VOL. 97 • NO. 17 • 1 SEP 2016

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Eos (ISSN 0096-3941) is published semi-monthly, on the 1st and 15th of the month by the American Geophysical Union, 2000 Florida Ave., NW, Washington, DC 20009, USA. Periodical Class postage paid at Washington, D. C., and at additional mailing offices. POSTMASTER: Send address changes to Member Service Center, 2000 Florida Ave., NW, Washington, DC 20009, USA.

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

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

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

Christine W. McEntee, Executive Director/CEO

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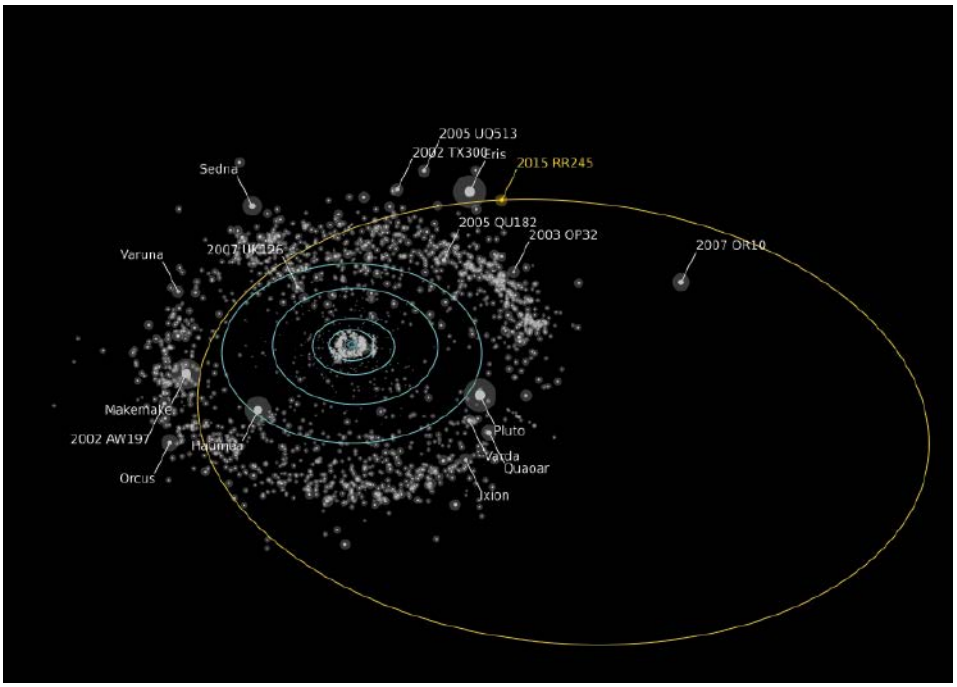
Newly Found Dwarf Planet Points to Solar System's Chaotic Past



Alex Parker/OSSOS

The likely orbit of the newly discovered dwarf planet 2015 RR245, depicted by the yellow ellipse. The orbits of the planets are depicted in turquoise, and every object brighter than RR245 that's not a planet is labeled.

Our orderly solar system hints at a violent past, if you know where to look. Telltale signs—from the battle wounds that scar Mercury's surface to the icy objects beyond Neptune that orbit the Sun in wacky paths—point toward a period of mayhem. Hundreds of millions of years after the giant planets formed, they swept into new orbits, flinging smaller objects every which way.

For decades, scientists have been trying to pin down the details of the solar system's hectic evolution. Now a newly discovered dwarf planet with a diameter about the length of Florida could do just that.

A Slow but Bright Speck

Astronomers first noticed the new world, dubbed 2015 RR245, in February 2016 when it appeared as a bright speck of light slowly moving across a sequence of images shot the previous year by the Canada-France-Hawaii Telescope on Mauna Kea. Its lethargic movement compared to that of bodies relatively close by meant that it must lurk in the fringes of the solar system. Any small object located so far away is going to be faint, but this object was relatively bright, suggesting that it was surprisingly massive.

The combination could mean only one thing: "Looking at it, I immediately knew that it was a dwarf planet," said J. J. Kavelaars, an astronomer on the team at the University of Victoria in Canada who made the discovery. Kavelaars, who was scanning the sky as part of the Outer Solar System Origins Survey (OSSOS), quickly called his postdoc Michele Bannister. She rushed downstairs to his office to look at the data and agreed: Only a dwarf planet could fit the bill. "It stood out like a searchlight," she said.

A Highly Elliptical Orbit

Within a day the team searched through other images of the object and teased out 2015 RR245's highly elliptical orbit. Over the course of 700 years it swings to as close as 5 billion kilometers from the Sun—a mere 500,000 kilometers beyond Neptune's average distance from the Sun. Then it heads out to nearly 20 billion kilometers—more than twice as far as Pluto's farthest point from the Sun. The team published the dwarf planet's orbital characteristics online and announced its discovery on 11 July (see http://bit.ly/DwarfRR245).

Currently located nearly 10 billion kilometers away toward the constellation Pisces, 2015 RR245 is swooping inward for a close-up in 2096. Extrapolating from its estimated distance and likely composition, 2015 RR245 is roughly 700 kilometers in diameter. At just one third the size of Pluto and one fifth the size of the Moon, the newfound object is on the low end of the dwarf planet spectrum.

The International Astronomical Union coined the term dwarf planet in 2006 to describe objects, like Pluto, that aren't proper planets. A dwarf planet must circle the Sun and be massive enough to pull its own weight into a rough sphere. Although the research team hasn't observed 2015 RR245's shape, its diameter suggests that it's likely heavy enough to be roughly spherical. But unlike the proper planets, it hasn't necessarily cleared the orbital neighborhood of debris.

Synchrony with Neptune?

Perhaps what is most exciting about the discovery is the fact that the dwarf planet could be in resonance with Neptune, Bannister said. Pluto, too, is in resonance with the ice giant, meaning that for every three times Neptune orbits the Sun, Pluto orbits twice. Such synchrony suggests that the two interacted in the past.

In fact, it was this exact resonance between Neptune and Pluto that led researchers to discover our solar system's violent history. To create the orbits of the icy outer solar system bodies that exist beyond Neptune today, the general consensus holds that Neptune likely formed closer to the Sun, then migrated to its current position.

> The dwarf planet could be in resonance with Neptune.

As Neptune swept outward, "poof—[it] snowplowed everything out of the way," explained Bannister. But every action triggers a reaction: Every small object thrown around would have slightly tweaked Neptune's orbit until they were in resonance with one another.

Still, scientists don't understand the specifics of Neptune's early migration. "Did it happen fast?" asks Bannister. "In less than a few tens of millions of years? Or did it take as much as several hundreds of millions of years?"

To answer these questions, scientists have to build models of the early solar system, run each through 4.5 billion years of history, and see if it creates the thousands of orbits—of planets, dwarf planets, asteroids, and comets—pinpointed today. If one of these models lands on today's snapshot, researchers may have their solution. But until then, every extra orbit helps.

A Cold Start

These icy objects can shed light on not only the solar system's chaotic evolution but also its frigid formation. Unlike the inner planets, which have been warmed by the Sun or their own internal heat, the distant and small objects are cold enough to have preserved some of the chemical ingredients that were present when the solar system formed.

"It's like archeology," said Scott Sheppard, an astronomer at the Carnegie Institution for Science in Washington, D. C., who has discovered many outer solar system objects but was not a part of this discovery. Outer solar system bodies "have a fossilized imprint of what happened in the past."

But these objects are rare. Even Pluto is so large that it has some internal heat. However, 2015 RR245 is what Bannister calls "Pluto's little sister," meaning that it's small enough and distant enough that it's the perfect laboratory to preserve the makeup of the solar system's ingredients.

Typically, such a small and distant object would be faint, but the latest discovery is bright enough that astronomers will be able to take follow-up images and peel away what ices might still exist on its frozen surface, said Bannister. But Sheppard warns that this likely won't be possible until the James Webb Space Telescope launches in 2018 or the next generation of giant, ground-based telescopes comes online within the next decade.

Kavelaars, however, is most excited about similar discoveries to come. "I had previously thought that all the things this bright and this large must have already been detected," he said. The fact that the team looked in such a small patch of sky—only 10%—and easily found one means that there could be perhaps nine more discoveries waiting to be found.

"So let's get on it," Kavelaars said. "Let's find some more!"

By **Shannon Hall,** Freelance Writer; email: hallshannonw@gmail.com

USGS Seeks to Contain Damage from Scientific Misconduct at Lab

Associated Press/David Zalubowski

The main entrance to the Federal Center in Lakewood, Colo., where the inorganic section of the Energy Geochemistry Laboratory was located until the lab closed this spring. The U.S. Geological Survey found evidence of scientific misconduct in the lab section.

Two separate but related "scientific integrity incidents" at a U.S. Geological Survey (USGS) laboratory have rattled the agency, which, officials told *Eos,* is striving to contain and repair the damage, fix management flaws, and protect the Survey's science reputation. A 15 June report by the Department of the Interior's Office of the Inspector General (OIG) found that "the full extent of the impacts are not yet known but, nevertheless, that they will be serious and far ranging," according to Deputy Inspector General Mary Kendall.

According to the OIG report (http://bit.ly/DOI-OIG-report), during the period 2008–2014, employees at the inorganic section of the Survey's Energy Geochemistry Laboratory in Lakewood, Colo., improperly manipulated mass spectrometer data. After learning of the improper activity in October 2014, USGS convened a Scientific Integrity Review Panel that concluded that the lab had a "chronic pattern of scientific misconduct." The agency self-reported the matter to OIG and shuttered the inorganic section of the lab this spring, according to USGS. In 2008, USGS had discovered an earlier spell of scientific misconduct at the same lab, from 1996 through 2008, but involving different staff. The 15 June OIG report focused on the newer, 2008–2014 episode.

