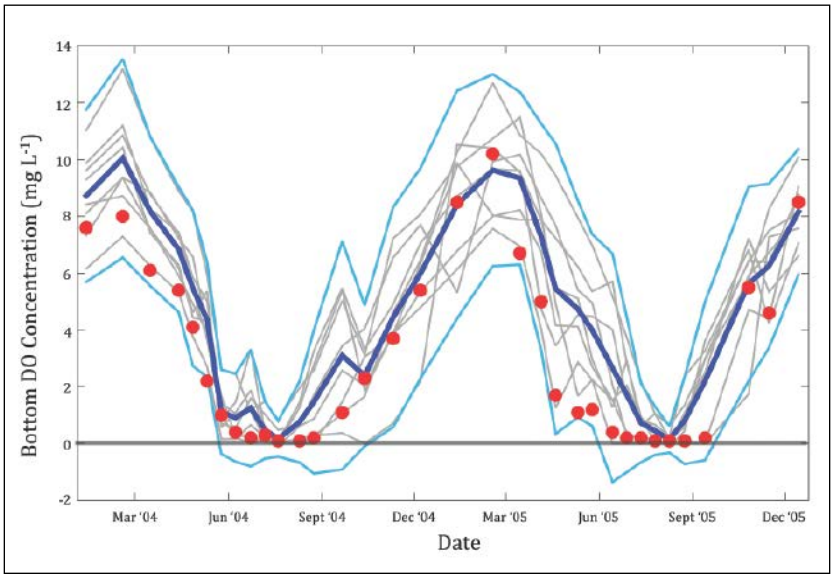
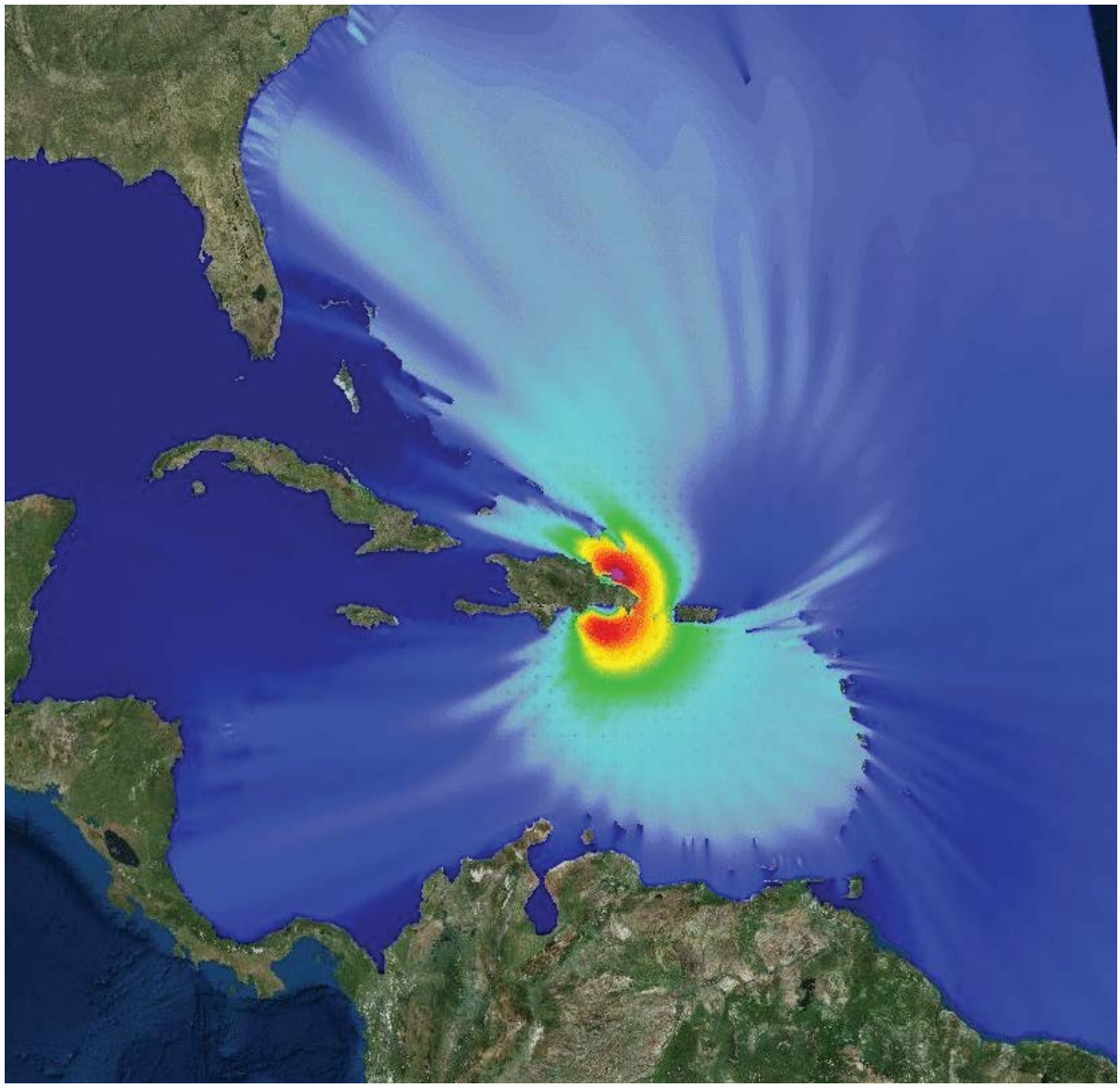


Fig. 1. Changing levels of dissolved oxygen concentrations were measured at U.S. Environmental Protection Agency station CB4.1C in Maryland near Kent Point in the upper Chesapeake Bay. Red dots represent 34 observations made during 2004–2005. Gray curves represent the predictions of several individual models. The dark blue curve represents the model mean, and the turquoise curves give the 95% confidence interval. The model mean does better in matching the observations than any individual model. Source: Irby et al. *[2016], CC BY 3.0 (http://bit.ly/ccby3-0)*



This visualization of a modeled surface wavefield, part of a study of storm surge and inundation prediction in the Caribbean, shows water level changes as Hurricane Georges moves into the Caribbean Sea in 1998. Colors indicate significant wave height. The Coastal and Ocean Modeling Testbed (COMT) program conducts targeted research and development to accelerate the transition of scientific and technical advances from the modeling research community into improved products and services for a wide range of users. Credit: COMT/RPS Applied Science Associates

The team also found that an ensemble mean of multiple models is better at predicting hypoxia than any individual model (Figure 1), illustrating the potential value of multimodel ensembles for decision making concerning the Chesapeake Bay.

Project researchers developed a simple one-term model for hypoxia (oxygen deficiency in the environment) for use in day-to-day operational forecasts. The model is currently providing same-day and 3-day forecasts of Chesapeake Bay hypoxia on the Virginia Institute of Marine Science website (see http://bit.ly/hypoxia-forecasts). The team is pursuing incorporation of this tool into NOAA's Chesapeake Bay Operational Forecast System (see http://bit.ly/CBOFS).

The Chesapeake Bay project is also running a variety of scenarios using multiple models, including the regulatory program model, to assess responses to nutrient load reductions and future climate change. These results will help inform coastal resource managers directing the restoration and protection of the Chesapeake Bay.

Gulf of Mexico Oxygen Depletion

Dissolved oxygen depletion is also a significant problem in the Gulf of Mexico, where a large hypoxic area forms every summer over the Texas-Louisiana shelf in the northern part of the gulf.

As in the Chesapeake Bay project, COMT's Gulf of Mexico study is focusing on identifying factors that influence the prediction of dissolved oxygen concentration. This is done to improve understanding of the controlling

processes and to provide guidance on the eventual implementation of dissolved oxygen forecasts in NOAA's Northern Gulf of Mexico Operational Forecast System (see http://bit.ly/NOAA-NGOFS).

A comparison of three coupled hydrodynamic-ecosystem models has shown that skillful hypoxia predictions in this region require accurate reproduction of bottom water temperature, bottom boundary layer thickness, and vertical attenuation of short-wave solar radiation (the way that the water column filters out the blue and ultraviolet wavelengths of sunlight at progressively greater depths) [*Fennel et al.*, 2016].

Project researchers are conducting scenario-based simulations to assess the potential impacts of nutrient management decisions in the Mississippi River Basin and future climate conditions on hypoxia in the northern Gulf of Mexico. Results are informing the interagency Hypoxia Task Force's efforts to devise near-term and long-term nutrient management strategies (see https://www.epa.gov/ms-htf).

West Coast Forecast System

COMT's West Coast project is part of a larger NOAA effort to develop a new U.S. West Coast basin-wide operational forecast system (WCOFS). Operational forecast systems provide near-term and long-term predictions of such factors as wind, temperature, water levels, salinity, currents, and, eventually, water biogeochemistry.

The project's 6-year evaluation of the Regional Ocean Modeling System (ROMS; https://www.myroms.org) shows that this model can realistically reproduce ocean variability on scales from a few days to years along the entire U.S. West Coast.

The project team is studying three biogeochemical models of differing complexity, already incorporated into ROMS, to identify advantages and limitations of the varying model formulations and to assess associated rate processes.

Data assimilation is a critical future component of WCOFS. Thus, we are also evaluating approaches to data assimilation in ROMS using new metrics for assessing model and assimilation system skill. We have shown that existing observational data are reasonably effective at correcting model representations of circulation associated with the California Current system.

Close coordination between the COMT team and the WCOFS implementation team is helping to accelerate the development of WCOFS at NOAA.

Caribbean Surge and Wave Modeling

Intense storms bring high waves and surges that can inundate coastal areas and flood rivers. COMT's Caribbean project aims to extend effective forecasting of waves and storm surges from gently sloped areas, such as the Gulf of Mexico's northern edge, to steep-sloped areas, like those surrounding Caribbean islands.

Taking advantage of observational data available for Puerto Rico and the U.S. Virgin Islands, the project team evaluated a number of models for their effectiveness in predicting storm surges and coastal inundation.

Regional-scale model runs for Hurricane Georges (1998) and Hurricane Irene (2011) elucidated the relative roles of wind forcing and wave forcing on storm surge and inundation in Puerto Rico. These model runs used the Advanced Circulation model (ADCIRC) and NOAA's Sea, Lake, and Overland Surges from Hurricanes (SLOSH) model, coupled to the Simulating Waves Nearshore (SWAN) model.

To see animations of a modeled surface wavefield, illustrating water level changes as Hurricane Georges approaches Puerto Rico, go to http://bit.ly/Georges-animations. These animations include a close-up showing wave heights as the hurricane makes landfall at Vieques and the eastern end of Puerto Rico. Red and yellow colors indicate significant wave height.

Comparisons between the coupled ADCIRC-SWAN model and the SLOSH-SWAN model, developed during the original COMT program, have helped to document the performance of the latter approach. On the basis of these findings, the National Hurricane Center used the coupled SLOSH-SWAN model to produce the first surge and inundation hazard database for Puerto Rico that includes the effects of waves.

The associated Storm Surge Maximum Envelope of Water (MEOW) and Storm Surge Maximum of the Maximum (MOM) models are now providing crucial guidance tools for the Puerto Rico Weather Forecast Office and are

being used in the development of evacuation zones for the National Hurricane Program's hurricane evacuation studies.

Model Viewer

The COMT computer infrastructure project is focused on archiving data for evaluating models, providing tools to discover and access these data, and creating visualizations of model outputs.

Although researchers often have in-house visualization and analysis tools tailored for use with their specific numerical models, our new model viewer allows the simultaneous visualization of results from different models (see http://oceansmap.com/comt). This facilitates model comparisons and helps extend the value of COMT results to future modeling research and development activities.

Fostering Collaboration

Since 2010, COMT has facilitated collaboration among more than 20 universities and a range of government agencies, including NOAA, the U.S. Navy, the Environmental Protection Agency, and the U.S. Army Corps of Engineers. COMT is now one of 11 official NOAA test beds (see http://www.testbeds.noaa.gov).

Collaboration has underpinned program success from the outset, within the academic community and, more important, between academia and operational users. Such collaboration requires dedicated effort, along with a mutual acceptance of goals, critical assessment of diverse approaches, iterative updates, promotion of new paradigms, and effective communication.

Scientific understanding, like nature, is impermanent and dynamic. We expect COMT to continue to evolve in concert with the operational use of the coastal and ocean models that it is intended to advance.

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INTERVIEWING 102:
QUESTIONS ABOUT QUESTIONS

By David Harwell and Nathaniel Janick

You constantly question the world; as a scientist, you feel that it's your responsibility to ask, "Why?"

Why were sauropods so successful? Why haven't we discovered life on other planets? Why did so many megafaunal species go extinct during the Quaternary period? Why can't someone else add water to the coffee machine?

You have become accustomed to answering scientific questions through research and experimentation. You were made for this, trained for this. It's what you do.

But then comes the dreaded job interview, and suddenly, without a scientific context, asking and answering questions seem more difficult.

Don't despair! The reality is that the chasm between scientific questions and interview questions is not as wide as it appears; just as scientific research has a methodology, there is also a methodology to interviewing, and by practicing you will become more proficient at formulating questions and answers related to an employer's needs, organizational practices, and your skills and competencies.

Interviews are simply conversations between people with questions. The goal is for two parties to learn more about each other (more about this in Interviewing 101, http://bit.ly/Interviewing-101). Let's take a look at the questions prospective employers might ask you and the questions you should ask them and also consider some questions that shouldn't be asked and how to handle them if they are.

Credit: Yuri_Arcurs/iStock/Getty Images Plus

Their Questions

Your first goal in an interview is to provide the information that they want in a way that paints a positive picture of you. You must be honest in your responses, but it is unlikely that you will have reason to add information beyond what they ask you.

It is tempting to blather on, especially when you are nervous, but don't. Like a politician, you need to stay on point. The exception, of course, is if you have key information about yourself that you want them to know.

Tell Me a Little About Yourself...

The most difficult question that you are likely to face is disguised as a statement: Tell me a little about yourself. You know it's coming, so you might as well prepare for it.

Like an elevator speech, your response should be brief and should illustrate the ways that you are uniquely qualified to address the employer's needs. Construct your response in advance on the basis of the job description and any insights that you may have about the employer and/or the person conducting the interview. You can find more advice about how to go about researching your interviewer in Lisa Balbes's recent *On the Job* post, "Interview Success: It's Not You, It's Them" (see http://bit.ly/Its-Not-You).

Contrary to what others might say, this is not the time for you to tell your life story. Your favorite color, your big sister's middle name, and your ability to simultaneously sing your national anthem and down a pint of ale are all special bits of information, but they have no relevance here. Focus your response on your potential employer's needs for now, and save your scintillating tidbits for your friends at a later date.

Any response that you may give to a question should be less than 3 minutes long—shorter is better. Remember, you are engaging in a conversation, not giving a lecture. *Don't underestimate the potential for this question to trip you up.* Formulate a response and practice giving it to a friend.

Behavioral Assessments: Tell Me About a Time When...

Your potential employer is very likely to ask a series of questions classified as behavioral interview questions. Behavioral assessment methodology is based on the premise that your past actions are the best predictor of your future actions.