The lab's inorganic section, which provided scientific support for the USGS Energy Resources Program (ERP), used its mass spectrometer to conduct chemical inorganic analyses of water samples and solid samples, including coal and rock, according to the agency.

Two Dozen Projects Potentially Affected

"Since ERP data is used to support both scientific decision-making and understanding, inaccurate data has significant scientific consequences," the OIG report stated. With regard to the 2008–2014 period, 24 research and assessment projects with national and global interest "were potentially affected by erroneous information," according to OIG. The projects represent about $108 million in funding from fiscal years 2008 through 2014, with the inorganic section of the laboratory receiving $4.1 million in funding since fiscal year 2008.

Potentially affected projects listed by OIG include a toxic trace metals analysis of water in the greater Everglades ecosystem in Florida, an analysis of metals released into waters associated with coal bed natural gas produc-

tion activities in Alaska, and an assessment of uranium in the environment in and around Grand Canyon National Park in Arizona.

One scientific report, on air quality studies relating to feed coals in South African boilers, was retracted, and at least seven other reports have been delayed, according to OIG.

Concern About the Broader Impact

USGS deputy director Bill Werkheiser told *Eos* that the damage from the 2008–2014 misconduct "is relatively well contained," with the agency knowing how the information is being used and contacting affected parties. However, he stressed that the bigger concern is the impact of this issue on the agency's reputation for high-quality, defensible science, which he said is the Survey's deepest core value.

"This issue threatens that reputation. So we take it very, very seriously," Werkheiser said, adding that the incident "goes counter to [USGS] standards."

Agency Response to OIG Report

In response to the incident, Werkheiser said USGS is implementing a quality management system for its minerals and energy programs to conduct quality assurance and quality control "in a very systematic and proactive way." In addition, he said, the agency has established a quality assurance management position.

In a written response to the OIG this summer, dated 13 July, USGS concurred with the OIG report's sole recommendation, that the agency notify all stakeholders of the scientific integrity incident. The agency stated that it has completed notifications to USGS-based and external customers and "will continue to assess the full impacts of this data quality issue on research and publications." The agency also stated that the majority of the 24 identified projects "are still viable and of value, and research is continuing. Consequently, we believe that the actual impacts were a subset of the total costs of the 24 projects."

Werkheiser told *Eos* that one person who worked at the lab is no longer with USGS and that "some disciplinary actions are still ongoing." According to a 25 May USGS notice (http://bit.ly/USGS-notice-5-25), some data were manipulated "to correct for calibration failures and to improve results of standard reference materials and unknowns." Also, some raw data from the mass spectrometer "are unavailable, thus the measured concentrations cannot be re-checked for accuracy."

Jon Kolak, associate coordinator within the USGS Energy Resources Program, told *Eos*, "As far as we can ascertain, there was no personal gain or [other self-serving] motive. Certainly, there does not appear to have been any intent to influence any particular decision or outcome," said Kolak, who has helped compile information about the episode.

Werkheiser said that after USGS uncovered the first incident, which lasted from 1998 to 2008, the agency replaced some personnel and attempted to implement quality assurance standards. "We'll admit that we had some managerial issues there and we weren't paying as close oversight as we should have. That since has changed," he said.

Congressional Interest

The most recent incident has caught the attention of Congress. Rep. Bruce Westerman (R-Ark.) raised the topic during a 23 June oversight hearing by the House Committee on Natural Resources.

In mid-July, USGS briefed the offices of Sens. John McCain and Jeff Flake and Rep. Paul Gosar, all of whom are Republicans representing Arizona. The agency told them there is no connection between the 2008–2014 data quality incident at the lab and USGS research related to uranium in the environment in and around the Grand Canyon. That research fed into a Bureau of Land Management study and then Secretary of the Interior Ken Salazar's 2012 decision to place a 20-year exploration and mining moratorium on about 1 million acres of federal lands in northern Arizona. At the time, Flake and McCain voiced opposition to the moratorium.

Legislation (H.R. 3882) introduced in 2015 by Rep. Raúl Grijalva (D-Ariz.) would permanently withdraw these lands and establish a Greater Grand Canyon Heritage National Monument.

Kolak, one of the briefers, told *Eos*, "No data from this laboratory made its way into the USGS report [http://on.doi.gov/2aybb00] that ultimately factored into considerations for whether to withdraw lands regarding uranium mining in the Grand Canyon area. In other words, there is no connection between data in the lab and that particular policy decision."

> "This issue threatens [USGS's] reputation. So we take it very, very seriously," Werkheiser said.

A spokesman for Sen. Flake told *Eos* that the Survey "has provided Sen. Flake and his staff additional information on how the lab that is a subject of the [OIG] report may have been involved in Arizona studies, including studies on uranium. That information is currently being evaluated."

By **Randy Showstack,** Staff Writer

Earth Fissures May No Longer Get Mapped in Arizona

Joe Cook

Rodgers fissure in Maricopa County, Arizona. The fissure opened in 1997 following heavy rains from Hurricane Nora. Initially, the crack stretched 1200 meters long, 3 meters wide, and 10 meters deep in some places. Since 1997, the crack has grown in length another 400 meters.

Recently melded with the University of Arizona at a reduced level of funding, the Arizona Geological Survey (AZGS) might need to shut down a program more than a decade old under which it has mapped fissures in the Earth that plague the state, officials at the geology agency say. Currently, AZGS maps the locations of and monitors the huge cracks, which can threaten lives and property when they suddenly form in Arizona's cities and deserts.

In June, in response to legislation signed the previous month by Arizona governor Doug Ducey, AZGS moved its offices into smaller quarters at the university, which has agreed to provide the $941,000 the agency would have otherwise received from the state for fiscal year (FY) 2017.

In Arizona, FY 2017 began 1 July 2016. After the current fiscal year ends, AZGS becomes a "soft money" organization, said Michael Conway, chief of the Geological Extension Service at AZGS, which means the agency will have to secure funds through research grants.

If the Survey can't secure those funds, it, along with the Earth fissure mapping program, "could potentially go away entirely after a year or two," Conway said. Some Arizona state legislators have said that they will try to restore funding to the agency (see http://bit.ly/AZGS-advocates).

When the Ground Splits

In Arizona, water and natural gas pumping erode the ground from below; as the land slowly sinks, hairline fractures form at the surface. If a storm suddenly hits, the weight of the water can turn the subtle fracture into a chasm. Fissures sometimes extend more than a kilometer and can yawn several meters wide and tens of meters deep.

Rapidly developing areas, such as Maricopa and Pinal counties in the southern portion of the state, run an especially high risk of fissures, Conway said. When the land was mainly used for agriculture, farmers pumped out groundwater faster than it was replenished, leaving behind unstable ground. When fissures appeared, farmers tilling the fields filled them in, obscuring them from view. Dirt moved from construction projects has also filled the cracks.

Such hidden cracks can remain hazards, said Joe Cook, a research geologist at AZGS and manager of the Earth fissure mapping program. For example, at some time since the 1960s in Chandler Heights, an unincorporated community spanning both Maricopa and Pinal counties, developers filled in a previously known fissure. In 2005, a storm dumped about 5 centimeters (2 inches) of rain on the residential area in just an hour, reopening the fissure, which measured 12 meters (39 feet) deep in some places.

Arizona lawmakers subsequently passed legislation requiring the Survey to map and monitor any existing fissures (the following year, the crack opened once again, swallowing a resident's horse). Cook and other AZGS scientists have mapped nearly 300 kilometers of Earth fissures using GPS and said there may be another 300 kilometers of unconfirmed fissures based on old reports and satellite images.

"Occasionally, you can see [fissures] in Google Earth if the timing is just right," Cook said. "But usually, the field is tilled annually, and any trace is erased." The fissures might not affect a farmer now, but if the agricultural land is converted into residential developments in the future, "they could be a hazard to those homes," he continued.

Threat to Houses

Once Cook visits and measures the fissures, he processes and uploads all his data to create maps, including an interactive map accessible to the public (see http://bit.ly/AZ-haz-map). The maps are of particular interest to realtors concerned with selling homes and city developers building roads or neighborhoods.

"When we were in the middle of the mapping program, we [were] receiving 75–100 requests per year" for information from realtors and developers who wanted to find out more about fissures, Conway said.

When a fissure opens near residential or private property, it can damage utility lines and walls and change the drainage of the surrounding landscape, which alters the flooding hazard, Cook said. That's why realtors representing home buyers and developers looking to build often need detailed information about existing fissures.

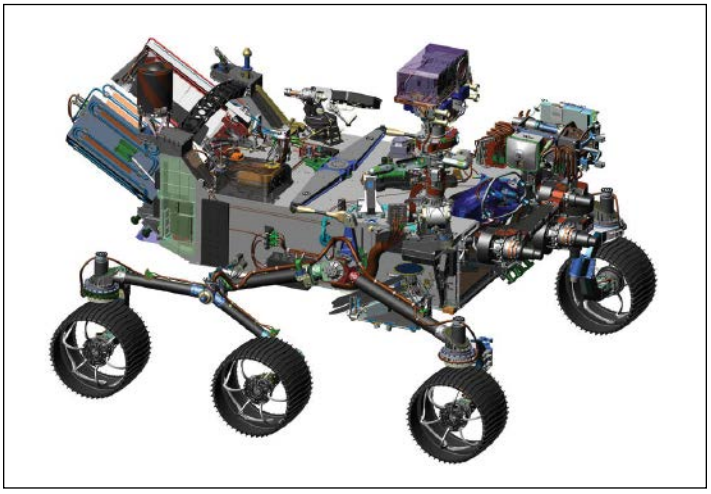
The legislation requiring AZGS to map Earth fissures also requires home sellers to disclose whether there is a fissure on their property, but if the mapping program ends because of a choked funding stream, existing maps won't be updated, Cook said. What's more, if new fissures form, home sellers may not "have to disclose anything because there won't be an additional map that shows anything," he added.

> "Who would step up and sustain that data?"

Conway worried about "all the [fissure maps] we have posted online and made available to everyone." When AZGS becomes a soft money organization, "I don't know what happens to these things," he said. "Who would step up and sustain that data? It certainly doesn't look like it would be the state of Arizona."

By **JoAnna Wendel,** Staff Writer

Precision Landing Will Be Key to NASA's Mars 2020 Rover



NASA/JPL-Caltech

A computer-generated rendition of NASA's Mars 2020 rover.

To scientists and engineers working on Mars rovers, a rover's entry into the Martian atmosphere and descent to its surface are known as the 7 minutes of terror. Hurtling at speeds exceeding 17,700 kilometers per hour, a rover has to put on some serious brakes if it is to land nimbly and delicately at the surface.

The process may be less terrifying during the next mission, thanks to the new Mars 2020 rover design that gives the craft more control as it lands. The NASA rover team announced plans for the craft on 1 July during a live Facebook question and answer (Q&A) session streamed from the Jet Propulsion Laboratory in Pasadena, Calif. At the Q&A, managers highlighted how new robotic features distinguish the Mars 2020 rover (named for its scheduled launch year) from past models sent to explore the Martian surface.

The new craft will look much like Curiosity, its six-wheeled, 1-ton predecessor that launched in November 2011. However, the Mars 2020 rover will have, among other features, a smarter parachute deployment system that will help it maneuver into an even tighter landing zone, a navigation system that uses pictures to guide landing, and even equipment to record ambient sound on Mars.

Equipped for a Rocky Landing

Because Curiosity relied upon velocity to activate parachute deployment and because it could not make decisions based on position, the craft opened its chute after passing below the ideal altitude. The Mars 2020 rover aims to avoid this nail-biting entry, said Allen Chen of the descent and landing team.

"By adding what's known as range trigger, we can specify where we want the parachute to open, not just at what velocity we want it to open," said Chen. In other words, certain altitudes could be programed to trigger the chute. "That shrinks our [required] landing area by nearly half."

What's more, the Mars 2020 rover will be equipped with terrain relative navigation, which uses pictures of the ground for orientation during entry and descent. The technique will help the rover avoid hazardous terrain by automatically comparing photos the rover takes of the landing zone with an onboard map generated from images previously taken by orbiting craft.

Curiosity took pictures of the surface during landing, but they were not matched to a map to facilitate better navigation. Instead, Curiosity and other previous rovers were sent to spans of flat, rock-free terrain at least 20 by 25 kilometers across to ensure that the landing location was safe. The craft then drove long distances to gather information and photograph rocky terrain.

In contrast, the range trigger and navigation system will allow the craft to maneuver into a tighter landing zone—a flat space a mere 18 by 14 kilometers across, half the prior area—surrounded by rock. Thus, after landing, the the Mars 2020 rover won't have to drive far to begin collecting samples, Chen explained.

"One of the key things for us is to land in an environment that has a lot of rocks, and rocks are challenging for landing," said project scientist Kenneth Farley from the NASA Mars Yard, a parking lot full of bedrock and red slab used to test-drive rover models. "Fortunately, we have some new capabilities with the landing system that will allow us to get into this tricky terrain."

Collecting Martian Rocks

The Mars 2020 rover will land in one of eight potential locations thought capable of once hosting microbes. Curiosity photographed areas that might have once been habitable, and using these data as well as information collected by other craft, researchers have now confirmed rock formations that appear to have been riverbeds, tsunami zones, and deltas.

In addition to taking photos, the Mars 2020 rover will collect 35 samples of rock for 7 months after arriving on the Red Planet. The rover will leave samples in designated locations for a second craft to retrieve at a later date. In contrast, Curiosity was equipped with gas analysis instruments and transmitted data about organic molecules, but no samples were returned to Earth.

NASA is currently testing the new rover's drilling tools on a variety of Earth's rock types. In addition, scientists are conducting drilling tests in a chamber that emulates Martian atmospheric pressure, which is only about 1% of that found on Earth, according to Matt Robinson of the Mars 2020 sampling and catching team. Robinson gave a live tour of the testing chamber and drilling facility during the Q&A.

The Mars 2020 rover will have a five-jointed robotic arm that can retrieve core samples for storage and transport, Robinson noted.

Searching for Water, Creating Oxygen, and More

In a press release sent after the conference, NASA announced that it will now proceed with final construction designs. Several intriguing instruments made the cut.

The Mars 2020 rover will be equipped with a ground-penetrating radar called the Radar Imager for Mars' Subsurface Experiment (RIMFAX), which will be used to search for ice and brine beneath the rover. In addition, several microphones will record Martian sound for the first time.

A device that ingests carbon dioxide from the atmosphere and produces oxygen using solid oxide electrolysis will also be included on the rover. If the device, the Mars Oxygen In Situ Resource Utilization Experiment (MOXIE), is successful, it could pave the way for instruments that allow people to breathe on Mars. The technology could also help overcome the need to transport oxygen for fuel.

Because of these and other new designs such as thicker wheels that avoid punctures and damage, the Mars 2020 rover will weigh about 150 kilograms more than Curiosity.

By **Amy Coombs,** Editorial Intern

Groundwater Contamination in Karst Regions Affects Human Health

Karst, Groundwater Contamination, and Public Health: Moving Beyond Case Studies

San Juan, Puerto Rico, 27 January to 1 February 2016

Chuck Sutherland

Karst landscapes are characterized by caves and underground drainage networks. Flowing groundwater dissolves limestone, opening up multiple levels of large cave passages like this one in Parque Cavernas del Río Camuy, Puerto Rico, which meeting attendees visited during a field trip. Participants gained a vivid understanding of how moving water could transport contaminants released on the surface rapidly without attenuation through the extreme porosity of the limestone bedrock. Here the water table is 120 meters below land surface, but the large conduits can transmit tremendous volumes of water (340 cubic meters per second during Hurricane Georges in 1998, for example).

Some characteristics of limestone aquifers, in contrast to porous media, make them particularly susceptible to contamination. Sinking streams and sinkholes provide a rapid route for unfiltered contaminants from the land surface to the underlying aquifer. This characteristic, along with swift groundwater flow in conduits that have been widened by mineral dissolution (karst aquifers) and difficulty characterizing and monitoring the highly heterogeneous karst subsurface, contributes to an elevated risk for degradation of water quality. The reliance on groundwater for drinking supplies in karst regions creates the potential for public health effects.

The nonprofit Karst Waters Institute held an interdisciplinary conference (http://bit.ly/Karst-Conf) to explore knowledge gaps between the science of contaminant transport in karst aquifers and our understanding of exposure pathways and health outcomes.

Sponsorship was provided by the National Institute of Environmental Health Sciences, the Puerto Rico Testsite for Exploring Contamination Threats (PROTECT), the National Science Foundation, and the Edwards Aquifer Authority of central Texas.

Seventy experts from seven countries attended. They specialized in karst hydrogeology, contaminant geochemistry, microbiology, public health sciences, and environmental law and regulation. Attendees grappled with identifying conceptual and practical obstacles while they learned of new tools, findings, and promising perspectives for protecting human health. Sessions highlighted emerging tools for investigating contaminant transport, for quantifying exposure concentrations, and for demonstrating linkages to human health outcomes.

Numerous presenters demonstrated that karst is particularly prone to groundwater contamination that may undermine human health, with several studies documenting higher concentrations of bacteria and protozoa in karst than in porous media aquifers. In addition, molecular tools for tracing and identifying potential pathogens in groundwater revealed large numbers of viruses derived from humans as well as from wildlife and livestock.

Most conclusions about human health outcomes are based on interpretation of public health data that are collected independent of information on the factors that exacerbate groundwater contamination. Only one study presented at the meeting had sufficient data to link the timing of disease outbreak to the occurrence of storm flow that mobilized contaminant migration into groundwater supplies used for drinking.

More commonly, scientists rely on simplistic geographic associations between groundwater contamination and disease outbreak. Given the place-based nature of hydrogeological studies, we recommend that spatially distributed health data be reported to help reveal the intersection of water quality and human health. Participants discussed ways that general regulations for water quality protection may not be appropriate in karst regions, where contaminants are transmitted rapidly from the land surface to the water table, and they debated creative nonregulatory approaches to managing land use as another means of protecting water supplies.

The significant time lag between the occurrence of water supply contamination, particularly by chemical agents, and the subsequent health outcomes in the population represents a fundamental misalignment of environmental and human data. Meeting participants discussed how newly applied methods in time series analysis hold promise for resolving the mismatch.

Because the perspective of each investigator determines what is measured in a given study, it is critically important to develop comprehensive observations by conducting interdisciplinary studies and by sharing data. Participants at this conference developed an expanded appreciation for the need to collect diverse types of data during their investigations. The consensus was that new insights and connections would emerge from increased communication. An edited volume of research papers from the meeting is under contract for publication.