Behavioral questions generally begin with a phrase like "Tell me about a time when...." For example, "Tell me about a time when you missed an important deadline." In response to the question, you will need to tell a story in which you are the protagonist or, better yet, the hero.

- As you answer the question, take a moment to set the context for your story. (*Once upon a time, at my previous employment, during a summer internship, etc., I....*)
- Tell what was happening and why. (*The U.S. National Park Service needed to develop a strategy to track endangered botanical species populations in the Ko'olau Range in Hawaii.*)
- Describe the action that you took to solve the situation, and follow up with the resultant outcome. (*Pulling*

from citizen science reports, NASA satellite imagery, and U.S. Geological Survey data sets, I was able to map these endangered species using Google Earth and ESRI ArcGIS, thereby facilitating the National Park Service's conservation efforts.)

- Choose a story in which you learned from the situation and were able to apply what you learned to make the situation better. (*Although it was initially challenging to effectively use the citizen science reports, their use had the unintended benefit of raising awareness of the Park Service's activities while providing a new avenue to engage with the public.*)

Coming up with a suitable story on the fly can be difficult, and I have seen a few job seekers go down in flames as they fumbled for the right one. Your best defense will be to think about the most probable questions in advance and formulate your stories before you go on the interview.

If you search for "behavioral interview questions" online, you will quickly find many different examples, but like Hollywood movies, they branch from a few common themes.

- Interacting with other people, for example, in times of stress, on a team, or when someone is a jerk
- Dealing with challenging situations, for example, solving problems, or dealing with conflict
- Managing, for example, people, time, resources, or processes
- Making choices, for example, ethical practices, or prioritization

Think about the most probable questions in advance and formulate your stories before you go on the interview.

For each of the examples above, reflect on your experiences and identify a time when you resolved a similar situation. Write a response for each, and practice telling your stories to someone else.

Preferably, you should tell the stories to that "friend" who is quick to point out that your haircut is lopsided and your socks don't match. The critical feedback may sting, but at least it won't hurt your chances for employment.

Safety note: Don't opt for a response that starts with "I've never…." Everyone has dealt with some form of adversity in their life.

The questions are less about exposing your weaknesses and more about highlighting your abilities to adapt and learn from a situation. Look on behavioral questions as opportunities for you to sell yourself and your capabilities.

What Is Your Greatest Weakness?

So you've gotten through "tell me about yourself." But don't drop your guard! An equally unforgiving question is, "What is your greatest weakness?"

Your strategy for response should be similar to the one described above for behavioral questions. Tell a story (see http://bit.ly/Pitch-Yourself). Don't say, "I don't have a weakness." You do.

Avoid "my weakness is the same as my strength. I work too hard." That one always makes me a little nauseated. Instead, consider a challenge that you are working to overcome, and tell how you are dealing with it. In other words, tell a story in which you successfully dealt with trials and tribulations.

For example, "I have a tendency to get wrapped up in what I am doing. If I'm not careful, I can forget about meetings or other important projects, so I've started putting placeholders and appointments on my calendar with alarms that remind me of what I need to do and when. Using technology, I have been able to compensate for a former liability, and it is seldom that I miss anything important."

Questions That Employers Should Not Ask (Warning: Some Will Anyway)

In the United States, it is illegal to discriminate on the basis of sex, race, age, disability, color, creed, national origin, or religion, and employers usually avoid related questions. Many countries have similar, sometimes even stricter, laws. Technically, there are no illegal questions, but if an employer asks questions related to a protected classification, it opens them up to litigation based on probable discrimination. That said, it still happens, and you should think through how you would address the situation.

When I was interviewing for academic positions, I was invited to a university in a pleasant locale. I was unpleasantly surprised when person after person asked whether I was married. I wanted to say, "You can't ask that," but I knew that they really could, and I didn't have a graceful way to push back on the question.

So I asked, "Why is that important?" As it turned out, the previous three hires had not lasted very long because they were single and there were few suitable dating candidates in the small town where the university was located.

A better strategy for the university would have been to tell me about the dismal matrimonial prospects of their small town up front. I would have run away on my own and saved them the time and expense of hosting me.

Many times, job candidates are not comfortable with confronting those asking difficult questions, but you have a lot to gain and very little to lose by doing so. Asking why a question is relevant can also make the interviewer aware of his or her own biases. As odd as it sounds, many people are unaware of their discriminatory practices. Hidden and subconscious bias can then manifest itself through questions lobbed to you.

In some countries, there may be few, if any, protections against discrimination. You may be expected to indicate your age and marital status when applying for a job. It may also be customary to include your picture. If it is required, then you should comply, but don't volunteer that kind of information. Give extra information only if it is to your advantage.

Your Questions: Getting to Know Them

Your first goal was to provide the interviewers with the information they need about you. Your second goal is to find out more about the job, the organization, and the people with whom you will be working.

There is only so much you can learn about an employer online, but gleaning basic information from organizational documents, Web pages, LinkedIn profiles, and news stories prior to the interview can lead you to the right questions to ask during an interview. So when the interviewer asks, "Do you have any questions," you should have something prepared. Try to ask questions that go beyond what you can easily learn from reading the "about" page on their website.

For example, ask the interviewer about his or her personal experiences at the company.

- What led him or her to work there?
- What is it that he or she likes most about your job?
- What is the most critical skill or ability needed to be successful there?
- In industry, who are the company's closest competitors, and what is the company's competitive edge?
- In academia, what are his or her students like? How well are they prepared for class?

Another line of questions to pursue involves organizational culture.

- What can the interviewer tell you about the organizational structure for this group? Who reports to whom?
- How are important decisions made? What would your role in the process be?
- How are teams created? Will team members come from within the department, or will they come from different parts of the organization?

The Bonus Question

In many cases, interviewers must ask the same set of questions in an effort to ensure each candidate is on a level playing field. If you and five other candidates have the exact same resume and answer each question in the same way, where is the variance? How will the interviewer come to a decision? That will come not from your answers, but from your questions.

Keep this in mind when you are preparing for their questions. If there's a question you are well prepared for and you really want them to ask you, figure out a way to ask it yourself. You can use your questions to them as an opportunity to raise a question yourself by driving the conversation toward your desired topic.

In the grand scheme of things, your questions to them can serve a dual purpose by providing them with answers about you.

Things to Ask About Later: All the Stuff I Want

Wait until you have a job offer before you ask about benefits or any special accommodations you might want.

If they proffer a list of benefits or inducements, that's a good thing. It means they really like you. However, if you ask about benefits before they have made a job offer, it will make you look needy or pushy. You will have more leverage to ask for what you want once they have placed an offer on the table.

Practice Makes Perfect

Over time, you have honed your technical skills and methodologies. It is through practice that you have become an expert, and it is through your work that you have been able to build your professional reputation.

Just as you hone your scientific skills, practice your interviewing skills. Now that you have a better understanding of interview methodologies, it's time to put that knowledge to use. You know why you should prepare in advance for interview questions, and you know why employers ask the questions they do. You even have a set of procedures to follow to formulate your answers.

So why are you waiting? You will get better only if you practice.

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Celebrating the 2017 Class of Fellows

AGU has selected its new class of Fellows. The organization will recognize these esteemed scientists at the 2017 AGU Fall Meeting in New Orleans during the Honors Tribute on Wednesday, 13 December 2017. President-elect Robin Bell will present the newly elected class. Please welcome our 61 colleagues who have joined our AGU College of Fellows!

A brief statement of the achievements for which each of the 61 Fellows was elected is provided below.

M. Joan Alexander

For outstanding contributions to understanding atmospheric gravity waves and their role in atmospheric circulation.

Jeffrey Alt

For pioneering and innovative contributions to understanding geochemical exchanges between seawater and the ocean crust.

David D. Breshears

For contributions to the discovery of how climate change interacts with biotic disturbance to cause large-scale forest mortality.

Bonnie J. Buratti

For fundamental contributions in applying quantitative radiative transfer models to interpret photometric data of planetary surfaces.

Wei-Jun Cai

For groundbreaking research on estuarine and coastal processes and their relationship to the global carbon cycle.

Josep G. Canadell

For significant and innovative work on the global carbon cycle, addressing natural and human systems, with broad impacts on science and society.

Don P. Chambers

For outstanding contributions to sea level research and ocean dynamics using satellite observations.

Kelly Chance

For contributions to the spectroscopy and remote sensing of atmospheric trace gases.

Marc Chaussidon

For developing microanalytical techniques to make major discoveries in geochemistry and cosmochemistry.

Alan D. Chave

For fundamental studies of the oceans and solid Earth using electromagnetic methods.

Wang-Ping Chen

For innovative and world-class studies of subduction zone earthquakes and evolution of the lithosphere during continental collision.

Hai Cheng

For breakthrough improvements in uranium series dating of cave deposits that reveal the causes of ice ages and abrupt hydroclimatic change.

Peter G. Decelles

For advancing the understanding of the dynamic evolution of foreland basins and mountain-building processes.

Gerald Dickens

For advances in understanding oceanic methane hydrates and their potential impact on Earth's climate.

Paul A. Dirmeyer

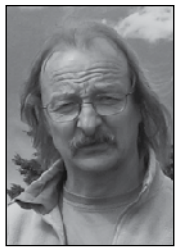
For pioneering the study of global soil wetness and its role in land-atmosphere coupling and seasonal predictability of the climate system.

Claudio Faccenna

For advances in understanding the processes and consequences of subduction in settings ranging from geologic to upper mantle in scale.

John Carl Foster

For transformative insights and work in magnetosphere-plasmasphere-ionosphere coupling, ionospheric storm response, and radiation belt dynamics.



Roger François

For profound applications of radioactive and stable isotopic tracers to studies of a wide range of physical and chemical cycles in the ocean.

Arthur D. Frankel

For exceptional insight into earthquake physics and extraordinary dedication to its use for effective risk reduction.

Helen Amanda Fricker

For advances in the understanding of Antarctic ice sheets, ice shelves, and subglacial hydrologic systems.

Jonathan Gregory

For profound and enduring contributions to our understanding of ocean dynamics, climate sensitivity, and global sea level change.

Stephen M. Griffies

For exceptional and sustained contributions to the understanding of large-scale ocean circulation and physics and seminal advances in ocean modeling.

Nancy Beth Grimm

For integration of desert and urban aquatic and terrestrial biogeochemistry with ecological and social theory to advance a biogeoscience of cities.

George Helffrich

For pioneering seismological and thermodynamic studies of Earth's mantle and core.

Susan S. Hubbard

For fundamental contributions to hydrology through the application of geophysics.

Erik R. Ivins

For varied and enduring contributions to the study of Earth structure, dynamics, and climate through the lens of geodesy and geophysics.

Fortunat Joos

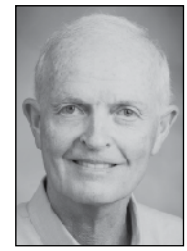
For fundamental development and application of coupled climate-biogeochemical models to understand the global carbon cycle.

Samantha Benton Joye

For groundbreaking investigations of the fate of and microbial response to oil and gas released into the marine environment.

Yann H. Kerr

For transformative remote sensing research to characterize and monitor local and global phenomena of the hydrosphere and biosphere.



Alan K. Knapp

For fundamental contributions to our understanding of the mechanisms underlying ecosystem responses to climatic variability and extremity.

Matthew J. Kohn

For outstanding contributions to metamorphic petrology, tectonics, and paleoclimatology.

Ronald Kwok

For advances in the remote sensing of sea ice covers of the Arctic and Southern oceans.

Upmanu Lall

For incisive contributions to the understanding and predictability of hydrologic processes at regional and global scales.

Murli H. Manghnani

For pioneering experiments on the elastic and structural properties of molten silicates and core alloys.

Barry H. Mauk

For pioneering investigations of charged particle injection, acceleration, and loss within the magnetospheres of Earth and the gas giant planets.

Klaus Mezger

For groundbreaking contributions to the chronology of terrestrial high-grade metamorphism and the early differentiation history of planetary bodies.

Alberto Montanari

For groundbreaking contributions to understanding hydrologic change through physically based stochastic modeling.

Louis-Noël Moresi

For fundamental contributions to the computational geodynamics of planetary interiors, plate tectonics, and deformation of the continental lithosphere.

Scott Lawrence Murchie

For innovative, revolutionary, and influential discoveries on the geology of Mars, Mercury, near-Earth asteroids, and the moons of Jupiter.

Teruyuki Nakajima

For innovative radiative transfer and remote sensing accomplishments and for exceptional international leadership in promoting climate science.

Richard Norby

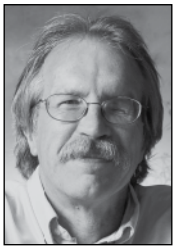
For outstanding research on organism and ecosystem responses to elevated carbon dioxide atmospheres and environmental changes.

John Plane

For fundamental advances in understanding the chemistry of Earth's upper atmosphere.

John Raymond

For outstanding contributions in developing and applying innovative theoretical tools for analyzing high-temperature plasmas in astrophysical environments, especially the Sun and solar wind.



Steven Roecker

For significant and sustained contributions to observational seismology leading to breakthroughs in understanding of mountain belt–building processes.

Eelco Johan Rohling

For original contributions to sea level reconstruction and for fundamental insights into understanding anoxic sediment formation.

Ares J. Rosakis

For monumental achievements in the field of experimental fracture dynamics that have transformed our understanding of earthquake rupture processes.

Yinon Rudich

For advances in the understanding of atmospheric chemical processes at the molecular level with implications for climate and human health.

Lynn M. Russell

For pioneering contributions to the fundamental science of organic aerosols through innovative theory, instrumentation, measurements, and modeling.

Daniel Schertzer

For pioneering works on multifractals and generalized scale invariance and their wide applications in geophysics.

Walter H. F. Smith

For fundamental contributions to marine geodesy, especially applying satellite altimetry to bathymetry, physical oceanography, and oceanic tectonics.

Robert J. Stern

For fundamental insights into subduction inception, ophiolite origins, arc and continent evolution, and the onset of plate tectonics.

Paul James Tackley

For fundamental contributions to the understanding of mantle dynamics on Earth and other planets.

Margaret S. Torn

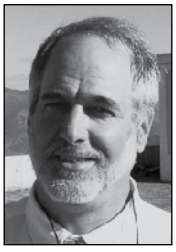
For fundamental contributions to understanding soil carbon stabilization and sustained leadership in quantifying feedbacks between the carbon cycle and climate.

Gregory E. Tucker

For leadership in exploring landscape evolution through empirically constrained numerical models forced by realistic geology, hydrology, and tectonics.

Susan L. Ustin

For pioneering work in hyperspectral remote sensing that has improved our ability to understand and manage changes in terrestrial ecosystems.



Richard M. Vogel

For development of hydrologic science and statistical methods in service to society and water resources and natural hazard management.

Patricia L. Wiberg

For insight into and development of widely used tools for the study of sediment dynamics from source to sink.

Teng-Fong Wong

For seminal contributions to the knowledge of the evolution of mechanical and hydrological properties during deformation of rocks.

Roger V. Yelle

For significant advances in understanding the upper atmospheres of planets and implications for planetary evolution.

Youxue Zhang (张有学)

For original theoretical, experimental, and observational contributions to geochemical diffusion processes on Earth and other solar system bodies.