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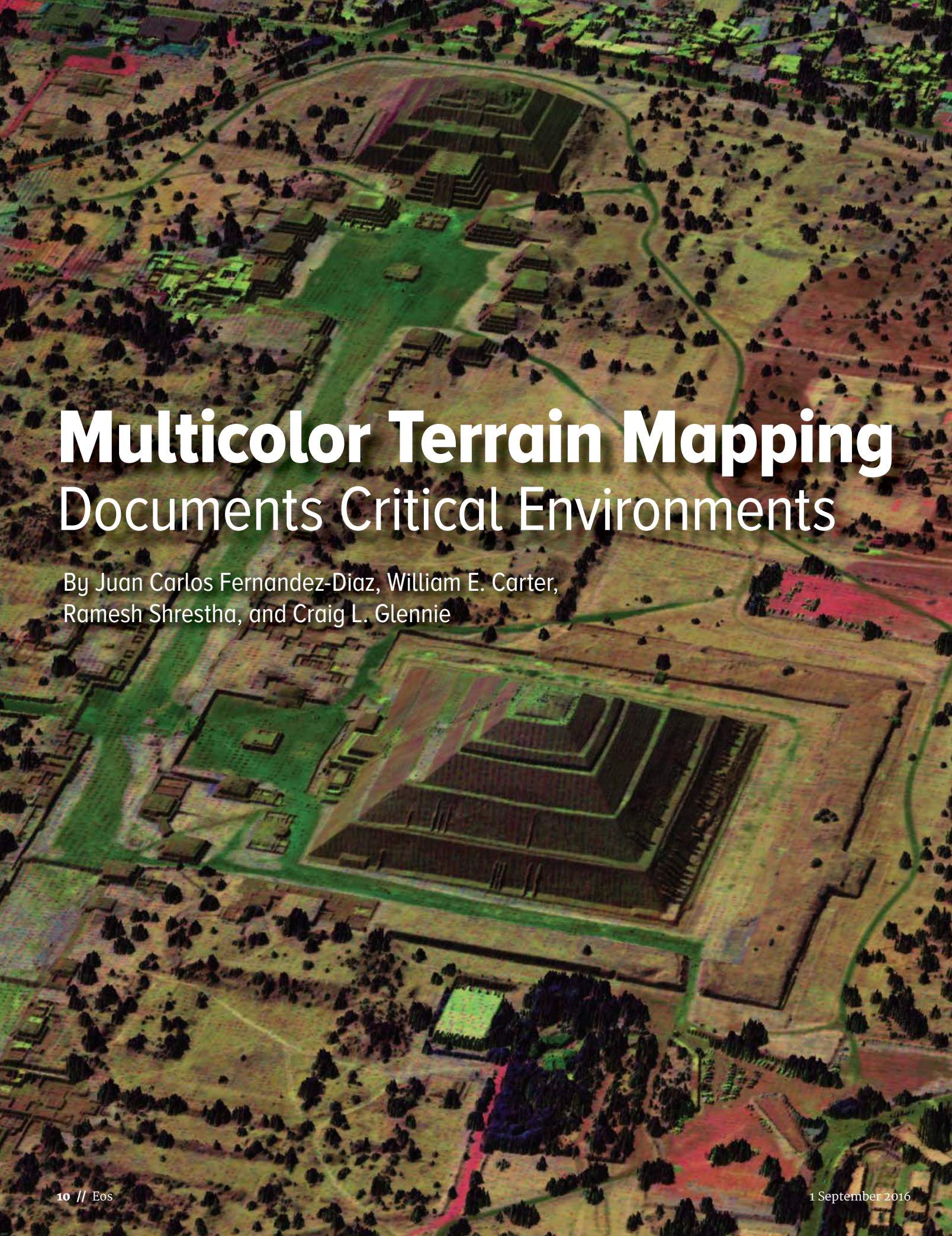


Multicolor Terrain Mapping Documents Critical Environments

By Juan Carlos Fernandez-Diaz, William E. Carter, Ramesh Shrestha, and Craig L. Glennie

National Center for Airborne Laser Mapping

The Titan airborne topographic laser system takes spatial and spectral data at three wavelengths at once, mapping threats from climate change and ecological disasters in regions with complex terrain.

The global nature of climate change means that all environments show evidence of abnormal change: continually rising average temperatures and increases in sea level that inundate coastal areas, along with an increase in the frequency and intensity of severe weather such as hurricanes, typhoons, and tropical storms.

New technologies provide ever clearer images and more detailed data on these effects and how they evolve from year to year. One such technology, lidar, is the laser equivalent of radar. The instrument sits aboard an aircraft that flies back and forth over an area, collecting data that are processed to produce a three-dimensional image of the surfaces below. The latest version of lidar collects data from three lasers at once, producing multispectral images that catch details a single-laser scan would miss.

Geoscientists are putting this new capability to work, monitoring landscape features crafted by melting ice in frigid regions, providing data for storm surge and sea level rise models for the Gulf of Mexico, and monitoring an ecosystem's recovery from a massive oil spill.

Lidar Goes from Black-and-White to "Color"

Lidar originated in the mid-1930s in the atmospheric research community. Evolutions and refinements in this

Three-dimensional surface model overlaid with a false-color laser intensity image of the ancient city of Teotihuacán, northeast of modern-day Mexico City. Colors represent reflectance properties of various types of land cover.

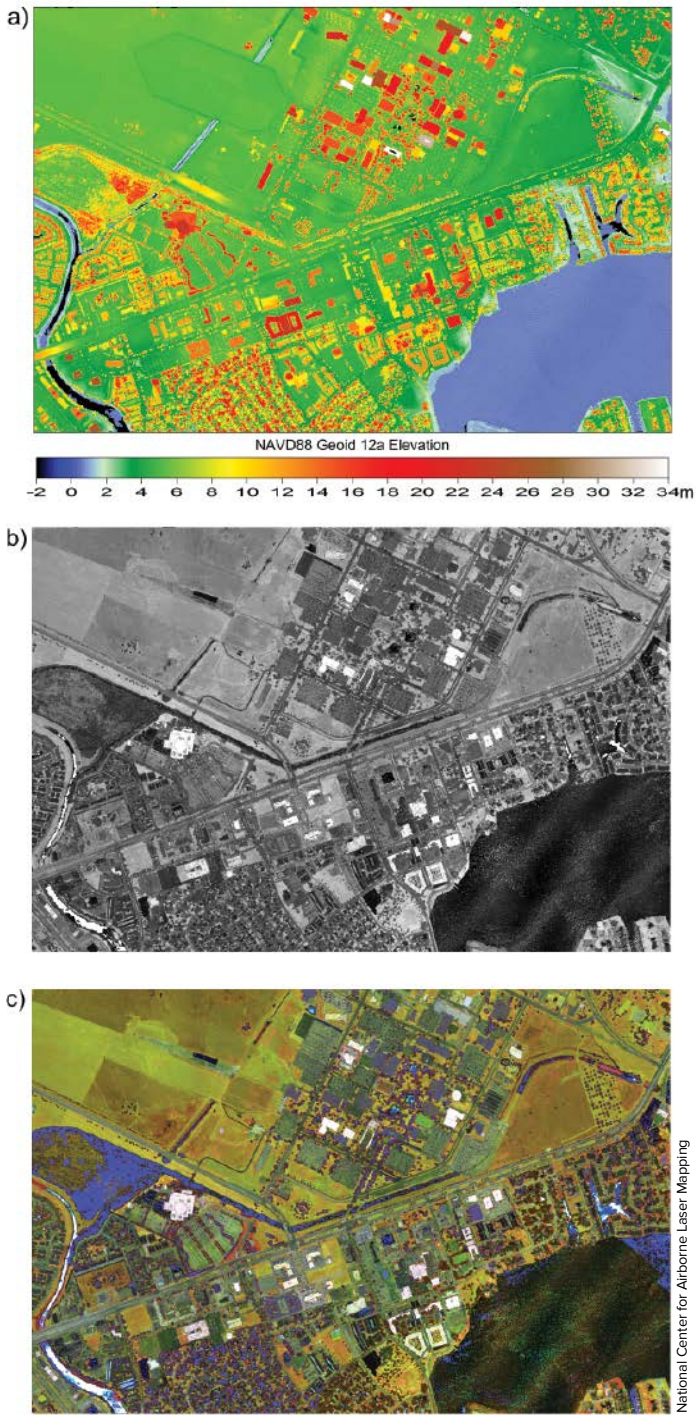


Fig. 1. (a) Lidar-derived digital surface model of the area surrounding NASA's Johnson Space Center in Houston, Texas. This is one of the basic data products obtained from airborne laser scanner (ALS) three-dimensional spatial data. NAVD88 = North American Vertical Datum of 1988. (b) A single laser wavelength lidar intensity image, a monochromatic representation of the backscattered laser energy reflected by the different target surfaces. (c) A false-color normalized laser intensity image generated by using the intensity data of the three different Titan laser wavelengths. Different colors represent different reflectance properties of materials and land covers. Comparing Figures 1b and 1c shows that reflectance data obtained at three different wavelengths enable an improved land cover and target classification using lidar data alone.

technology have enabled breakthroughs in various fields of the geosciences [*Fernandez-Diaz et al.,* 2013].

The first airborne mapping lidar instruments were developed in 1966 to map Arctic pack ice [*Ketchum,* 1971] and hunt for submarines [*Sorenson et al.,* 1966]. However, it was not until the end of the 1990s that the enabling technologies—including satellite systems, navigation sensors, lasers, and detectors—were mature enough to produce the high resolution and accuracy in the topographic data that geophysical research requires [*Slatton et al.*, 2007].

During an airborne lidar survey, an aircraft outfitted with a laser emitter and a sensor scans a swath of surface below the flight path. Laser pulses, emitted at rates of hundreds of thousands of pulses per second, bounce back from the surface below, and these "returns" are picked up by the lidar sensor. By analyzing how long it takes the laser's pulse to return to the sensor, a computer can determine the distance to the reflecting surface. Simultaneously, GPS receivers and inertial measuring units collect position and orientation data that enable determination of the aircraft's trajectory to within 10 centimeters.

Later, the range data are combined with aircraft trajectory and other data to produce a highly accurate "point cloud," a set of data points containing information on the three-dimensional coordinates of the reflecting surface and the intensity, or relative strength, of each recorded return.

Algorithms classify the likely sources of the returns as vegetation, artificial structures, ground surfaces, or other sources. Further processing of the point cloud generates digital elevation models. Depending on the science requirements, flight plans and sensor configurations can provide digital elevation models of the topography at resolutions of a few tens of centimeters horizontally and a few centimeters vertically [*Glennie et al.*, 2013].

Traditional mapping lidars provide rich and accurate three-dimensional data (Figure 1a) as point clouds and digital elevation models. They also produce "intensity" images that are the equivalent of aerial black-and-white photographs (Figure 1b). The spectral data from these intensity images are monochromatic, limited to a measure of the laser backscatter at the specific laser wavelength. Various laser wavelengths provide additional information on the terrain below, but before now, gathering this information required compiling data collected from several lidar sensors operating at different wavelengths.

The Optech Titan multispectral airborne laser scanner (ALS; http://bit.ly/Titan-ALS) is the first operational system designed to per-

Juan Carlos Fernandez-Diaz

The Titan multispectral airborne laser scanner unit aboard a Twin Otter aircraft.

form mapping at three different wavelengths simultaneously through the same scanning mechanism. The Titan collects data at near-infrared wavelengths (1550 and 1064 nanometers (nm)) and near the center of the visible light spectrum (532 nm; Figure 2). This three-wavelength capability enables users to map elevations above sea level (topography) and depths below sea level (bathymetry) simultaneously at high resolution.

This three-channel spectral information can be combined into false-color laser backscatter images, which improve researchers' ability to distinguish between varied types of land cover (Figure 1c). Combining the three-dimensional spatial and three-channel spectral information yields a new kind of data set (Figure 3) that previously was available only by combining lidar data (which actively illuminate the target) with passive imagery (which gathers ambient light reflected by the target and can vary with sunlight conditions).

The U.S. National Science Foundation's National Center for Airborne Laser Mapping (NCALM; http://ncalm.cive.uh.edu) had the opportunity to explore the capabilities of this novel sensor in regions as different as the McMurdo Dry Valleys of Antarctica and the rain forests of Central America during the first year of its deployment. NCALM collected data for investigators studying the consequences and effects of climate change and other ecological disasters. These efforts, aimed at understanding how our planet and its climate are changing at relatively small scales and high resolutions, complement ongoing efforts to study similar changes at global scales and lower resolutions [*Intergovernmental Panel on Climate Change (IPCC)*, 2013].

Melting Ice in the McMurdo Dry Valleys

Even though scientists were aware as early as the mid-1970s of the negative climate effects from increased levels of atmospheric carbon dioxide [*Mercer*, 1978], it has taken decades for them to gather and analyze data quantifying

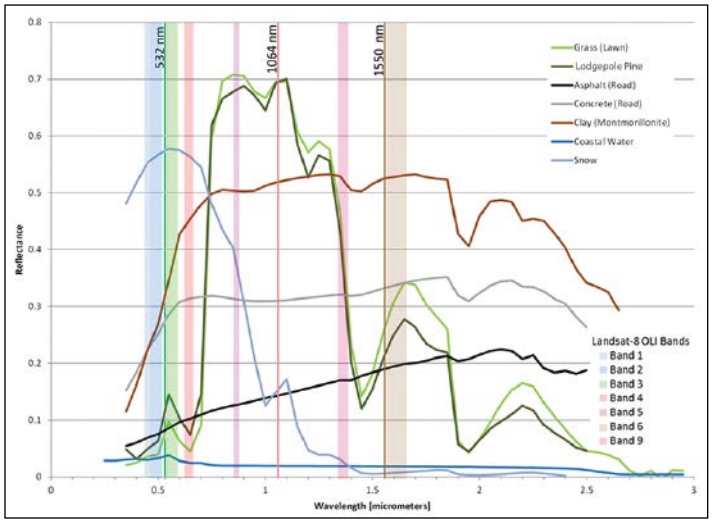
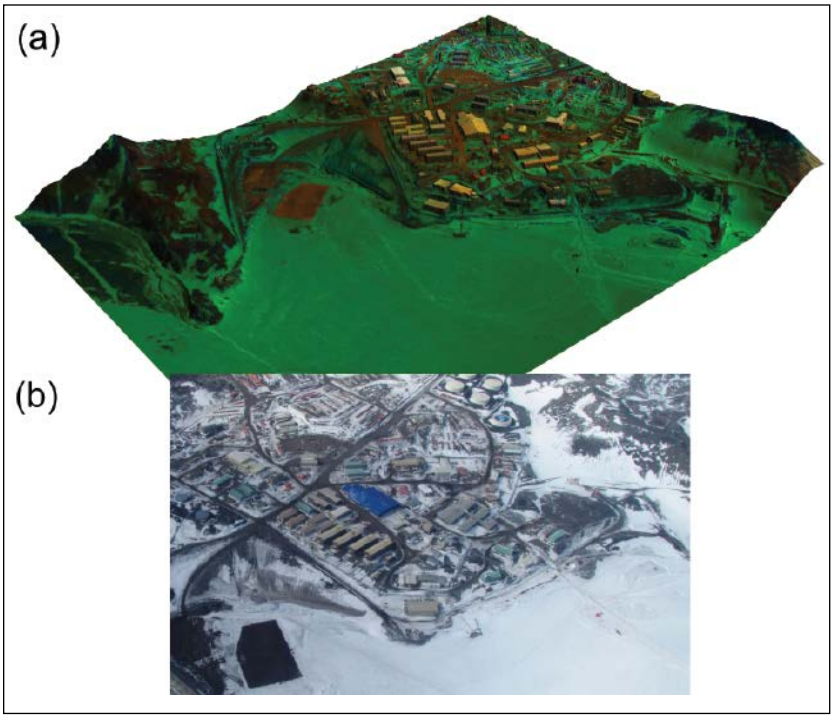


Fig. 2. Reflectance spectra from various types of land cover, showing the operating wavelengths of the Titan multispectral ALS, illustrating the advantages of having multiple wavelengths for mapping areas with different land covers. OLI = Operational Land Imager.



National Center for Airborne Laser Mapping

Fig. 3. (a) A synthetic view of Antarctica's McMurdo Station, generated by overlaying a lidar three-dimensional (3-D) surface model with a false-color image derived from the lidar's return intensity. Intensities from the laser's 1550-nanometer wavelength were used to generate the red channel in the false-color image; the laser's 1064- and 532-nanometer wavelengths were used to generate the green and blue channels, respectively. This type of data set obtained from the new Titan sensor combines 3-D spatial and three-band spectral data from single imaging geometry. Because these data do not depend on solar illumination, they are free of shadows and enable an enhanced classification of the targets that reflect the lidar beams. (b) An oblique aerial image of McMurdo Station, taken at the time of the lidar data collection for reference and comparison. Various types of land cover and different materials produce different colors in the synthetic false-color representation.

these effects across the globe [*IPCC*, 2013]. Many of the most visible effects are related to melting ice at high latitudes.

The frozen water that constitutes the cryosphere is critically important, and it is mainly concentrated in the Arctic, Greenland, and Antarctica [*Vaughan et al.*, 2013]. Andrew Fountain of Portland State University leads a group of scientists who are studying the causes and effects of melting subsurface ice in the Dry Valleys near McMurdo Station in Antarctica (Figure 3). They are particularly interested in detecting the small changes in the valley's topography caused by melting permafrost (thermokarsts) as well as mapping their extent throughout the valley system [*Fountain et al.*, 2014].

Titan has an advantage over traditional airborne laser scanner systems for mapping areas like the McMurdo Dry Valleys, where areas of soil and snow overlap.

To map the current surface, NCALM flew the Titan multispectral ALS on a Twin Otter aircraft over a surface area of more than 3500 square kilometers for a 6-week period during the austral summer of 2014–2015. NCALM and the science team are in the process of developing change detection maps that will enable the identification of the thermokarsts by comparing this recent data set to a previous one collected by NASA with the Airborne Topographic Mapper in the austral summer of 2001–2002 [*Csatho et al.*, 2005].

Titan has an advantage over traditional ALS systems for mapping areas like the McMurdo Dry Valleys, where areas of soil and snow overlap. A traditional ALS operating at 1550 nm would obtain strong returns from the soil surfaces but would have difficulties obtaining returns from the ice and snow, which reflect little light at that wavelength. The Titan can use the 1064- and 532-nm channels, which have better response to snow, at the same time it is collecting the 1550-nm data. Scientists working in the Dry Valleys and on monitoring the polar regions can use the resulting open-access data set to calibrate satellite data as they generate maps of other Antarctic regions.