Edward Zipser

For fundamental contributions to the study of convective clouds by creative use of field programs and satellite observations.

Grant Will Advance Standards Promoting Open, High-Quality Data

shulz/iStock/Getty Images Plus

Scientific advancement increasingly relies on large and complicated databases and models to thrive. Earth and space scientists, in particular, often grapple with complex systems to help society manage the threats of natural hazards and climate change. The scientific community faces many challenges to preserving often nonreproducible data and to cataloging and storing them in ways that are searchable and understandable.

To address these challenges, the Laura and John Arnold Foundation has awarded a grant to a coalition of scientific groups, convened by AGU, representing the international Earth and space science community. The grant will allow the coalition to develop standards to connect researchers, publishers, and data repositories across the sciences. These standards are meant to render data findable, accessible, interoperable, and reusable (FAIR), with the aim of enhancing the integrity and reproducibility of data and accelerating scientific discovery (see http://bit.ly/FAIRprinciples).

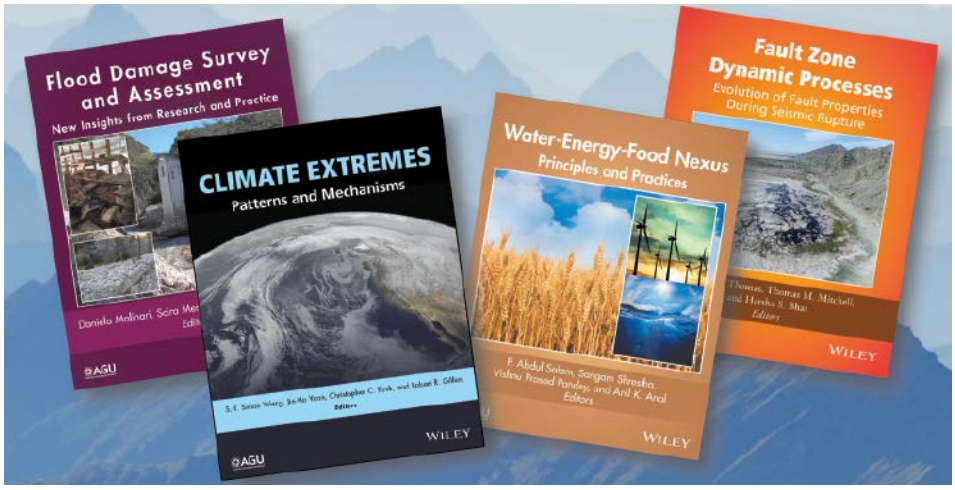
"AGU's commitment to open data and data stewardship started in 1997 when we developed one of the first society position statements on open data," said Chris McEntee, AGU's executive director/CEO. Now, with the foundation's support and close collaboration among scientific organizations, publishers, and data centers, the Earth and space sciences will become "the first scientific field to have open and well-described data as a default."

> The Earth and space sciences will become "the first scientific field to have open and well-described data as a default."

The coalition currently includes AGU, Earth Science Information Partners, and the Research Data Alliance and has support from the *Proceedings of the National Academy of Sciences of the United States of America*, *Nature*, *Science*, the Australian National Data Service, AuScope, and the Center for Open Science.

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

AGU Books Program Continues to Grow



Some of the books that AGU, in partnership with Wiley, has recently published. Credit: AGU

When AGU moved publications production to Wiley in 2013, it was not only the journals portfolio that shifted but also AGU's long-standing program of scientific book publishing. In the few years prior to the move, AGU was issuing no more than six titles per year. Thanks to the resources provided by Wiley, an average of 10 new titles were published annually during the first few years of our partnership. The goal is to reach 15–20 books per year encompassing subjects across Earth and space science with a particular effort to complement the journal coverage.

At Wiley, AGU's books are overseen by a dedicated editor and Ph.D. Earth scientist, Rituparna "Ritu" Bose. "My own academic background is in geosciences, but working with the AGU portfolio is really exciting because of the diverse subject matter," Bose said. "From one day to the next I can be dealing with topics from undersea volcanoes and solar wind to soil carbon dynamics and atmospheric modeling. It's also a privilege to be able to interact with researchers from around the world at the cutting edge of scientific research and to support them in bringing their work to publication."

Call for Proposals

Bose is active in reviewing sessions at AGU Fall Meeting and other conferences throughout the year for potential book ideas and is meeting with prospective editors and authors to talk about the possibilities of publishing with AGU. She is also happy to be contacted by individuals at any time at rbose@wiley.com to discuss book ideas and the proposal process. Currently, she is specifically interested in proposals for textbooks to support upper level undergraduate and graduate level classes and edited collections of chapters exploring key research topics.

Interviews with Editors

AGU aims to distill and convey some of the scientific knowledge and advances from each new book in an accessible way as part of the *Editors' Vox* section of Eos.org. These discussions about fields and topics explored in the latest books typically take the form of interviews with the editors. Here are some of the most recent ones:

- Working Towards a Sustainable Future
- The Value of Disaster Damage Data
- How Does Changing Climate Bring More Extreme Events?
- Neotectonics and Earthquake Forecasting
- Where and How Can We Find New Sources of Oil and Gas?
- A Foundation for Modeling Time-Periodic Groundwater Flow

New Titles

During the past year, we published these new volumes, listed below by thematic area.

Climate

Climate Extremes: Patterns and Mechanisms

Hydrology

Terrestrial Water Cycle and Climate Change: Natural and Human-Induced Impacts

Hydrodynamics of Time-Periodic Groundwater Flow: Diffusion Waves in Porous Media

Natural Hazards

Natural Hazard Uncertainty Assessment: Modeling and Decision Support

Plate Boundaries and Natural Hazards

Flood Damage Survey and Assessment: New Insights from Research and Practice

Natural Resources

Water-Energy-Food Nexus: Principles and Practices

Oil and Gas Exploration: Methods and Application

Tectonics and Seismology

Active Global Seismology: Neotectonics and Earthquake Potential of the Eastern Mediterranean Region

Crustal Permeability

Fault Zone Dynamic Processes: Evolution of Fault Properties During Seismic Rupture

Space Weather and Space Physics

Magnetosphere-Ionosphere Coupling in the Solar System

Ionospheric Space Weather: Longitude Dependence and Lower Atmosphere Forcing

Dawn-Dusk Asymmetries in Planetary Plasma Environments

Forthcoming Titles

Bioenergy and Land Use Change

Scientific Integrity and Ethics in the Geosciences

Microstructural Geochronology: Planetary Records Down to Atom Scale

Geochronology and Thermochronology

Reducing Uncertainty in Hazard Prediction
Filling Earth's Space Environment from the Sun or the Earth?

Marketing and Promotion

AGU promotes new books to members and beyond through a variety of means, including its books web page, newsletters, and social media. Editors of books and their contributors also benefit from the marketing services of Wiley. These include access to global sales outlets such as large online retailers, national bookstore accounts, and wholesalers.

Don Kehoe, senior marketing manager at Wiley, said, "We strategically place Web adverts, send targeted email communications, promote through social media, present to librarians and other institutional buyers, and have a global presence at related conferences. Books also receive attention from Wiley's dedicated academic sales teams and global rights group, who focus on licensing and translations opportunities."

Member Discounts and Free Access

All AGU books are available via Wiley as well as Amazon and other distributors. AGU members receive 35% off all books available at Wiley.com, including AGU monographs. AGU members are also entitled to one free e-book every quarter, which can be accessed via the My AGU page.

New Web Platform

Wiley is in the process of migrating all journal and book content to the Atypon Web platform, a new interface that will offer users a much better experience. The move is targeted for January 2018. In terms of AGU books, the site will have a modern design and be responsive to the device you use to access book titles. There will also be better search and filtering capabilities, making it easier to navigate through book content. Following the migration, the goal is to have ongoing enhancements continue to bring book content into closer alignment with journal content.

Although changes in scholarly publishing, higher education, and technology are challenging the concept, function, and form of the academic book, AGU and Wiley are committed to the books program. With the move to the new Web platform, we are eager to explore additional functionality and make connections to other online resources that add value to future books. The reputation of the AGU brand, together with the publishing expertise and resources of Wiley, makes now a great time to consider authoring or editing a book in Earth and space science.

By **Jenny Lunn** (email: jlunn@agu.org), Director, Publications, AGU

NSF Grant: AGU and Partners Aim at Gender Issues in Geosciences

The National Science Foundation (NSF) has recently awarded a grant to AGU and partners from higher education institutions and other geoscience societies to help combat sexual harassment. The ADVANCE grant, awarded this past summer, will support development of bystander intervention training and materials for the Earth, space, and environmental sciences.

NSF's support totals $1.1 million over 4 years across participating institutions and will end on 31 July 2021. The funded project, "ADVANCE Partnership: From the Classroom to the Field: Improving the Workplace in the Geosciences," includes a team of Earth and space scientists; science, technology, engineering, and mathematics (STEM) education experts; and leaders from the Earth Science Women's Network.

Erika Marín-Spiotta of the University of Wisconsin–Madison will lead the initiative. Blair Schneider of the Association for Women Geoscientists and Billy Williams of AGU will act as co-principal investigators. Four additional partnering institutions—California State University, Los Angeles; University of California, Merced; Brown University; and Colorado College—will participate as well.

> AGU has been at the forefront of addressing sexual and other types of harassment in the sciences.

Aided by the grant, the project team aims to improve workplace climate and increase gender parity in the sciences. Bystander intervention training will enable scientists in positions of authority not only to recognize sexual harassment but also to respond appropriately to prevent and even eliminate the behavior from their workplaces.

AGU has been at the forefront of addressing sexual and other types of harassment in the sciences. Last year, the organization convened a workshop of leaders from scientific societies, academia, and government to discuss gender-based harassment on campus, in the field, and at scientific meetings.

AGU's participation in the ADVANCE grant will build on these prior workplace climate activities. AGU members and others interested in further information and resources can visit http://bit.ly/stop-harass.

By **Billy M. Williams** (email: bwilliams@agu.org), Vice President, Ethics, Diversity, and Inclusion, AGU

With help from NSF, science institutions will develop bystander intervention training and materials. Credit: Rawpixel/iStock/Getty Images Plus

Deciphering Deluges

Aerial image of a 2016 flood in Louisiana, created using data collected by National Oceanic and Atmospheric Administration aviators for the National Geodetic Survey. Credit: Jason Burton/USGS

Over the past century, the U.S. Geological Survey, the Federal Emergency Management Agency, and other agencies have collected data on flooding activity to assess damage and help predict future events. Accurately forecasting the frequency and magnitude of flooding events is critical for infrastructure design, environmental management, and disaster preparedness and response.

Although long-term flood records are useful, there may also be large-scale, systematic forces at work that past studies have not adequately captured. For one, traditional prediction methods often assume that flood hydrology is stationary or, rather, that the magnitude and variability of flood events do not change systematically over time. However, climate change and water management practices could significantly alter the magnitude and variability of extreme flooding events, causing floods to become nonstationary.

Second, flood models often assume that a river channel's capacity to convey water will remain static, yet river channels are known to be dynamic, constantly adjusting their width, depth, or gradient in response to changes in water flows or the amount of sediment being transported by the river.

These phenomena, and their impacts on the area covered by an individual flood (inundation), can be difficult to study because of the limited data available to link them together.

Call et al. explore how changes in flood magnitudes, sediment supplies, and associated adjustments in channel geometry could alter the frequency or extent of flood inundation by either amplifying or subduing it. The team developed a model of reduced complexity to investigate these dynamics, incorporating data on the width, depth, and slope of a river channel, as well as sediment transport and annual peak discharges.

They also compared the model to real-life measurements in two river systems. These sites, the Le Sueur River and the Maple River in Minnesota, have experienced several major floods since 2008. Because of climate change and artificial drainage of agricultural fields over the past 50 years, the region provided an apt example of the nonstationary hydrology the researchers hoped to study.

The team found that the long-term average horizontal width of floodplain inundation depends mainly on the coefficient of variation (standard deviation divided by the mean) of peak flows, whereas the frequency of floodplain inundation over a period of time depends on annual changes in channel geometry.

The study has the potential to change the face of flood inundation modeling. Recognizing the importance of changes in the variability of flood flows and accounting for the ability of river channels to adapt over time enable scientists to provide improved flood risk predictions to environmental organizations, government agencies, affected communities, and more. (*Water Resources Research*, https://doi.org/10.1002/2016WR020277, 2017) **—Sarah Witman, Freelance Writer**

Improving Our Understanding of El Niño in a Warm Climate

The El Niño–Southern Oscillation (ENSO) has been a preoccupation of scientists in recent years. It has also entered the public consciousness because this climatic phenomenon in the tropical Pacific Ocean has worldwide effects.

It is uncertain how ENSO will behave in a future warmer world, but one source of possible clues is warm climates of the past. About 3 million years ago, during the mid-Pliocene warm period, global temperatures were 2°–3° warmer than present, and polar ice extents were about one third smaller, making this period interesting as a comparison to the near future.

Understanding climate conditions of the past is no simple task. There are two approaches to this—using proxy data or climate models—but each has strengths and weaknesses, and correlating various measures between the two can be difficult.

Good quality proxy data are accurate and can reconstruct long timescales but are collected from limited locations and may not have broad geographic relevance; translating measurements from proxy data into useful climate variables (such as temperature and precipitation) may also be difficult. On the other hand, climate models can be run on regional and global scales and examine climate variables directly, but they cover shorter timescales and may have errors.

Tindall et al. compare and combine proxy data and climate models in an attempt to reduce the uncertainties in our understanding of ENSO in a warmer climate of the past. Their hope is that their results and analysis might also help us to better understand how warm climates will influence ENSO in the near future.

They focus on two maritime sources of proxy data: coral and individual planktonic foraminifera (monocellular organisms that float in seawater at various depths). The ratio of stable isotopes oxygen-18 and oxygen-16 in the foraminifera is an indicator of ocean temperature. From these ratios, scientists can infer El Niño (warmer than average sea surface temperatures in the tropical Pacific) and La Niña (cooler than average sea surface temperatures) conditions.

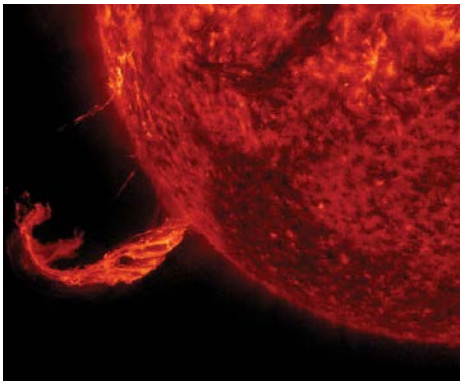
The scientists used climate model results representing the mid-Pliocene warm period to verify that signals in the proxy data that appeared to be due to ENSO were being correctly interpreted. For example, extreme values of the ratio of stable isotopes in foraminifera from the eastern Pacific have previously been interpreted as ENSO activity, but modeling suggests that this interpretation may not always be suitable for past climates due to variability caused by other factors.