Threat of Rising Seas near the Gulf of Mexico

In 2015, NCALM was commissioned to carry out an airborne topographic and bathymetric lidar survey of the area surrounding NASA's Johnson Space Center in Houston, Texas. This center's campus is 6 meters above sea level at its highest and surrounded by a network of streams, bayous, and lakes that connect to Galveston Bay (Figure 1a). The campus is less than 50 kilometers from the Gulf of Mexico, which is known as an incubator of major storm systems. In 2008, one such storm, Hurricane Ike, devastated the Houston metropolitan area, causing billions of dollars in property damage in Texas alone.

The effects of climate change might compound similar events. In preparation, this survey was designed to gather highly detailed spatial data to assist NASA in developing storm surge and sea level rise models. The Titan ALS is ideal for this project because it was specifically designed to carry out high-resolution seamless surveys in a single pass over areas where land meets water. William Stefanov of the Astromaterials Research and

Exploration Science Division at the Johnson Space Center and his colleagues will use the information coming from this project to assess strategies and mechanisms to mitigate negative weather and climate effects on these NASA facilities.

Disasters of Human Origin

Titan's multispectral data are being used to study other environmental issues, including monitoring the evolution of ecosystems affected by the Deepwater Horizon oil spill in the Gulf of Mexico in 2010. Five years after this environmental disaster, NCALM was called upon to assist in mapping wetlands in the Barataria Bay system along Louisiana's Gulf Coast.

In this project, researchers from the Coastal Waters Consortium (http://cwc.lumcon.edu) plan to supplement lidar data with hyperspectral imaging data, which produce not only images but also the light spectrum of each pixel in the image. The hyperspectral data will be used to evaluate the presence or absence of pollutants, as well as the general health of the vegetation. Titan's spatial data will be used primarily to estimate the biomass of the vegetation, and researchers will also assess how its active three-band multispectral data can complement the passive hyperspectral data. Information gathered in the survey will be used to study how the ecosystem responds to and evolves from exposure to the oil spill.

Data processing and analysis for this first-year deployment are still under way, and we will publish our results in science and engineering journals. We are hopeful that this new sensor and the enhanced spatial and spectral information it provides will lead to new applications and discoveries in the geosciences.

References

Csatho, B., T. Schenk, W. Krabill, T. Wilson, W. Lyons, G. McKenzie, C. Hallam, S. Manizade, and T. Paulsen (2005), Airborne laser scanning for high-resolution mapping of Antarctica, *Eos Trans. AGU, 86,* 237–238, doi:10.1029/2005EO250002.

Fernandez-Diaz, J. C., W. E. Carter, R. L. Shrestha, and C. L. Glennie (2013), Lidar remote sensing, in *Handbook of Satellite Applications,* pp. 757–808, Springer, New York.

Fountain, A. G., J. S. Levy, M. N. Gooseff, and D. Van Horn (2014), The McMurdo Dry Valleys: A landscape on the threshold of change, *Geomorphology, 225,* 25–35.

Glennie, C. L., W. E. Carter, R. L. Shrestha, and W. E. Dietrich (2013), Geodetic imaging with airborne LiDAR: The Earth's surface revealed, *Rep. Prog. Phys., 76,* 086801.

Intergovernmental Panel on Climate Change (IPCC) (2013), *Climate Change 2013: The Physical Science Basis—Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change,* edited by T. F. Stocker et al., Cambridge Univ. Press, Cambridge, U.K.

Ketchum, R. D. (1971), Airborne laser profiling of the Arctic pack ice, *Remote Sens. Environ., 2,* 41–52.

Mercer, J. H. (1978), West Antarctic ice sheet and CO_2 greenhouse effect: A threat of disaster, *Nature, 271,* 321–325.

Slatton, K. C., W. E. Carter, R. L. Shrestha, and W. Dietrich (2007), Airborne laser swath mapping: Achieving the resolution and accuracy required for geosurficial research, *Geophys. Res. Lett., 34,* L23S10, doi:10.1029/2007GL031939.

Sorenson, G., R. Honey, and J. Payne (1966), Analysis of the use of airborne laser radar for submarine detection and ranging, *Rep. NADC-AE-6613.*

Vaughan, D. G., et al. (2013), Observations: Cryosphere, in *Climate Change 2013: The Physical Science Basis—Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change,* edited by T. F. Stocker et al., chap. 4, pp. 317–382, Cambridge Univ. Press, Cambridge, U.K.

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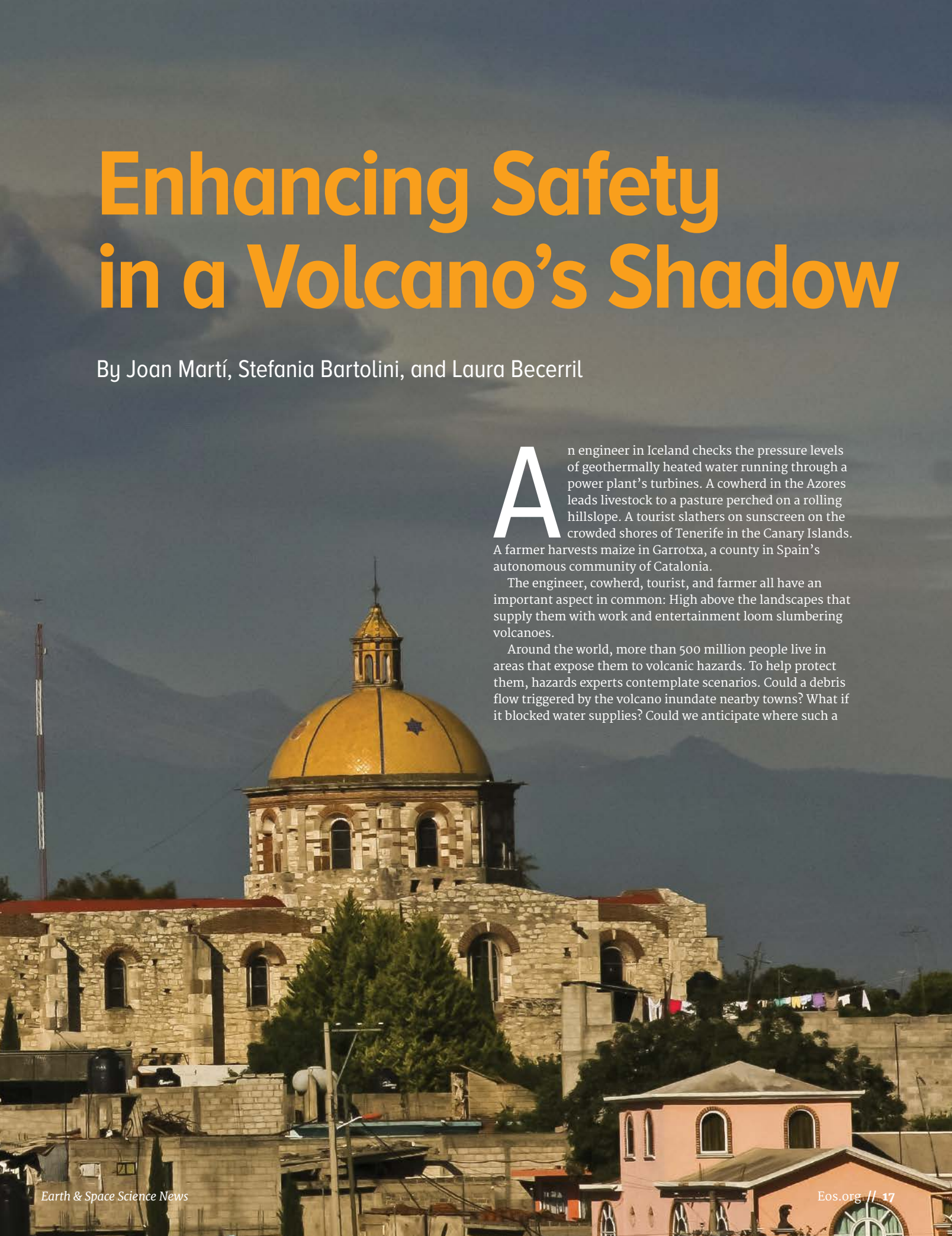
Ash spews from Mexico's Popocatepetl volcano, some 55 kilometers from Mexico City, as seen from the municipality of San Damian Texoloc on 9 July 2013.

J. Guadalupe Perez/AFP/Getty Images

Enhancing Safety in a Volcano's Shadow

By Joan Martí, Stefania Bartolini, and Laura Becerril



An engineer in Iceland checks the pressure levels of geothermally heated water running through a power plant's turbines. A cowherd in the Azores leads livestock to a pasture perched on a rolling hillslope. A tourist slathers on sunscreen on the crowded shores of Tenerife in the Canary Islands. A farmer harvests maize in Garrotxa, a county in Spain's autonomous community of Catalonia.

The engineer, cowherd, tourist, and farmer all have an important aspect in common: High above the landscapes that supply them with work and entertainment loom slumbering volcanoes.

Around the world, more than 500 million people live in areas that expose them to volcanic hazards. To help protect them, hazards experts contemplate scenarios. Could a debris flow triggered by the volcano inundate nearby towns? What if it blocked water supplies? Could we anticipate where such a

USGS

Lahar from the 13 November 1985 eruption of Nevado del Ruiz smothered the town of Armero, Colombia, killing more than 20,000 of its 29,000 residents. The town was never rebuilt.

flow would go? How much lead time could we get to evacuate inhabitants?

People in the shadow of an active volcano depend on early warnings of volcanic unrest from their civil authorities. These authorities, in turn, rely on scientists to supply them with critical information. Ideally, officials have close and efficient collaboration as well as effective communication with scientists, who provide them with accurate assessments of innate hazards and who recommend practical strategies to reduce risk.