By simulating the presence of the two types of proxy data over a whole grid of locations in the Pacific, the team identifies, theoretically, the best potential locations for actual collection of samples to provide further evidence of ENSO variability in the Pliocene era. The team also suggests that at many locations, ENSO may be easier to detect in proxy data of Pliocene age than similar data from more recent times, as the model suggests that ENSO was stronger in the Pliocene.

As we face an uncertain climatic future, the past can provide some illumination of possible changing conditions, and a combination of data and modeling brings the best of science together. (*Paleoceanography*, https://doi.org/10.1002/2016PA003059, 2017) **—Jenny Lunn, Contributing Writer**

Federal Space Weather Research Could Improve Hazard Preparation

The Sun provides light and warmth that fuel life on Earth, but it can also generate disruptive space weather. This space weather is caused by solar wind, coronal mass ejections, and other solar phenomena that can influence conditions on or near Earth, with potentially harmful effects for spacecraft, communications systems, electrical power grids, and other infrastructure.



Coronal mass ejections like this one that occurred in February of 2015 can disrupt spacecraft, radio communications, critical infrastructure, and human health and safety on and near Earth. Credit: NASA/SDO

The U.S. federal government has funded research on the dangers of space weather for decades. A new paper by *Caldwell et al.* reviews this history and calls for continued investment in related research to prepare for the ongoing hazards posed by space weather.

Federal involvement in space weather research began between World Wars I and II, when the government first became concerned that space weather might interfere with high-frequency radio transmissions. Such research was useful for both military and civilian applications—commercial aviation also required radio communications.

Key results of the government's early involvement in space weather research included the establishment of the Interservice Radio Propagation Laboratory during World War II, which relied on a network of 44 global observation stations to collect ionospheric data that could be used to better understand and predict solar disturbances to radio communications.

A decade later, in 1952, the U.S. government opened the Sacramento Peak Observatory in New Mexico to advance understanding of solar flares and other solar physics. The Cold War and the space race motivated further government-funded research to study the potentially harmful effects of space weather on both manned and unmanned spacecraft.

Two recent events illustrate the continued threat to civilians posed by space weather. In March of 1989, a powerful solar storm triggered a 12-hour blackout throughout the entire province of Québec, Canada. During the Halloween storms of 2003, seventeen large solar flares caused numerous disruptions worldwide, including a major blackout in Sweden. They also led to high levels of atmospheric radiation that required flights to be rerouted to avoid unsafe exposure for passengers.

In light of such events, the authors conclude, the U.S. federal government still has a critical role to play in observing and forecasting space weather phenomena. Development of new technologies and improved prediction methods will enable the country to better prepare for space weather events while maintaining security and well-being. (*Space Weather*, https://doi.org/10.1002/2017SW001626, 2017) **—Sarah Stanley, Freelance Writer**

What Controls the Shape of Steep Mountain Streams?

Mountain stream channels come in many shapes, from alternating steps and pools, such as the stream seen here in Kauai, Hawaii, to tumbling cascades. New research provides key insights into the factors that determine a streambed's form. Credit: Michael P. Lamb

Steep mountain streams composed of gravel and boulders can take on many forms. For example, a streambed may have alternating sequences of pools and bars formed by sediment deposits, or it may flow in a channel with a relatively featureless planar bed. *Palucis and Lamb* explore why these streambed types tend to occur over a specific range of slopes and whether slope alone determines the shape of a stream channel.

Previous observations of natural streams show that the steepness of a stream channel is linked to its shape. In general, as channel slope increases, channel beds tend to transition from having alternate bars to a plane bed to steps and pools. At the steepest slopes in the channel network, water tumbles over large, individual boulders in cascade-type streams.

Field observations, experiments, and theoretical analyses have also shown that other factors, such as channel width to depth ratios, the grain size of streambed sediments relative to the channel width, and the occurrence of debris flows, influence channel shape. However, the link between these factors and channel slope has remained unclear.

In this new study, the authors investigated this link by combining field data from 373 mountain streambeds with theoretical equations describing sediment transport and water flow. The team found that the factors that control channel shape, such as the channel width to depth ratio, also change with slope. This variability explains why a channel's slope can be a good predictor of its shape.

However, although the analysis predicted that certain slope ranges correspond to unique channel forms, it also found that some slopes correspond to multiple forms. This finding suggests that for a stream whose steepness favors more than one channel form, the most stable form will arise from competition between mechanisms that vary in strength depending on local conditions.

For example, the range of slopes that can result in alternate bars overlaps with the slope range for step-pool formation. If a stream with a slope in this overlapping range is confined to a narrow channel width (such as by a canyon or closely spaced hillslopes) or it experiences a high influx of sediment from landslides, steps and pools may be more likely to emerge than alternating bars.

Scientific understanding of factors controlling stream shape will continue to evolve as more field data become available. For this study, the authors demonstrated that slope alone cannot always predict a certain streambed shape and local conditions should be considered. Accounting for local conditions may be especially important when predicting streambed shape in unique conditions, such as after a disturbance (a fire, e.g.), in an artificial channel (such as a laboratory flume), or on another planet. (*Geophysical Research Letters*, https://doi.org/10.1002/2017GL074198, 2017) **—Sarah Stanley, Freelance Writer**

Following Carbon in an Age of Fire

The 2012 wildfire season in the United States was record-breaking, burning an area equivalent to the entire state of Maryland, Washington, D. C., and most of Delaware, and in the coming century, fire activity is expected to increase in California and other western states. In the face of this incendiary trend, a better understanding of the interaction between wildfires and the carbon cycle is vital.

Wildfires release huge volumes of carbon into the air as carbon dioxide, but the blackened landscapes the fires leave behind are filled with pyrogenic carbon, organic materials that are charred but not fully destroyed by the fire. Pyrogenic carbon is an important part of the carbon cycle because it is supposedly more stable than other forms of carbon. It remains in its charred form rather than breaking down and continuing through the carbon cycle and eventually back into the atmosphere as carbon dioxide.

In a recent study, *Maestrini et al.* quantify pyrogenic carbon in the wake of California's record-breaking 2012 Chips wildfire, 2–3 years after the burn finished. By this time, initial erosion and loss of pyrogenic carbon should already have happened, and whatever pyrogenic carbon that they found in the area should be there long-term.

To get the fullest picture of the forest's carbon profile, researchers examined different parts of the scorched forest, from blackened trees that stood upright, to chunks of logs lying on the forest floor, all the way down to the mineral soil. The researchers also considered the severity of the fire, which is measured by the amount of damage done to the forest.

The team found that areas that experienced high-severity fire built up a high pyrogenic carbon stock in standing trees and in large pieces of debris on the forest floor. Areas that burned at a low to moderate severity, on the other hand, resulted in more pyrogenic carbon in forest floor debris. Because pyrogenic carbon on the forest floor tends to erode or leach away, aboveground carbon stores may hold the carbon in the area longer.

California will continue to be vulnerable to intense wildfires in part because of its changing climate and in part because human efforts to prevent natural fires have led to a buildup of flammable materials that allow fires that do break out to burn hotter and longer. A season of wildfires can already release as much carbon dioxide into the atmosphere as the annual vehicle emissions of entire states. This research illuminates how fires fit into the carbon cycle, a key piece in understanding how these blazes will affect the problems we already face with carbon. (*Journal of Geophysical Research: Biogeosciences*, https://doi.org/10.1002/2017JG003832, 2017) **—Elizabeth Thompson, Freelance Writer**

The Chips fire burned more than 300 square kilometers of California forest, releasing plumes of carbon dioxide into the air. The fire also left behind pyrogenic carbon in the charred material across the burn scar, shown here in pink. Credit: NASA Earth Observatory

New Data Record Extends History of Global Air Pollution

The World Health Organization calls air pollution the invisible killer, as it can be difficult to trace yet is responsible for 36% of lung cancers, 35% of pulmonary diseases, and 27% of heart disease fatalities each year.

To better track air pollution, scientists use a variety of measurements to quantify the problem. One of these, aerosol optical depth, is the measure of how much sunlight is blocked from reaching Earth's surface by particles in the atmosphere, such as dust and smoke, which absorb and scatter light.

With the advent of satellites, aerosol optical depth can be determined over land and sea with sufficient accuracy for use in a broad range of scientific applications, from climate studies to air quality, among others. Modern satellite sensors fly hundreds of miles above Earth's surface, scanning vast regions as they pass by, viewing the whole world every day or so. These frequent updates contribute to a growing record of data from multiple sensors that have been in orbit for years. The first advanced very high resolution radiometer (AVHRR) was launched by the National Oceanic and Atmospheric Administration in 1978, for example, and versions of the instrument have flown on a total of 16 satellites and continue to the present day.

Scientists use computer algorithms to process aerosol optical depth data. For example, the Deep Blue algorithm has been used to process data collected over land, and the Satellite Ocean Aerosol Retrieval (SOAR) algorithm has been used for over-sea data. Recently, *Hsu et al.* and *Sayer et al.* applied a combined version of Deep Blue and SOAR to the nearly 40-year data record from AVHRR. Many past studies have used AVHRR data, but those focused on the ocean, whereas these two studies cover land and sea.

In addition to creating this new, two-pronged algorithm, the researchers cross-checked it by comparing the results to data collected on board ships, via satellite, and from ground-based instrumentation, such as AERONET, NASA's network of Sun-sky scanning sensors. Their data and user guide are both available online.

Not only does this study extend existing Deep Blue and SOAR data sets, but also it lays the groundwork for a long-term, continuous data record of aerosol optical depth. Such a record would be invaluable for future climate studies and to help improve environmental and public health. (*Journal of Geophysical Research: Atmospheres*, https://doi.org/10.1002/2017JD026932, 2017 and https://doi.org/10.1002/2017JD026934, 2017) **—Sarah Witman, Freelance Writer**

How Can We Best Manage Shared Resources?

In 1968, a biology professor at the University of California, Santa Barbara, named Garrett Hardin famously wrote about the tragedy of the commons, theorizing that when a natural resource is freely available to all people, we inevitably destroy it. The example Hardin gave was of cattle herders sharing an open pasture. Adding one cow to a herd will always directly benefit the person who owns it, he explained. The potential benefit that the cow would provide far outweighs the potential drawback of overgrazing the pasture, the cost of which is distributed among all of the herders and thus has a smaller impact on the individual.

In a new study, *Muneepeerakul and Anderies* review the scope of scientific literature on the social dilemmas that arise in attempting to govern shared resources, including the overexploitation of the commons (also called common-pool resources) and the inability to adequately provide goods and services to the public.

Livestock in south central Ethiopia in 2015. A new model explores social and ecological dilemmas in the management of shared resources such as the grazing land seen here. Credit: Getachew Abate (FEWS NET) and Kelbessa Beyene (World Food Programme)

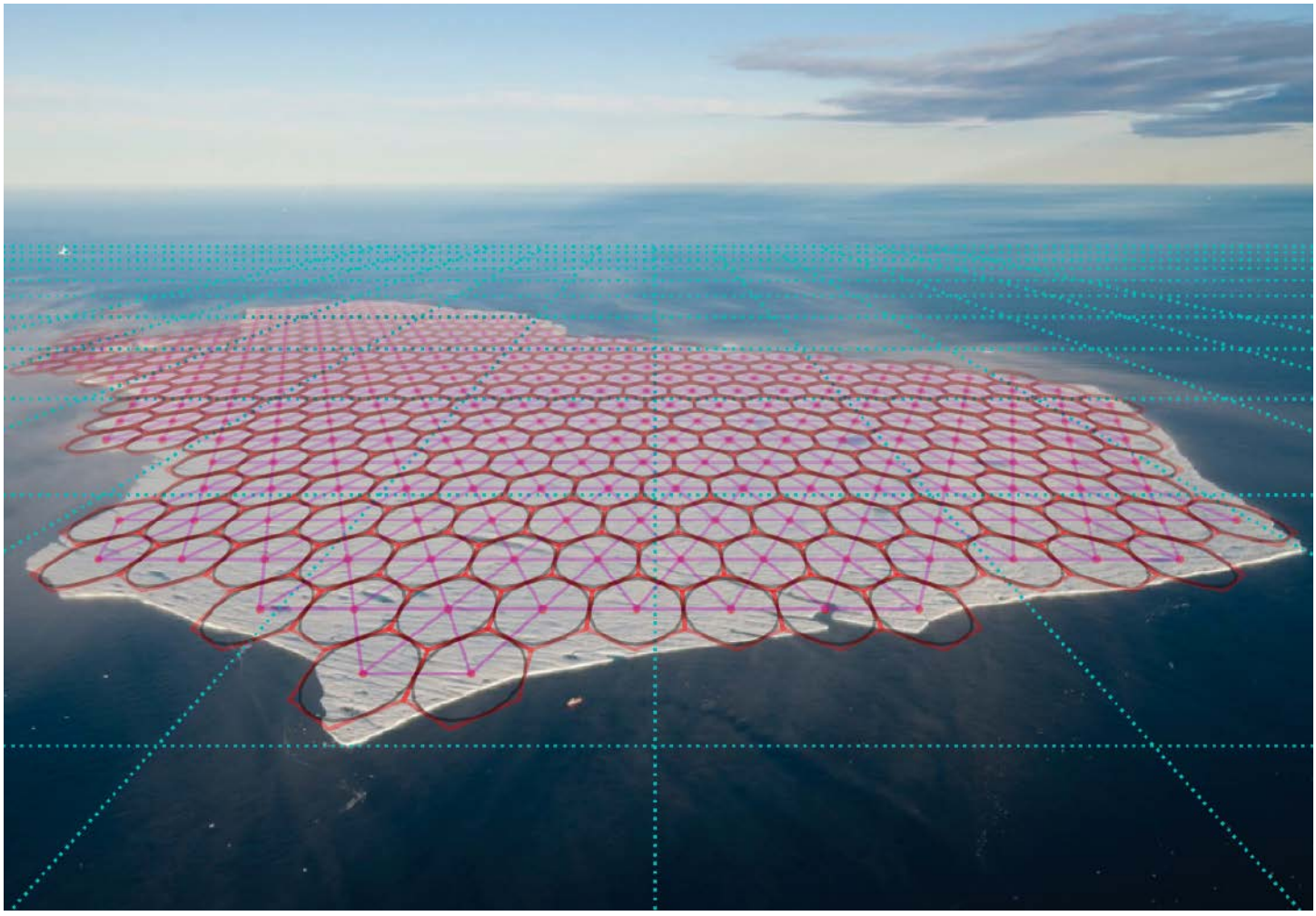
As a foundation for their work, the researchers examined existing solutions to these problems, such as regulation and taxation, clearly defined and agreed-upon property rights, and some other alternatives. They then provided examples of shared resources that have been thoroughly studied, including fisheries, forests, and the atmosphere, and discussed some specific challenges of governing them, such as scale and cost.

Using the existing literature and with the help of a framework to assess the robustness of the system through which resources are used, the researchers developed a mathematical model that explores the relationship between public infrastructure providers and people who use environmental resources. The model also encompasses the external social, economic, and environmental factors (including both natural and built environments) that might inspire the creation of effective governance structures.

Using this model, the researchers focused on conditions that may lead to a stable, sustainable system in which a governing body provides human-made infrastructure (e.g., canals, bridges, and roads) while allowing the people who use resources, such as farmers, to use natural infrastructure (e.g., water and forests) to meet their own needs while supporting the governance structure.

The researchers hope that their model will lead the way for policy professionals to try to develop more precise mathematical analyses of social-economic-environmental systems. Such analyses have the potential to improve the quality and performance of environmental infrastructures to serve people (and ecosystems) more effectively. (*Earth's Future*, https://doi.org/10.1002/2017EF000562, 2017) **—Sarah Witman, Freelance Writer**

How to Find an Iceberg's Breaking Point



A schematic showing how tabular icebergs can be modeled using "particles." The image is an aerial photograph of a 42-square-kilometer tabular iceberg seen in Baffin Bay in 2012 with hexagonal particles superimposed over it. The dashed lines show the underlying ocean grid. Credit: Chris Packham

In July, an iceberg the size of Delaware calved, or broke away, from Larsen C, the fourth-largest ice shelf surrounding Antarctica. A crack that had been growing in size for decades finally gave way, setting the iceberg afloat and shrinking the shelf's overall area by about 10%.

Icebergs rarely form in this manner; in fact, large calving events happen just once every 40–50 years. But when they do, the icebergs are typically tabular, or wide and flat-topped. Tabular icebergs can be more than 110 kilometers across and 300 meters high (with about 90% of their height underwater). Because of their large size, tabular icebergs often travel great distances, and their movement can affect ocean circulation, the formation of bottom water (the dense layer of water at the very bottom of the ocean) and sea ice, and the productivity of life-forms in their path.

Icebergs vary in size, shape, and buoyancy, so attempting to model them mathematically is a significant challenge. However, in a recent study, *Stern et al.* demonstrate an effective technique for modeling tabular icebergs.

In their method, a large iceberg floating in the sea is represented by many small "particles," which store all the information about the iceberg and exert pressure on their surroundings. The particles are connected by theoretical bonds, and interact with one another and hold the theoretical iceberg together. The model shows what would happen during a calving event when bonds break and a tabular iceberg forms. The model also illustrates the behavior of an existing tabular iceberg breaking apart into smaller pieces.

Iceberg calving, although infrequent, has a major global impact. It is responsible for about half of all ice shelf decay in the Antarctic (the other half is from melting) as well as the formation of more than 90% of all iceberg mass in the Southern Hemisphere. This study provides a helpful way to mathematically model large calving events off of ice shelves and individual tabular icebergs. (*Journal of Advances in Modeling Earth Systems* (*JAMES*), https://doi.org/10.1002/2017MS001002, 2017) **—Sarah Witman, Freelance Writer**

Atmospheric Sciences

TEXAS TECH UNIVERSITY ATMOSPHERIC SCIENCE GROUP DEPARTMENT OF GEOSCIENCES

TENURE-TRACK POSITION ANNOUNCEMENT

The Department of Geosciences at Texas Tech University (TTU) invites applications for a tenure- track faculty position in Atmospheric Science to begin in Fall 2018. We seek candidates with a research interest related to boundary layer meteorology and atmospheric turbulence. The successful candidate will establish an innovative, externally-funded academic research program, mentor M.S. and Ph.D. students, and instruct graduate and undergraduate courses.

Service duties include program-building, as well as commitment to extra-curricular activities. Service to the department, college, and university is expected. The position will be filled at the Assistant Professor level. A Ph.D. in Atmospheric Science or a closely related field is required at the time of appointment.

The applicant may be observationally, computationally or theoretically oriented, but will advance the science of the atmosphere by addressing challenges that range from basic insights to their application through interaction with a broad range of colleagues both within the Department of Geosciences, TTU's National Wind Institute (http://www.depts.ttu.edu/nwi/), and the broader TTU campus. Collaborations also are possible with the local NWS and USGS offices. Candidates who have very strong records of scholarship supported by extramural funding and who have the proven capacity or clear potential to bring externally sponsored research to Texas Tech University are encouraged to apply

The Department maintains significant strength in making agile measurements and in responsive modeling of atmospheric states and processes exhibiting sensitive interdependencies. The Department web site (www.geosciences.ttu.edu) describes the laboratories, facilities and current research programs. TTU has assembled a unique array of capabilities for observation and simulation of the atmosphere (e.g., the TTU High Performance Computing Center, two Ka-band (mobile) and an X-band Doppler radar, 24 StickNet in situ observation stations, the 104- station West Texas Mesonet, a 200-m tower instrumented at 10 levels). A newly renovated electronics lab is available to support the development and maintenance of field instrumentation.

Applicants must first visit the TTU employment website at http://jobs.texastech.edu. Once there, go to "Search Jobs," search for requisition number 11493BR, and provide the required information. Afterwards, applicants must submit a letter of application, curriculum vitae, a statement of teaching and research interests, names and contact information (including e-mail address) of at least three professional references. These documents must be uploaded to the employment website. Inquiries regarding the position should be sent to john.schroeder@ttu.edu. Review of applications will begin November 15, 2017.

As an Equal Employment Opportunity/Affirmative Action employer, Texas Tech University is dedicated to the goal of building a culturally diverse faculty committed to teaching and working in a multicultural environment. We actively encourage applications from all those who can contribute, through their research, teaching, and/or service, to the diversity and excellence of the academic community at Texas Tech University. The university welcomes applications from minorities, women, veterans, persons with disabilities, and dual-career couples.

Biogeosciences

Assistant Professor of Soil Microbiology in the College of Natural and Agricultural Sciences, University of California, Riverside

The Department of Environmental Sciences at the University of California, Riverside invites applications for a tenure-track position in Soil Microbiology at the rank of Assistant Professor. The position has 75% Instruction and Research and 25% Organized Research in the Agricultural Experiment Station (http://cnas.ucr.edu/about/aes/). The successful candidate will develop a nationally recognized research program in Soil Microbiology encompassing but not limited to one or more of the following areas: cycling of macro and trace elements in agroecosystems and other managed or natural systems; microbe-plant interactions; basic and applied research in microbial transformations of legacy and emerging contaminants; microbial processes in greenhouse gas production and responses to climate change; development of antimicrobial resistance; and microbial ecology. The applicant should have training or knowledge in genomics, proteomics, next-generation sequencing, bioinformatics or other advanced approaches. The incumbent will be highly encouraged to collaborate with current faculty in related fields including soil and water sciences, environmental chemistry and toxicology, plant pathology, environmental microbiology, and atmospheric sciences. The successful candidate is expected to fully engage in the teaching mission of the department and university, including formal classroom instruction in the Environmental Sciences undergraduate and graduate programs (including mentoring of both M.S. and Ph.D. students). Teaching responsibilities will include an undergraduate class in soil or environmental microbiology; rotation in teaching a large introductory Environmental Science class; and graduate instruction in the candidate's area of specialty.

A Ph.D. in Soil/Environmental Microbiology, Environmental Science, Soil Science, Microbial Ecology, Environmental Chemistry, Environmental Toxicology, or related field, and a proven ability to conduct innovative research are required. Preferred qualifications include demonstrated experience in using genomics, sequencing, other molecular techniques, or bioinformatics in basic and applied research; strong background in soil, agroecosystems, and soil-plant nutrition relationships; and a record of high-quality scientific publications and excellent communication skills.

Evaluation of applications will begin on January 2, 2018, but the position will remain open until filled. Applicants should submit the following materials online at https://aprecruit.ucr.edu/apply/JPF00843: (1) a cover letter, (2) a curriculum vitae, (3) transcripts, (4) a statement of research and teaching interests, (5) a statement of contributions to diversity, and (6) three letters of recommendation (requested directly through our online application system). For more information about the position, please contact Dr. Jay Gan, Chair of the Search Committee, Department of Environmental Sciences, University of California, Riverside; jgan@ucr.edu.

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

UCR is a world-class research university with an exceptionally diverse undergraduate student body. Its mission is explicitly linked to providing routes to educational success for underrepresented and first-generation college students. A commitment to this mission is a preferred qualification.

Advancement through the faculty ranks at the University of California is through a series of structured, merit-based evaluations, occurring every 2-3 years, each of which includes substantial peer input.

Additional information about the Department of Environmental Sciences can be found at: http://envisci.edu/.

Geochemistry

Faculty position in Pedology (Assistant or Associate level) in the College of Natural and Agricultural Sciences, University of California, Riverside

The Department of Environmental Sciences at the University of California, Riverside invites applications for a tenure-track or tenured position in Pedology at the rank of Assistant or Associate Professor. The position has

75% Instruction and Research and 25% Organized Research in the Agricultural Experiment Station (http://cnas.ucr.edu/about/aes/). The successful candidate will develop a nationally recognized research program in pedology focused on how soils occur and function at landscape and regional scales in both natural and managed ecosystems. Expertise to span scales using soil mineralogy, soil morphology, and soil geomorphology approaches is desired. Research may include using the soil record to interpret past climatic, geomorphic, and environmental conditions; the role of soils in watershed and ecosystem functions; soil processes that affect air and water quality; disturbed land reclamation; landscape distribution of soil biogeochemical processes; and evaluation of regional scale soil and landuse issues. The incumbent will be encouraged to work with current faculty in related fields including hydrology, atmospheric science, geomorphology, and ecosystem sciences.

The successful candidate is expected to engage fully in the teaching mission of the department and university, including formal classroom instruction in the Environmental Sciences undergraduate and graduate degree programs (including mentoring of both M.S. and Ph.D. students). Teaching responsibilities will include an undergraduate class in soil morphology, genesis, and classification; rotation in teaching Introduction to Soil Science; and graduate instruction in the candidate's area of specialty. A Ph.D. in soil science, or related field, and a proven ability to conduct innovative pedologic research are required. A broad educational background in soil science with a focus in pedology is expected, along with supporting education in earth and ecosystem sciences. UCR is a world-class research university with an exceptionally diverse undergraduate student body. Its mission is explicitly linked to providing routes to educational success for underrepresented and first-generation college students. A commitment to this mission is a preferred qualification.

Evaluation of applications will begin on December 1, 2017, but the position will remain open until filled. To apply: Application materials for the Assistant Professor position should be submitted through https://aprecruit.ucr.edu/apply/JPF00837. Associate level applicants should apply through https://aprecruit.ucr.edu/apply/JPF00840.

Please provide a cover letter, a curriculum vitae, transcripts, a statement of research and teaching interests, and a statement of contributions to diversity. Junior-level applicants should arrange for submission of three letters of recommendation (requested directly through our online application system). Senior-level applicants should provide names and addresses of three reference letter writers. For more information about the position, please contact Dr. Robert Graham (robert.graham@ucr.edu), Chair of the Search Committee, Department of Environmental Sciences, University of California, Riverside.

Advancement through the faculty ranks at the University of California is through a series of structured, merit-based evaluations, occurring every 2–3 years, each of which includes substantial peer input.

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

Global Environmental Change

Postdoctoral Scholar in Mapping, Monitoring, and Modeling Forest Ecosystems, Northern Arizona University

Northern Arizona University seeks a postdoctoral researcher to participate in research projects focused on mapping, monitoring and modeling forest ecosystems, incorporating climate, land use, and disturbance dynamics. The successful candidate will work closely with the principle investigator and collaborators, using remote sensing observations, biodiversity data, and models to analyze the influence of multiple factors on forest ecosystem dynamics. The position will require processing multi-sensor imagery, primarily satellite-based but also airborne remote sensing, to derive geospatial products characterizing ecosystem properties (e.g. canopy 3D structure, composition, habitat, biomass, regrowth dynamics). The research will advance analyses of disturbance and drivers of change through time. Exploration of state-of-the-art techniques to quantify relationships between structure and diversity in tropical environments is desirable. Ability to synthesize complex information and develop structured analyses in written and visual form is essential.

The qualified candidate should have a PhD in Environmental Science, Remote Sensing, Computer Science and/or a related discipline. Relevant qualifications include experience working with earth observation imagery, lidar data, large databases, geospatial software/tools and advanced scripting. A strong publication record and familiarity with principles of ecosystem dynamics and macroscale conservation is highly desirable. This is a two-year, full-time position based in Flagstaff, AZ. Application deadline is Jan. 1st, 2018. Apply online at https://tinyurl.com/y7afhyr2.

NAU is a committed Equal Opportunity/Affirmative Action Institution.

The University of Oklahoma
Norman Campus
Director - School of Meteorology
Mark and Kandi McCasland Chair in Meteorology

The School of Meteorology of the University of Oklahoma is internationally recognized for innovative, state-of-the-art education and research in the atmospheric sciences. It is one of the leading programs nationwide in developing forward-looking curricula to prepare undergraduate and graduate students for careers in the 21st Century. The School is now seeking an outstanding individual to serve as its Director and the Mark and Kandi McCasland Chair in Meteorology.

The School is an academic program in the College of Atmospheric and Geographic Sciences and is located in the National Weather Center on the University's 271-acre Research Campus. The Campus brings together university programs with State and Federal research and operational facilities, including several NOAA organizations and several private-sector weather companies. This provides for a dynamic meteorological community, where learning extends beyond the classroom and research is linked directly with practical applications.

The School seeks a Director who will continue to advance its leadership position in meteorology, anticipate and react to the ongoing rapid changes in the field, work proactively with all stakeholders to implement the vision for the School, and interact effectively with the Dean of the College to augment the School's funding base from academic, government, and private sector sources. Specific qualifications for the Director include: career experience in academia, industry, or government sufficient to award tenure at the rank of Professor; a strong commitment to excellence in education as demonstrated by instruction in institutions of higher education, in industry, or in government training/outreach programs; a distinguished record of scholarly achievement; demonstrated leadership and administrative skills in an academic, research, or similar setting; an appreciation of the diverse research disciplines in the School; and an ability to communicate effectively with faculty, staff, students, the Dean and other University administrators, alumni, and federal and industry representatives in a variety of venues. The area of research expertise is open.

This position is available on July 16, 2018. The new Director will be appointed in the School as a tenured faculty member with the rank of Professor. Appointment as Director and McCasland Chair will be for an initial four-year term, with the possibility of renewal. The McCasland Chair provides salary support, as well as discretionary funds to support the Director's work for the good of the School.

An application should include a letter of interest describing the applicant's views on teaching, research, and leadership; a complete curriculum vitae; the names and addresses of six references. Review of applications will begin on December 15, 2017; applications will be considered until the position is filled. Applications should be uploaded to ByCommittee at **http://apply.interfolio.com/45056**. Please contact Lee Anne Sallee at 405-325-3095 or email **lasallee@ou.edu** for any questions.

Additional information may be obtained from the following web pages: **www.ou.edu** (University of Oklahoma); **www.ou.edu/ags.html** (College of Atmospheric and Geographic Sciences); **www.ou.edu/nwc.html** (National Weather Center); and **meteorology.ou.edu** (School of Meteorology).

The University of Oklahoma is an equal opportunity employer. Women, minorities, protected veterans, and individuals with disability are strongly encouraged to apply.