The real world, however, is far from ideal. Past eruptive events offer several examples of failed communications between scientists and first responders or decision makers. A tragic example is the 1985 eruption of Colombia's Nevado del Ruiz, in which more than 23,000 people lost their lives, partly because local governments did not consider the warnings of scientists who knew the volcano was awakening.

An important goal for improving the management of volcanic crises is to develop objective, real-time methodologies for evaluating how an emergency will develop and how scientists communicate with decision makers. Scientists need to know what first responders expect from them and should build a system to transmit scientific results. At the same time, first responders need to know the limits of science.

To facilitate collaboration, physical and social scientists developed VeTOOLS, a project that integrates in a systematic and sequential way a series of well-tested tools addressing various aspects of the volcanic hazard assessment process. Using VeTOOLS, experts provide community planners with long-term hazard assessments and vulnerability analysis during quiescent times and supply first responders with short-term hazard assessments and cost-benefit analysis as unrest unfolds.

A Disconnect Between Scientists and First Responders

Modern assessments of volcanic hazards rely on probabilistic approaches, where volcanologists develop models that combine eruptive scenarios and their expected recurrence with information on population distribution, infrastructure vulnerability, and other factors that help calculate risks to the general public. With these models, decision makers can conduct a holistic analysis of a volcanic crisis, including assessments of costs versus benefits.

Scientists and civil authorities do not always work sufficiently closely to enable the authorities to always understand the science behind hazard assessments. Also, the scientific community has not always clearly understood the needs and exact requirements of officials.

As a result, collaboration between scientists and community planners is not always as successful as it could be. Scientific literature offers a considerable number of methodologies and tools addressing hazard assessment (e.g., http://bit.ly/seis-hazard-models-opn). However, community planners sometimes prefer to ignore these methodologies and tools and use their own approaches, so the methodologies end up being only a good academic exercise.

Because probabilistic methodologies play such a prominent role in volcanic hazard assessment, scientists seek to develop methodologies and protocols to bridge this disconnect. These methods aim to provide better scientific support to the civil authorities who must base their decisions on them. In this vein, VeTOOLS was born.

The VeTOOLS Project

In volcanology, e-tools (computer or Web-based applications intended to make a task easier) can help users employ probabilistic methods to assess and forecast volcanic eruptions and their likelihood of occurrence. For example, the VHub collaboration site (https://vhub.org/) offers a

good choice of freely available models and methodologies. However, VHub's resources are not integrated into a single platform that can homogenize programing languages and facilitate their systematic use and guidance in hazard assessment.

The VeTOOLS project, which seeks to develop and implement e-tools for volcanic hazard assessment and risk management, goes a step forward in creating and integrating software packages (see http://www.vetools.eu/). This integration can facilitate collaboration between community officials and scientists in conducting effective hazard assessments and in helping decision makers develop emergency programs and manage volcanic crises.

A Simple, Multiplatform Method

Scientists involved with VeTOOLS created a simple multiplatform method (VOLCANBOX), capable of running on Windows, Mac OS X, and Linux, for assessing hazards and risks. It includes a series of e-tools that allow experts to evaluate the possible hazards that could affect a volcanic area and develop appropriate hazard and risk maps. In short, VOLCANBOX allows experts to assess information and package it into a form that community planners need.

Currently, the VOLCANBOX platform includes a database design (using Volcanic Management Risk Database Design (VERDI), an open platform for debugging computer code [*Bartolini et al.,* 2014a]) created to structure and store all data necessary to conduct hazard assessment. The database is contained in five modules: spatial analysis, temporal analysis, simulation models, risk analysis, and communication protocols (Figure 1).

Each of these modules includes different e-tools already developed by Spain's research council (Consejo Superior de Investigaciones Científicas (CSIC)). These tools include Quantum Geographic Information Systems (GIS) for Volcanic Susceptibility (QVAST) [*Bartolini et al.*, 2013], which provides quantitative assessments of a new eruptive vent; Hazard Assessment Event Tree (HASSET) [*Sobradelo et al.*, 2014], an event tree structure that uses Bayesian inference to estimate the probability of occurrence of a future volcanic scenario; Volcanic Risk Information System (VORIS) [*Felpeto et al.*, 2007], a GIS-based tool that allows users to simulate lava flows, fallout, and pyroclastic density current scenarios; Volcanic Damage (VOLCANDAM) [*Scaini et al.*, 2014], which generates maps that estimate the expected damage caused by volcanic eruptions; and Bayesian Decision Model (BADEMO) [*Sobradelo and Martí,* 2015], which enables a previous analysis of the distribution of local susceptibility and vulnerability to eruptions to be combined with specific costs and potential losses.

We are working to integrate other tools or models that have been developed by other authors. Also, we intend to offer experts different options based on the available input data they may have and the accuracy they require.

Applying the Tools

VOLCANBOX is a resource to build the strategies required to successfully confront and minimize the impact of future volcanic eruptions in a homogeneous and systematic way (Figure 2).

Experts select the tools in each module that they want to apply in a sequential workflow. The nature of this workflow can be adapted to a long- or short-term hazard assessment, and it takes the different tasks assumed in the volcanic management cycle as a reference.

For a long-term hazard assessment, for example, the user could obtain a susceptibility map (spatial analysis, e.g., QVAST) showing the probability of where a new vent will form on a volcano, a temporal analysis of the occurrence of possible eruptive scenarios (e.g., HASSET), a simulation of possible volcanic and associated hazards and elaboration of qualitative and quantitative hazard maps (e.g., VORIS), vulnerability analysis (e.g., VOLCANDAM), and cost-benefit analysis to determine the most appropriate mitigation measures (e.g., BADEMO).

In the case of a short-term analysis (covering a single unrest episode), we would use the previous results and add monitoring information through the use of a specific tool (e.g., ST-HASSET) [*Bartolini et al.*, 2016] to refine the spatial and temporal constraints of the most probable scenarios.

Connecting to Civil Protection

VeTOOLS also looks at how to make scientific information understandable for decision makers and commu-

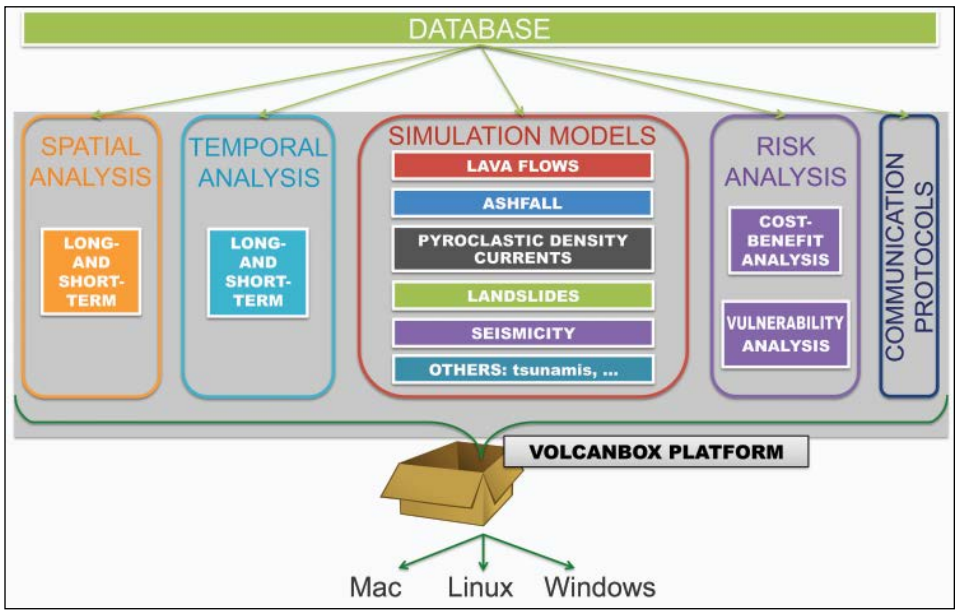


Fig. 1. Simplified structure of the new platform (VOLCANBOX) of the VeTOOLS project.

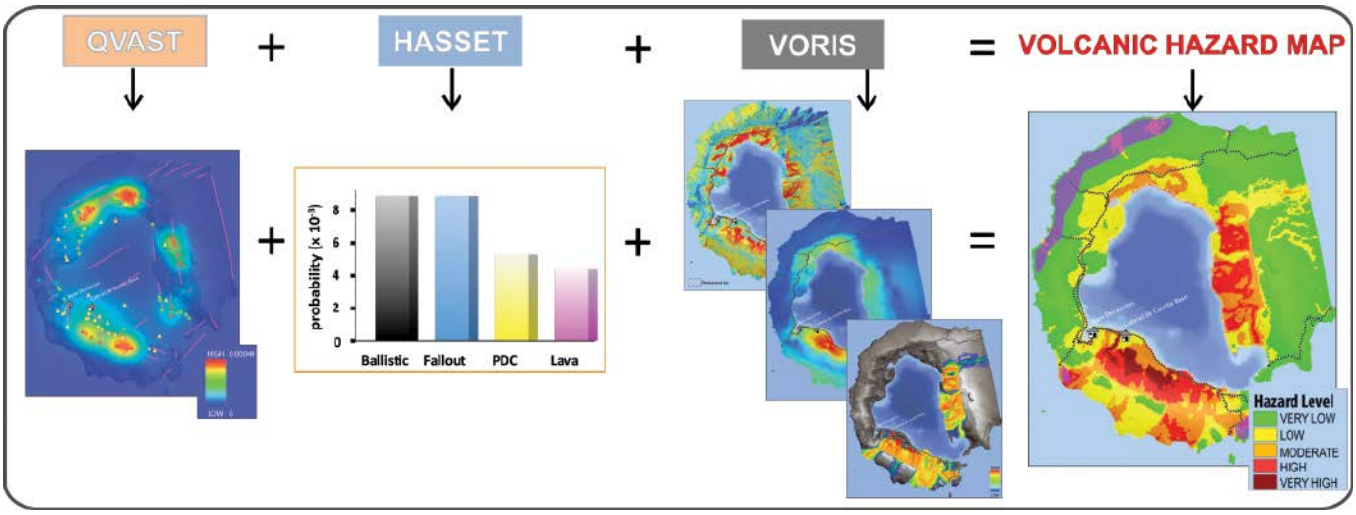


*Fig. 2. Example of the methodology used and results obtained using VOLCANBOX for long-term volcanic hazard assessment on Deception Island, between Antarctica and Argentina [*Bartolini et al., *2014b]. The Quantum Geographic Information Systems (GIS) for Volcanic Susceptibility (QVAST) map shows the probability of a new vent forming, with warm colors representing high values. The Hazard Assessment Event Tree (HASSET) plot shows probabilities for the occurrence of different volcanic hazards for projectiles (ballistic), ash (fallout), pyroclastic density currents (PDC), and lava. The Volcanic Risk Information System (VORIS) maps give simulations for (top) lava flows, (middle) PDC, and (bottom) lahar. Combining all these products yields an aggregated volcanic hazards map.*