Hydrology

ASSISTANT PROFESSOR OF HYDROGEOLOGY CONOCOPHILLIPS SCHOOL OF GEOLOGY AND GEOPHYSICS
UNIVERSITY OF OKLAHOMA

The University of Oklahoma invites applications for a tenure-track hydrogeology faculty position at the Assistant Professor rank. We are seeking applications from a broad range of hydrogeology experiences, including hydrogeochemistry and hydrogeophysics. This new applied hydrology position will complement the ConocoPhillips School of Geology and Geophysics' existing strengths in petroleum, geophysical, and geochemical research while also diversifying research and career options for our students with non-petroleum interests. We seek an innovative colleague who will teach and mentor undergraduates and graduate students at the M.S. and Ph.D. level. We expect the successful applicant to develop a strong research and teaching program that includes a substantial field component and integrates local, regional, national, and international issues. The candidate should have an interest and ability to develop into an excellent teacher; the candidate will teach 3 courses a year, including a hydrogeology course and a graduate course in the applicant's area of expertise. The candidate may also participate in our summer field course. The successful candidate will hold a Ph.D. at the time of appointment, have a demonstrated research record, and strong potential to acquire externally derived funding.

Salary, benefits, and start-up funds will be competitive and commensurate with experience. The ConocoPhillips School of Geology and Geophysics has a large, vibrant faculty with a broad range of research activities from fundamental to applied science and strong ties to the petroleum industry. The student body currently includes 180 undergraduates and 95 M.S. and Ph.D. students. The University of Oklahoma employees many faculty with water research programs in different departments on campus as well as several active initiatives focused on water monitoring, conservation, remediation, and management (e.g., OU WaTER Center, Hydrometeorology and Remote Sensing Laboratory, Oklahoma Water Survey, Oklahoma Geological Survey Hydrogeology Lab, Water-Energy-Food Institute (WEFI), the Neeson Lab, and Center for Restoration of Ecosystems and Watersheds). This environment will provide the successful applicant with many opportunities for collaboration both within the College of Earth and Energy and the broader University community.

Review of applications will begin immediately, with on-campus interviews taking place in November 2017. The anticipated start date is August 2018. The position will remain open until filled. Members of the search committee will be available for in-person meetings during the 2017 GSA Annual Meeting in Seattle, WA. Please contact Dr. Shannon Dulin to schedule a meeting. Applicants are encouraged to apply at http://apply.interfolio.com/44170 and submit their cover letter, vitae/resume, statements of teaching and research, and a list of four references with names, e-mail addresses, and mailing addresses. Questions may be addressed to the Chair of the Hydrogeology Search Committee, Dr. Shannon Dulin, at 405-325-3253 or ouhydrogeologysearchchair@ou.edu.

The University of Oklahoma is an equal opportunity employer and all qualified applicants will receive consideration for employment without regard to race, color, religion, sex, sexual orientation, gender identity, national origin, disability status, protected veteran status, or any other characteristic protected by law. We encourage members of underrepresented groups to apply.

Faculty Position in Hydrogeology at the University of Georgia

The Department of Geology at the University of Georgia seeks applications for a tenure-track faculty position at the Assistant Professor level in the general field of Hydrogeology with backgrounds in geochemical, quantitative, and/or geophysical methods starting August 2018. Expected areas of research and teaching interest include critical zone science, assessing water fluxes, surface and groundwater interactions, mineral weathering impacts on groundwater quality, determining aqueous geochemical mass balances, coastal aquifer dynamics, assessment of recharge and sustainable yields in complex hydrologic systems, simulation of flow and reaction transport processes, and contaminant fate and transport and source identification.

The applicant must have a strong record of research and a Ph.D. in Geology or related discipline by the time of appointment. The successful candidate will be expected to teach introductory geology courses, and undergraduate and graduate courses in their research specialty, supervise student research projects at the masters and doctoral levels, and establish a vigorous externally-funded research program. The successful candidate will have opportunities to interact with the University-wide Water Resources Faculty that includes representatives from Forestry & Natural Resources, Crop and Soil Science, Ecology, Marine Science, Geology, Geography, and Engineering.

Find the full job posting at: https://facultyjobs.uga.edu/hr/postings/2869

Please submit a cover letter, research and teaching statements, curriculum vitae, and contact information for at least three referees. Applications received by December 20, 2017 will be assured full consideration.

For more information, please contact search committee chair, Dr. Adam Milewski: milewski@uga.edu.

The University of Georgia is an EOO/AA institution, and does not discriminate based on race, color, religion, sex, sexual orientation, gender identity, national origin, disability, or protected veteran status.

Tenure-Track Faculty Position in Hydrology and Water Resources, University of California Irvine

The Department of Civil and Environmental Engineering at the University of California Irvine (UCI) invites applications for a tenure-track Assistant Professor position in the area of hydrology and water resources. Areas of interest include (but not limited to) remote sensing of water in the environment, physically-based hydrologic modeling at the watershed to global scales, ecohydrology, water in coupled human-natural systems, river basin management, climate sciences as related to water, water in urbanized environments, coastal hydrology, and water-related environmental and food security issues. Strong quantitative skills are required and research expertise that combines field observations, theory and modeling will be given special consideration. We are particularly interested in candidates with an interest in interdisciplinary research and building collaborations across engineering, earth system sciences, and public policy as related to water. This position is part of a "water cluster hire" with the other three positions filled last year in the areas of water and ecosystems, water and food security, and water and resource economics, placing UCI in a unique leadership position to address water challenges in the 21st century.

Southern California is a mosaic of cities and open spaces whose history and future are inextricably tied to water, and whose experiences with water are paralleled by coastal metropolitan areas around the world facing population growth, development pressure, demands for ecosystem protection, and water scarcity. UCI has an exceptional array of field sites, open-space preserves, partner relationships, and research facilities that are strategically aligned in the context of water, geography, climatology, economic and social structures of southern California.

Applicants are expected to have a doctoral degree from an accredited university in a relevant science or engineering discipline. Successful candidates will be expected to develop a vigorous externally funded research program, maintain a strong publication record, advise students, provide outstanding teaching at the undergraduate and graduate levels, and contribute their leadership and innovative thinking towards an excellent water sciences and engineering program within the Department and UCI. Successful candidates will also be expected to contribute towards a campus-wide initiative to create more field-based (off-campus) student learning opportunities with the goal of increasing the number of students (especially underrepresented minority students) pursuing graduate degrees in water-related programs.

Applications should include a cover letter, a description of research and teaching interests, including ability to contribute to Departmental and interdisciplinary programs, a curriculum vitae, a statement describing commitment to diversity, and the names and contact information of at least four references. References will not be contacted until later stages of consideration, in consultation with the candidate.

Applications received by November 30, 2017 will be given full consideration but the search will remain open until the position is filled. Applications should be submitted electronically at https://recruit.ap.uci.edu/apply/JPF04258

The University of California, Irvine is an Equal Opportunity/Affirmative Action Employer advancing inclusive excellence. All qualified applicants will receive consideration for employment without regard to race, color, religion, sex, sexual orientation, gender identity, national origin, disability, age, protected veteran status, or other protected categories covered by the UC nondiscrimination policy.

TENURE-TRACK POSITION IN HYDROGEOLOGY, University of Iowa

The Department of Earth & Environmental Sciences at the University of Iowa (www.clas.uiowa.edu/ees) invites applications for a tenure-track Assistant Professor position with interdisciplinary interests in the broad field of hydrogeology. We seek an outstanding researcher with expertise in, but not limited to, physical hydrogeology, groundwater and shallow subsurface flow, surface/ground water interaction, fluid flow through rocks, geothermal energy, reactive and/or contaminant transport, or environmental hydrogeology who best complements current strengths in the Earth and Environmental Sciences Department. The candidate is expected to develop an active, externally-funded research program, mentor graduate and undergraduate students, and teach introductory geology courses as well as upper division and graduate courses in hydrogeology and related fields.

The start date of the appointment is August 15, 2018. A Ph.D. in geological sciences or a related field is required by the time of appointment. Candidates must submit applications online at http://jobs.uiowa.edu/ (requisition #71638). The application should include a cover letter, a curriculum vitae, a statement detailing current and future research activities, a statement of teaching interest, and contact information for three referees. Referees will receive directions by e-mail regarding the electronic submission of letters to the University of Iowa.

Screening of applications will begin November 17, 2017 and will continue until the position is filled. Questions regarding this position can be directed to Dr. Jeff Dorale (Search Committee Chair; 319-335-1818; jeffrey-dorale@uiowa.edu) or Dr. C.T. Foster, Jr. (Department Chair; 319-335-1820; tom-foster@uiowa.edu). The Department of Earth and Environmental Sciences is home to sixteen faculty conducting research in environmental science, geochemistry, paleontology, and tectonics. The selected candidate will have the opportunity to interact with researchers associated with the Intensively Managed Landscapes Critical Zone Observatory(www.criticalzone.org/iml), the Iowa Flood Center, IIHR-Hydroscience and Engineering(www.iihr.uiowa.edu), the Iowa Geological Survey (www.iihr.uiowa.edu/igs), and the Center for Global and Regional Environmental Research (www.cgrer.uiowa.edu), and have access to University-administered high-performance computing clusters. The Department of Earth & Environmental Sciences and the College of Liberal Arts & Sciences are strongly committed to diversity; the strategic plans of the University and College reflect this commitment. All qualified applicants are encouraged to apply and will receive consideration for employment free from discrimination on the basis of race, creed, color, national origin, age, sex, pregnancy, sexual orientation, gender identity, genetic information, religion, associational preference, status as a qualified individual with a disability, or status as a protected veteran. The University of Iowa is an equal opportunity/affirmative action employer.

Interdisciplinary

Assistant Professor in Geochronology, Purdue University

The Department of Earth, Atmospheric, and Planetary Sciences at Purdue University invites applications for a tenure track faculty position at the rank of Assistant Professor in the area of geochronology.

We encourage applicants from all areas of geochronology and thermochronology, spanning timescales from deep time to modern, who will diversify our expertise and build instrumentation capabilities. The successful candidate will complement and strengthen areas of research in the department, which include cosmogenic nuclides and accelerator mass spectrometry, Quaternary geology, tectonics, stable isotope geochemistry, petrology, planetary science and sedimentary geology.

Candidates must have completed a Ph.D. in Earth, Atmospheric, or Planetary Science, or a related field at the time of employment. The appointee is expected to develop and maintain a vigorous, externally funded, internationally recognized research program and to teach and mentor students at the undergraduate and graduate levels.

Purdue University's College of Science/Department of Earth, Atmospheric, and Planetary Sciences is committed to advancing diversity in all areas of faculty effort, including scholarship, instruction, and engagement. Candidates should address at least one of these areas in their cover letter, indicating their past experiences, current interests or activities, and/or future goals to promote a climate that values diversity and inclusion.

Interested applicants should visit https://hiring.science.purdue.edu, submit a curriculum vitae, a research statement, a teaching statement, and complete contact information for at least 3 references. Review of applications will begin November 13, 2017, and will continue until the position is filled. Questions related to this position should be sent to Dr. Darryl Granger, chair of the search committee (phone: 765-494-0043, email dgranger@purdue.edu. Applications will be accepted until the position is filled. A background check will be required for employment in this position.

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

Assistant Professor of Earth System Science (tenure track): Humans in the Earth System

The Department of Earth System Science (ESS) at The University of California Irvine seeks to hire an Assistant Professor with expertise in the coupling of human and natural systems, with the goal of strengthening the department's commitment to understanding and teaching how Earth system change interacts with human systems. The department is particularly interested in interdisciplinary researchers who integrate methods of the natural and social sciences to assess the connections between the global environment and human activities. Research areas might include, for example, pathways of sustainable development, the future of global fisheries, integrated assessment modeling, quantification of regional- to global-scale ecosystem services, econometric analyses of climate change impacts, and the drivers and consequences of land use change.

The ESS vision at UC Irvine began in in 1992 with a focus on global environmental changes that occur on human time scales. Currently the department has twenty-five full time faculty with research and teaching in climate dynamics, biogeochemistry of oceans and atmospheres, atmospheric chemistry, cryosphere, ecohydrology, food security, and global energy systems (see http://www.ess.uci.edu/). We seek

a new colleague who will build on these core strengths. The new hire will be at the assistant professor level and in the UC tenure track. Candidates must have a Ph.D. in a suitable discipline. Apply online at https://recruit.ap.uci.edu/apply/JPF04234 or contact facultysearch@ess.uci.edu. The selection process begins 1 Oct. 2017, and the position will remain open until filled.

The University of California, Irvine is an Equal Opportunity/Affirmative Action Employer advancing inclusive excellence. All qualified applicants will receive consideration for employment without regard to race, color, religion, sex, sexual orientation, gender identity, national origin, disability, age, protected veteran status, or other protected categories covered by the UC nondiscrimination policy.

Director–Pacific Northwest Seismic Network, Tenured Faculty Position, The University of Washington

The University of Washington (UW) seeks an energetic and visionary leader to become Director of the Pacific Northwest Seismic Network (PNSN). The tenured faculty position within the Department of Earth & Space Sciences is expected to be at the rank of associate or full professor. The Director will advance the mission of the PNSN (https://pnsn.org/about/mission) through scientific pursuits, advocacy, and effective leadership. Operational and managerial duties with the PNSN will be shared or divided among existing faculty and staff.

As part of the Advanced National Seismic System, the PNSN is the authoritative regional seismic monitoring network in the states of Washington and Oregon. It is a collaboration of the UW, the University of Oregon, and the US Geological Survey. Currently there are 15 FTE PNSN staff positions at the UW. With a current annual budget of approximately 4 million dollars, PNSN staff operate more than 300 seismic stations in the Pacific Northwest, and make and distribute earthquake alerts, earthquake catalogs, ground motion maps, and earthquake early warnings (ShakeAlert). The network also monitors seismicity at the region's 9 high-threat active volcanoes, and has provided critical data for studies of abundant regional non-volcanic tremor.

The Director is expected to maintain a vigorous externally funded research program and to demonstrate a commitment to both undergraduate and graduate teaching. The successful candidate will have: research expertise in geophysics or related discipline and evidence of an innovative and collaborative research portfolio; skills at mentoring staff and students; the ability to communicate effectively to a broad range of stakeholders, including politicians, corporate partners, funding agencies and foundations, the media, the public, and students; and the ability to identify new opportunities, pursue funding, and facilitate project management.

This is a 100% FTE, multi-year, 9-month service period position with six months of state funded support and three months of salary support from PNSN operations. The accompanying administrative appointment as Director of PNSN is a 12-month appointment that provides an additional 3 months of salary support at 100% FTE. Teaching duties are expected to be 2 courses per year.

Applicants must hold a Ph.D. or foreign equivalent in Geophysics or similar field, with a preference towards seismology. All University of Washington faculty engage in teaching, research and service. The UW promotes diversity and inclusivity among our students, faculty, and staff and the public; we seek applicants who are committed to these principles. Thus, we are strongly seeking candidates whose research, teaching, and/or service have not only prepared them to fulfill our commitment to inclusion, but have also given them the confidence to fully engage audiences in higher education from a wide spectrum of backgrounds.

Application Instructions

https://ap.washington.edu/ahr/academic-jobs/position/aa25465/

To apply, please send a curriculum vitae with publication list, and the contact information of 3 references. Applicants should also send 4 statements (less than 10 pages total for all statements combined): 1) A statement addressing research and leadership accomplishments, as well as future research plans. 2) A strategic vision for the seismic network. 3) A statement on teaching and mentoring. Applicants are also encouraged to include evidence of teaching effectiveness (e.g. teaching evaluations). 4) A statement on their past or potential contributions to diversity, equity, and inclusion (see http://www.washington.edu/diversity/diversity-blueprint/), including reflections on social vulnerability with respect to natural hazards.

Electronic materials (.pdf) should be sent to essasst@uw.edu with "PNSN Director Search: [Your Name]," in the subject line. Consideration of applications will begin immediately and continue until the position is filled. Preference will be given to applications received prior to December 1, 2017, but applications received after this date may be considered. Questions pertaining to the application process or potential disability accommodations can be addressed to Scott Dakins (essasst@uw.edu). Questions about the position can be addressed to Professor David Schmidt, search committee chair (dasc@uw.edu).

University of Washington is an affirmative action and equal opportunity employer. All qualified applicants will receive consideration for employment without regard to race, color, religion, sex, sexual orientation, gender identity, gender expression, national origin, age, protected veteran or disabled status, or genetic information.

Doctoral Fellowship in Transdisciplinary Tectonics at Utah State University

The Department of Geology at USU seeks outstanding PhD applicants for a Presidential Doctoral Research Fellowship pursuing research in tectonics, starting fall 2018. This selective fellowship provides four years of support in the form of a competitive stipend, tuition, and health benefits. Two research themes in tectonics within the department are:

1. What controls fault zone and plate boundary behavior through time? Critical to understanding these processes are constraints on earthquake process, timing, and physics, characterization of Earth material properties and petrology, the role of fluids in fault slip, and the rheological evolution of the lithosphere.

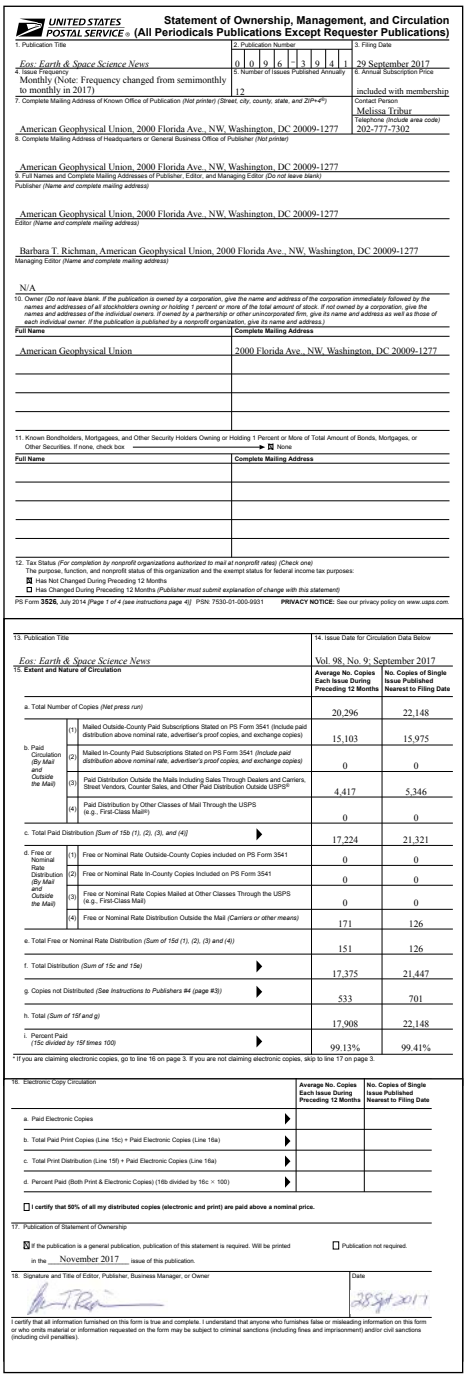
2. What are the interactions among tectonics, surface processes, and landscape evolution? Tectonic activity is expressed in topography through feedbacks between climate and surface process. Research in tectonic geomorphology and geodynamics involves deep-Earth and near-surface/critical zone processes, drainage analysis, and natural hazards.

The Department of Geology at USU is field oriented, has a dynamic graduate program, and is located in northern Utah surrounded by excellent outdoor opportunities.

Visit http://geology.usu.edu for more information about our program and possible faculty mentors, and contact tammy.rittenour@usu.edu for questions. Applications are due January 8, 2018 at http://www.usu.edu/graduateschool/.

Faculty positions at the Department of Geosciences, National Taiwan University

The Department of Geosciences at NTU is seeking active scientists to fill two faculty positions starting from August 1st, 2018. The positions are open to candidates from all fields in geosciences, but those who have strong background in the fields of petrology and geochemistry, geo-resources, energy exploration, stratigraphy, sedimentology, structural geology and hydro- and applied geology will receive more favorable consideration. Applicants are requested to submit the following documents: CV, list of publications, statements of teaching and research inter-



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ests, names and contact information of three referees, and three to five articles published within the last seven years (one of which need to be designated as representative paper and must be published after August 1st, 2013). Application materials should be sent by email to Professor J. Bruce H. Shyu, the Chair of the Searching Committee, at jbhs@ntu.edu.tw.

Deadline for application: December 15th, 2017. For more information, please refer to the website: http://web.gl.ntu.edu.tw/

Graduate Assistantships at Indiana University–Purdue University Indianapolis (IUPUI)

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 2018. The department has 14 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, 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.

Program Directors, Division of Earth Sciences, National Science Foundation, 2415 Eisenhower Ave, Alexandria, VA 22314

The Division of Earth Science (EAR) at the National Science Foundation is seeking candidates for program directors in Education and Human Resources, Geoinformatics, Geophysics, Geomorphology and Land-use Dynamics, Geobiology and Low-Temperature Geochemistry, Sedimentary Geology and Paleobiology, and Tectonics. In addition, we seek program directors to support integrated research activities across the division. Further information about EAR and these programs can be found at http://www.nsf.gov/div/index.jsp?div=ear.

The individuals selected for these positions will be knowledgeable in the scientific areas covered by the respective programs and will help identify emerging opportunities in the Geosciences. In addition, the incumbent will undertake the design, development, analysis, documentation, management and implementation of programs and activities within the program and across disciplinary boundaries. Program Director responsibilities include long-range planning for the areas of science represented by the program; administration of the merit review process and proposal recommendations; preparation of press releases, feature articles and material describing advances in the research supported; and coordination with other NSF programs as well as those at other Federal agencies and organizations.

Candidates must have a Ph.D. in an appropriate field plus, after award of the Ph.D., six or more years of successful research, research administration, and/or managerial experience pertinent to the position.

Individuals interested in applying for these vacancies should submit their materials to the appropriate announcement:

Education and Human Resources Rotator, Permanent

Geoinformatics Rotator, Permanent

Geophysics Rotator

Geomorphology and Land-Use Dynamics Rotator, Permanent

Geobiology and Low-Temperature Geochemistry Rotator

Integrated Research Activities Rotator, Permanent

Sedimentary Geology and Paleobiology Rotator

Tectonics Rotator

Position requirements and application procedures are located on the NSF Home Page at www.nsf.gov/about/career_opps/. Hearing impaired individuals may call TDD 703-292-5090. Applications must be received by November 9, 2017.

NSF is an Equal Opportunity Employer.

Tenure-track position in Coastal/Marine Sciences or Coastal Engineering (fluvial-coastal-deltaic sedimentology, sediment transport), University of New Orleans

The Departments of Earth and Environmental Sciences and Civil and Environmental Engineering at the University of New Orleans (UNO) invite applications for a dual-appointment tenure-track position at the assistant professor level to begin fall 2018. We seek a candidate with a strong commitment to high quality research as well as undergraduate and graduate education and expertise in Coastal/Marine Sciences or Coastal Engineering with specialization in fluvial, coastal or deltaic sedimentology, hydrology and sediment transport or surface hydrology/hydraulics. Candidates must hold a Ph.D. in Geoscience, Marine Science, Civil Engineering, Coastal Engineering or a related field and including postdoctoral research experience. The position involves teaching courses in fluvial geomorphology and river dynamics, coastal engineering, design of coastal/hydraulic structures, coastal/marine sedimentology, sediment transport, surface hydrology and contributing to the departments' (EES and CEE) core curricula in coastal and environmental science and civil and environmental engineering. A strong background in numerical modeling is desirable. A successful candidate is expected to build his/her original independent research programs and to seek interdisciplinary collaborations within and outside the University, and seek extramural funding to support their research. Excellent opportunities exist for interdisciplinary research and work with faculty, staff, and students from diverse backgrounds, and the candidate is expected to collaborate with the departments' faculty members, affiliate with research units on campus. Both departments support undergraduate and M.S. programs in Earth and Environmental Sciences and Civil & Environmental Engineering, and both departments participate in our interdisciplinary Ph.D. program in Engineering and Applied Sciences.

The Texaco Postdoctoral Fellowship, The California Institute of Technology

The California Institute of Technology will offer a fellowship in Geological and Planetary Sciences that is available each academic year. The Texaco Postdoctoral Fellowship is an award funded by endowments from the Texaco Philanthropic Foundation. The fellowship carries an annual stipend of $62,000 plus a research expense fund of $5,000 and one-way travel costs to Pasadena. The duration of the appointment is normally two years, contingent upon completion of the Ph.D. degree and good progress in the first year. Fellows are eligible to participate in Caltech's benefit programs, including health and dental programs.

This fellowship has been established to support the research of scientists typically within two years after receipt of the Ph.D. The intent of the program is to identify and support innovative and creative work in the earth and planetary sciences, with particular emphasis on interdisciplinary work.

Applicants with training in physics, chemistry, biology, or computer sciences are urged to apply. The Division is currently active in geobiology, geochemistry, geology, geophysics, petrology, seismology, environmental science and engineering, and atmospheric and planetary sciences. It is expected that the fellowship recipient be hosted by one or more division professors (designated by the Chair) who will provide both financial support and mentorship.

Materials in support of an application should include curriculum vitae, list of publications, a one-page statement of research interests, and three letters of reference. Complete applications including letters of reference are due by December 1, 2017. Applications can be submitted at: https://applications.caltech.edu/job/gpspd

Fellowship candidates will automatically be considered for other available postdoctoral positions at Caltech in their fields of interest.

If there are any questions during the search process, please contact us at shechet@gps.caltech.edu

We are an equal opportunity employer and all qualified applicants will receive consideration for employment without regard to race, color, religion, sex, sexual orientation, gender identity, or national origin, disability status, protected veteran status, or any other characteristic protected by law.

Mineral and Rock Physics

OPEN-RANK PROFESSOR IN EXPLORATION GEOPHYSICS CONOCOPHILLIPS SCHOOL OF GEOLOGY AND GEOPHYSICS MEWBOURNE COLLEGE OF EARTH AND ENERGY UNIVERSITY OF OKLAHOMA

The ConocoPhillips School of Geology and Geophysics at the University of Oklahoma invites applications for a tenure-track or tenured position in Exploration Geophysics at the rank of Assistant to Full Professor. Exceptional candidates will be considered for the Frank and Henrietta Schultz Endowed Chair. The candidate must hold a Ph.D. in related fields, have a strong research record, and an interest in teaching both undergraduate and graduate courses and mentoring graduate students. Relevant industry experience is an advantage. Areas of interest may include acquisition, processing, imaging, and/or interpretation of seismic data with an emphasis in conventional and unconventional petroleum exploration. The candidate is expected to establish an externally funded research program and build collaborations within and outside the School. Salary and start-up funds are commensurate with experience.

The ConocoPhillips School of Geology and Geophysics, part of the Mewbourne College of Earth and Energy, has a large, vibrant faculty with a broad range of research activities. The School and College maintain strong ties with the petroleum industry. The world's first School of Petroleum Geology was established here a century ago; furthermore, members of our School contributed to the first application of reflection seismology in petroleum exploration. Our research facilities are detailed at http://www.ou.edu/content/mcee/geology/Research.html and include computer labs with PC and Linux platforms networked to a dedicated cluster within the OU supercomputer center. The School maintains a comprehensive pool of geophysical equipment including wired and wireless seismic acquisition systems, active seismic sources, GPR, ERT, magnetics, and gravimetrics, as well as extensive rock physics characterization laboratories.

Review of applications will begin immediately and the search will continue until the position is filled. The anticipated starting date is Fall semester 2018. Applicants can apply online at http://apply.interfolio.com/44266. Applicants are requested to submit a cover letter, complete vita/resume, statement of research and teaching interests, and a list of five references who can be contacted, including phone numbers, e-mail addresses, and mailing addresses. Questions or information requests may be addressed to ougeophysicssearchchair@ou.edu. Applications and nominations should be addressed to Exploration Geophysics Search Committee, University of Oklahoma, Sarkeys Energy Center, 100 E. Boyd Street, Room 710, Norman, OK 73019-1008.

The University of Oklahoma (OU) is a Carnegie-R1 comprehensive public research university known for excellence in teaching, research, and community engagement. In 2014, OU became the first public institution ever to rank #1 nationally in the recruitment of National Merit Scholars. The 277-acre Research Campus in Norman was named the No.1 research campus in the nation by the Association of Research Parks in 2013. Norman is a culturally rich and vibrant town located just outside Oklahoma City. With outstanding schools, amenities, and a low cost of living, Norman is a perennial contender on the, "Best Places to Live," rankings. Visit http://soonerway.ou.edu for more information.

The University of Oklahoma is an Affirmative Action, Equal Opportunity Employer. Individuals from underrepresented groups are encouraged to apply.

Ocean Sciences

Coastal and Marine Science Faculty in Physical and Chemical Oceanography, The Louisiana Universities Marine Consortium for Research and Education (LUMCON)

The Louisiana Universities Marine Consortium for Research and Education (LUMCON) (www.lumcon.edu) seeks to hire at least one new Assistant Professor in the second phase of a multi-year faculty expansion. Candidates should have strong field-based research programs with notable research achievements, demonstration of or potential for funded research, and a commitment to education and outreach. Our research vessel fleet and proximity to the coast facilitate the use of a broad mix of traditional and innovative instruments and observational techniques to make measurements in many settings, from open-ocean to coastal regions. We are looking to hire a physical oceanographer and/or chemical oceanographer that addresses a wide range of fundamental problems in ocean and coastal sciences, as well as interdisciplinary research questions, using observations, modeling, theory, and laboratory experiment. Specifically, we seek a physical oceanographer with expertise in: 1) air-sea interactions, 2) decadal-scale climate variability, 3) coastal dynamics and circulation, and/or 4) oceanic scale circulation with an emphasis on the Gulf of Mexico and/or a chemical oceanographer with specialties of interest that include but are not limited to: 1) ocean acidification, 2) marine inorganic carbon chemistry, 3) carbon cycle-climate interactions. LUMCON represents a consortium of universities and colleges across the State of Louisiana. Preference will be given to candidates who can clearly demonstrate a research program that maximizes the locality and research assets of the DeFelice Marine Center and the strengths of the consortium. Review of applications will begin October 15, 2017. More information can be found at https://lumcon.edu/employment/.

Postdoctoral Research Associate in Sea-Ice Predictability, Princeton University

The Atmospheric and Oceanic Sciences Program at Princeton University, in association with NOAA's Geophysical Fluid Dynamics Laboratory (GFDL), and the Andlinger Center for Energy and the Environment, seeks a postdoctoral or more senior research associate to investigate the predictability of Arctic sea ice on seasonal to inter-annual timescales using a dynamical prediction system.

This work will specifically focus on the impact of ocean, atmosphere, and sea ice initial conditions on the seasonal prediction skill of Arctic sea ice. The successful candidate will perform and analyze a suite of idealized and operational prediction model experiments using GFDL coupled global climate models. Key research questions targeted in this work include: (1) Initialization of sea-ice thickness using satellite and in situ observations, and its impact on summer sea-ice predictions; (2) The role of subsurface ocean initialization in predictions of winter sea ice; and (3) The development of data assimilation techniques for sea-

ice concentration and sea-ice thickness.

Candidates with expertise in data assimilation, sea-ice modeling, or ensemble prediction are especially encouraged to apply. Candidates must have a Ph.D. in atmospheric and oceanic sciences, applied mathematics, physics, or a related field. Initial appointment is for one year with the possibility of renewal subject to satisfactory performance.

Complete applications, including a cover letter, CV, statement of research interests (max 3 pages), and contact information for 3 references should be submitted by November 15, 2017 for full consideration. Applicants must apply online to https://www.princeton.edu/acad-positions/position/3581. For more information about the research project and application process, please contact Mitch Bushuk (mitchell.bushuk@noaa.gov), Michael Winton (michael.winton@noaa.gov), and Alistair Adcroft (aadcroft@princeton.edu). This position is subject to the University's background check policy.

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

Assistant Professor – Oceanography, University of Colorado – Boulder

The Department of Atmospheric and Oceanic Sciences (ATOC) at the University of Colorado Boulder invites applications for a tenure-track faculty position in the field of oceanography at the assistant professor level. Our highest priority is for a candidate whose research focuses on satellite remote sensing of the ocean surface and/or autonomous underwater observation. It is expected that such a candidate will develop technology for and/or heavily utilize data streams from these observational platforms, significantly enhancing and tightly coupling to current research capabilities within the department. These include, but are not limited to, physical and chemical oceanography, remote sensing, climate modeling, polar regions research, air-sea interactions, sea ice variability, and offshore wind energy exploration. The candidate is expected to have the ability to attract external funding, build a vigorous research group, and teach oceanographic graduate and undergraduate courses. This person must have a PhD in oceanography, atmospheric science, or a related field, with an outstanding record of research that meets the standards expected for appointment as an assistant professor at an R1 doctoral university.

Review of applications will begin November 15, 2017, and will continue until the position is filled. Informal inquiries can be made to the chair of the search committee, Weiqing Han, at whan@colorado.edu.

Please go to https://cu.taleo.net/careersection/2/jobdetail.ftl?job=10141&lang=en to view posting and submit application. Qualified candidates should submit: cover letter, CV, a research statement, a teaching statement, list of references to submit written letter of reference upon request, and two sample publications. The University of Colorado is an Equal Opportunity/Affirmative Action employer.

Paleoceanography and Paleoclimatology

Tenure-Track Assistant Professor in Sedimentary Geology: Department of Geosciences, Texas Tech University,

The Department of Geosciences at Texas Tech University invites applications for a tenure-track Assistant Professor position in the broader field of sedimentary geology to begin in fall 2018. Applicants who demonstrate skills in carbonate sedimentology, paleoclimatology, basin analysis, or micropaleontology will be preferred. The ideal candidate will employ a combination of field, laboratory and/or computational techniques and be willing to participate in the development of petroleum-relevant research and teaching programs in the university. The department has a broad array of in-house analytical equipment; interested applicants should visit the department website http://www.geosciences.ttu.edu/geo.php.

The successful candidate is expected to establish an innovative, externally funded academic research program, teach and advise graduate and undergraduate students, and provide service to the department, college, university and the community. A PhD in Geology or a closely related field is required at the time of appointment.

Applicants must first visit the TTU employment website at http://jobs.texastech.edu. Once there, go to "Search Jobs," search for requisition number 11599BR, and provide the required information.

Afterwards, applicants must submit a letter of application, curriculum vitae, a statement of teaching and research interests, names and contact information (including e-mail address) of at least three professional references. These documents must be uploaded to the employment website. Inquiries regarding the position should be sent to dustin.sweet@ttu.edu. Review of applications will begin November 27, 2017, and will continue until the position is filled.

As an Equal Employment Opportunity/Affirmative Action employer, Texas Tech University is dedicated to the goal of building a culturally diverse faculty committed to teaching and working in a multicultural environment. We actively encourage applications from all those who can contribute, through their research, teaching, and/or service, to the diversity and excellence of the academic community at Texas Tech University. The university welcomes applications from minorities, women, protected veterans, persons with disabilities, and dual-career couples.

Solid Earth Geophysics

Assistant Professor Geophysics (tenure track), University of Florida

The Department of Geological Sciences at the University of Florida invites applications for a tenure track position in Geophysics at the Assistant Professor level. Applicants should be able to contribute to an existing internationally known program in observational and computational solid Earth geophysics. We have a preference for candidates with expertise in Earth or space-based sensor analyses of neotectonics, geodesy, seismology, natural hazards, remote sensing of planetary surfaces, water resources, basin analysis, and resource exploration. We seek scholars committed to teaching classes in their discipline at the undergraduate and graduate levels and who show evidence of strong research trajectories. The successful candidate will be expected to develop an active, externally funded research program that includes supporting and mentoring graduate students. Preference will be given to candidates whose research interests complement and enhance existing research programs in the Department (geology.ufl.edu). Candidates who would utilize and benefit from University of Florida's high performance computing facilities are also encouraged to apply (https://www.rc.ufl.edu/services/computation/hipergator/). Applicants must hold a Ph.D. and preferably have some postdoctoral experience. The salary is competitive and commensurate with qualifications and experience, and includes a full benefits package.

For full consideration, applications must be submitted online at http://explore.jobs.ufl.edu/cw/en-us/listing/. Applications should include a cover letter, curriculum vitae, a summary of current and future research plans, an overview of teaching experience and goals, and the names and contact information of three references. The Search Committee will begin reviewing applications on October 31, 2017; the position will remain open until filled. The start date is August 2018. Inquiries can be directed to the Search Committee Chair, Ray Russo, (rrusso@ufl.edu).

The successful candidate will be required to provide an official transcript to the hiring department upon hire. A transcript will not be considered "official" if a designation of "Issued to Student" is visible. Degrees earned from an educational institution outside of the United States require evaluation by a professional credentialing service provider approved by the National Association of Credential Evaluation Services (NACES), which can be found at http://www.naces.org/.

The University of Florida is an equal opportunity institution dedicated to building a broadly diverse and inclusive faculty and staff. The successful candidate must be able to work with students, faculty and staff from a wide range of social and cultural backgrounds. We are especially interested in candidates who can contribute to the diversity and excellence of the academic community. Searches are conducted in accordance with Florida's Sunshine Law. If an accommodation due to disability is needed to

apply for this position, please call (352) 392-2477 or the Florida Relay System at (800) 955-8771 (TDD).

Volcanology, Geochemistry, and Petrology

Assistant Professor, Earth Materials, University of Maryland–College Park

The Department of Geology at the University of Maryland invites applications for a tenure-track assistant professor in Earth Materials. Research areas of interest include, but are not limited to: experimental and theoretical aspects of petrology, mineral physics, nanogeoscience, and economic geology. The appointee will be expected to develop and maintain an active, externally funded research program that will involve both graduate and undergraduate students, and to participate fully in teaching at all levels, including mineralogy. We particularly encourage applications from those who integrate across traditional disciplinary boundaries both within the Department of Geology (http://www.geol.umd.edu) and throughout the College of Computer, Mathematics, and Natural Sciences (http://www.cmns.umd.edu). Candidates from underrepresented groups are encouraged to apply.

A Ph.D. in Geology or a related discipline is required at the time of appointment. The appointment may begin as early as August 1, 2018. Applications should be submitted online at https://ejobs.umd.edu/postings/54884 and should include the following: a letter of application stating research and teaching goals; a complete CV; and contact information for three (3) professional references. Review of applications will begin in December 2017, and will be ongoing until the position is filled.

The University of Maryland, College Park, an equal opportunity/affirmative action employer, complies with all applicable federal and state laws and regulations regarding nondiscrimination and affirmative action; all qualified applicants will receive consideration for employment. The University is committed to a policy of equal opportunity for all persons and does not discriminate on the basis of race, color, religion, sex, national origin, physical or mental disability, protected veteran status, age, gender identity or expression, sexual orientation, creed, marital status, political affiliation, personal appearance, or on the basis of rights secured by the First Amendment, in all aspects of employment, educational programs and activities, and admissions.

Assistant Professor Solid Earth Petrology/Geochemistry, Department of Geological Sciences at the University of Florida.

The Department of Geological Sciences at the University of Florida (UF) invites applications for a tenure-track position in Solid Earth Petrology/Geochemistry at the Assistant Professor level. Applicants should be able to contribute to an existing internationally known program in analytical, observational and theoretical petrology, solid Earth geochemisty and geodynamics. We have a preference for candidates who have expertise in magmatic and chemical processes of the whole Earth (and planets), rock-fluid interactions, tectonics, geochronology and volcanic/hydrothermal systems. We seek scholars with the desire to teach classes in their discipline at the undergraduate and graduate levels and who show evidence of strong research trajectories. The successful candidate will be expected to develop an active, externally funded research program that includes supporting and mentoring graduate students. Preference will be given to candidates whose research interests compliment and enhance existing research programs in the Department (geology.ufl.edu). Researchers who would benefit from our established and new analytical facilities (field emission EMPA and MC-ICP-MS) are also encouraged to apply. Applicants must hold a Ph.D. in Earth Sciences and preferably have some post-doctoral experience. The salary is competitive and commensurate with qualifications and experience, and includes a full benefits package.

For full consideration, applications must be submitted online at http://explore.jobs.ufl.edu/cw/en-us/listing/. The application should include a cover letter, curriculum vitae, a summary of current and future research plans, an overview of teaching experience and goals, and the names and contact information of three references. The Search Committee will begin reviewing applications on October 31, 2017 and remain open until filled. The position will begin as early as August 2018. Inquiries can be directed to the Search Committee Chair, Michael Perfit, (mperfit@ufl.edu).

The final candidate will be required to provide an official transcript to the hiring department upon hire. A transcript will not be considered "official" if a designation of "Issued to Student" is visible. Degrees earned from an educational institution outside of the United States require evaluation by a professional credentialing service provider approved by the National Association of Credential Evaluation Services (NACES), which can be found at http://www.naces.org/.

The University of Florida is an equal opportunity institution dedicated to building a broadly diverse and inclusive faculty and staff. The successful candidate must be able to work with students, faculty and staff from a wide range of social and cultural backgrounds. We are especially interested in candidates who can contribute to the diversity and excellence of the academic community. Searches are conducted in accordance with Florida's Sunshine Law. If an accommodation due to disability is needed to apply for this position, please call (352) 392-2477 or the Florida Relay System at (800) 955-8771 (TDD).

The Geophysical Laboratory of the Carnegie Institution of Washington invites applications for postdoctoral fellowships. The Geophysical Laboratory emphasizes interdisciplinary experimental and theoretical research in fields ranging from geoscience, microbiology, chemistry, to physics. The Laboratory supports world-class facilities in high-pressure research; organic, stable isotope and biogeochemistry; mineral physics and petrology; and astrobiology.

Carnegie Postdoctoral Fellowships are awarded once a year. The deadline for submitting an application is 1 December 2017 and the position begins the following summer or autumn.

Carnegie Fellowship applications must include a curriculum vitae, brief description of thesis research, three-to-five page research proposal, list of publications, and three letters of reference sent by those familiar with your work.

If you are not familiar with our current research, we suggest that you look at our recent publications listed on the home page, Carnegie Institution Yearbooks, and/or speak with staff members and current postdoctoral associates.

The fellowship committee evaluates research proposals for evidence of original thinking and to determine a candidate's ability to develop and carry out a research project that can be accomplished at the Laboratory. You are encouraged to contact a Geophysical Laboratory Staff Member about the suitability of your project.

Also, please see our listing of personnel, research areas, and major facilities.

Completed applications for a Carnegie fellowship should be submitted through this website: https://jobs.carnegiescience.edu/jobs/2018-carnegie-fellowships-for-the-geophysical-laboratory/ no later than 1 December 2017.

The Carnegie Institution of Washington is an equal opportunity employer. All qualified applicants will receive consideration for employment and will not be discriminated against on the basis of gender, race/ethnicity, protected veteran status, disability, or other protected group status.

Faculty Position Economic Geology, Auburn University

The Department of Geosciences at Auburn University invites applications for a new nine month, tenure-track Assistant Professor Position in Economic Geology.

The economic geologist will be expected to teach courses at the undergraduate and graduate level, including (but not limited to) Economic Geology, Mineral Resources and the Environment, Introductory Geochemistry, and Aqueous and Environmental Geochemistry. The successful applicant will stimulate and promote departmental and interdisciplinary research in the environment, energy and mineral resources (strategic, precious, and industrial), and the application of isotopic and geochemical data in their research. We seek a dynamic individual who will play a leadership role in building cross-disciplinary collaborations within and beyond the Geosciences department and in launching our new interdisciplinary PhD program in Earth System Science.

Auburn University is a Land Grant Institution and this faculty hire will support that mission as well as the University's new Strategic Plan that emphasizes research in areas of the environment, energy, and natural resources and their critical connectivity with public health.

Applicants must possess a Ph.D. in Geology or related fields. The successful candidate is expected to develop a vigorous, externally funded research program, publish scholarly work with international recognition, and advise graduate and undergraduate students. The Department of Geosciences is equipped with an array of analytical instruments (see http://www.auburn.edu/cosam/departments/geosciences/Equipment/index.htm).

The candidate selected for this position must meet eligibility requirements to work in the United States and have completed requirements for their Ph.D. on the date the appointment is scheduled to begin (August 2018), and must be able to continue working legally for the proposed term of employment.

The candidate must possess excellent written and interpersonal communication skills.

Applications must include curriculum vitae, letter of application describing professional experience, research and teaching statements, copies of official transcripts, and the names and contact information for three professional references. To apply please go to: http://aufacultypositions.peopleadmin.com/postings/2496, complete the online form and upload the required application documents.

Applicants are encouraged to visit the AU website to learn more about Auburn University and Geosciences program http://www.auburn.edu/academic/cosam/. Review of applications will begin January 10, 2018 and will continue until the position is filled.

Auburn University is an EEO/Vet/Disability employer.

Postcards from the Field

Dear AGU:

Hello from sunny, hot, and humid Baltimore! Not all fieldwork involves far-flung exotic locales—I'm putting up thermometers around the city to better understand urban microclimates, the urban heat island, and how our city will respond to climate change. In this photo, I'm hanging an iButton thermometer in a tree on the east side of Baltimore in the Broadway East neighborhood.

Happy field season!

—Anna Scott, Department of Earth and Planetary Sciences, Johns Hopkins University, Baltimore, Md.

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

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2018

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Register early to save up to $220.

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Housing deadline: 17 January 2018, 11:59 P.M. ET

osm.agu.org