nity planners who manage risk in volcanic areas. Through step-by-step instructions, scientists using VOLCANBOX show community planners how to identify the most probable eruptive scenarios and their potential effects, which helps officials triage emergency responses in the event of an eruption. These instructions were developed after testing VOLCANBOX with civil protection agencies in Spain, the Azores, and Iceland.

As of now, however, scientists must use VOLCANBOX and then deliver assessments to community officials, and it is incumbent on scientists to use VOLCANBOX to gather the information that community officials seek. Thus, before using VOLCANBOX, experts must engage community planners to discover what they need. In this way, experts who effectively use VOLCANBOX will actively work with civil protection agencies to share, unify, and exchange procedures, methodologies, and technologies, thereby reducing the effects of volcanic disasters by improving assessment and management of volcanic risk.

A Versatile Toolbox

VeTOOLS provides an option to improve volcanic risk assessment and management capacities in active volcanic regions by providing an integrated set of e-tools and methodologies to conduct long- and short-term hazard assessment.

It is even possible that the application of VOLCANBOX will help identify differences between the levels of hazard assessment in various volcanic areas and possible existing gaps in the basic information (e.g., census data, maps of key infrastructure) required to conduct volcanic risk management, regardless of local specific features. VOLCANBOX, if used at volcanoes across the globe, may help reveal such gaps.

Although volcanic eruptions are infrequent, they present multiple hazards and thus create problems similar to or even greater than those of more frequent natural events. For that reason, the VeTOOLS project is currently working to incorporate into the platform existing tools for assessing potentially related hazards, including earthquakes, landslides, and tsunamis.

For more on VeTOOLS, see http://bit.ly/vetools.

Acknowledgments

This research is funded by the European Commission's Humanitarian Aid and Civil Protection Unit (EC ECHO grant SI2.695524: VeTOOLS).

References

Bartolini, S., A. Cappello, J. Martí, and C. Del Negro (2013), QVAST: A new Quantum GIS plugin for estimating volcanic susceptibility, *Nat. Hazards Earth Syst. Sci., 13*(11), 3031–3042, doi:10.5194/nhess-13-3031-2013.

Bartolini, S., L. Becerril, and J. Martí (2014a), A new Volcanic management Risk Database design (VERDI): Application to El Hierro Island (Canary Islands), *J. Volcanol. Geotherm. Res., 288,* 132–143, doi:10.1016/j.jvolgeores.2014.10.009.

Bartolini, S., A. Geyer, J. Martí, D. Pedrazzi, and G. Aguirre-Díaz (2014b), Volcanic hazard on Deception Island (South Shetland Islands, Antarctica), *J. Volcanol. Geotherm. Res., 285,* 150–168, doi:10.1016/j.jvolgeores.2014.08.009.

Bartolini, S., R. Sobradelo, and J. Martí (2016), ST-HASSET for volcanic hazard assessment: A Python tool for evaluating the evolution of unrest indicators, *Comput. Geosci., 93,* 77–87, doi:10.1016/j.cageo.2016.05.002.

Felpeto, A., J. Martí, and R. Ortiz (2007), Automatic GIS-based system for volcanic hazard assessment, *J. Volcanol. Geotherm. Res., 166,* 106–116, doi:10.1016/j.jvolgeores.2007.07.008.

Scaini, C., A. Felpeto, J. Martí, and R. Carniel (2014), A GIS-based methodology for the estimation of potential volcanic damage and its application to Tenerife Island, Spain, *J. Volcanol. Geotherm. Res., 278–279,* 40–58, doi:10.1016/j.jvolgeores.2014.04.005.

Sobradelo, R., and J. Martí (2015), Short-term volcanic hazard assessment through Bayesian inference: Retrospective application to the Pinatubo 1991 volcanic crisis, *J. Volcanol. Geotherm. Res., 290,* 1–11, doi:10.1016/j.jvolgeores.2014.11.011.

Sobradelo, R., S. Bartolini, and J. Martí (2014), HASSET: A probability event tree tool to evaluate future volcanic scenarios using Bayesian inference presented as a plugin for QGIS, *Bull. Volcanol., 76,* 770, doi:10.1007/s00445-013-0770-x.

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2016 AGU Union Medal, Award, and Prize Recipients Announced

Since its founding, AGU has paid special tribute to outstanding contributors to the advancement of Earth and space sciences. We also recognize individuals who have given exceptional service to our scientific community or have enhanced public understanding and awareness of our disciplines and their impacts on human knowledge and society. On behalf of AGU's Honors and Recognition Committee, our Union selection committees, and our organization's leadership and staff, we are very pleased to present the recipients of AGU's 2016 Union medals, awards, and prizes.

Realizing Our Vision

AGU offers a vision of collaboratively advancing and communicating science and its power to ensure a sustainable future. Our honorees' achievements help build the foundations on which we will realize that vision. We thank all who have given their support and commitment to AGU's honors program, including the volunteers who serve on the medals, awards, and prizes selection committees that have chosen this year's Union honors recipients. We also thank the nominators and supporters who made this all possible with dedicated efforts to recognize their colleagues.

Celebrate at Fall Meeting

We look forward to celebrating our honorees' profound contributions and breakthrough achievements at this year's Honors Tribute, to be held on Wednesday, 14 December 2016, at the Fall Meeting in San Francisco.

Please join us in congratulating our esteemed class of 2016 Union honorees listed below.

Medals

William Bowie Medal
Stanley R. Hart, Woods Hole Oceanographic Institution

James B. Macelwane Medal
Andy Hooper, University of Leeds
Maureen D. Long, Yale University
Toshi Nishimura, University of California, Los Angeles
Appy Sluijs, Utrecht University
Gabriele Villarini, University of Iowa

John Adam Fleming Medal
Rob Coe, University of California, Santa Cruz

Walter H. Bucher Medal
Samuel A. Bowring, Massachusetts Institute of Technology

Maurice Ewing Medal
Peter G. Brewer, Monterey Bay Aquarium Research Institute

Robert E. Horton Medal
Thomas Dunne, University of California, Santa Barbara

Harry H. Hess Medal
Alex Halliday, University of Oxford

Roger Revelle Medal
Ellen R. M. Druffel, University of California, Irvine

Inge Lehmann Medal
Shun-ichiro Karato, Yale University

Charles A. Whitten Medal
Veronique M. A. Dehant, Observatoire Royal de Belgique

Awards

Africa Awards for Research Excellence in Earth and Ocean Science
Musa Siphiwe Doctor Manzi, University of the Witwatersrand

Africa Awards for Research Excellence in Space Science
John Bosco Habarulema, South African National Space Agency and Rhodes University

Ambassador Awards
Ashanti Johnson, Mercer University–Cirrus Academy
M. Susan Lozier, Duke University
Anne Meltzer, Lehigh University
Naomi Oreskes, Harvard University

Edward A. Flinn III Award
Pavel Ya Groisman, University Corporation for Atmospheric Research

Excellence in Geophysical Education Award
Ashanti Johnson, Mercer University–Cirrus Academy

Charles S. Falkenberg Award
Kevin J. Murphy, NASA Headquarters

William Kaula Award
Louis J. Lanzerotti, New Jersey Institute of Technology

Waldo E. Smith Award
Mark Moldwin, University of Michigan

Athelstan Spilhaus Award
Roberta Johnson, University of Illinois

International Award
Tom Beer, Safe System Solutions

Science for Solutions Award
David Seekell, Umeå University

Walter Sullivan Award for Excellence in Science Journalism–Features
Lizzie Wade, *Science*

David Perlman Award for Excellence in Science Journalism–News
Alexandra Witze, Correspondent, *Nature*

Prizes

The Asahiko Taira International Scientific Ocean Drilling Research Prize
Heiko Pälike, MARUM Center for Marine Environmental Sciences, University of Bremen

Climate Communications Prize
Richard B. Alley, Pennsylvania State University

By **Margaret Leinen,** AGU President; and **Sam Mukasa,** Chair, Honors and Recognition Committee; email: agu_unionhonors@agu.org

2016 Class of AGU Fellows Announced

Since AGU established its Fellows Program in 1962, the organization has elected outstanding members as Union Fellows. This special honor recognizes scientific eminence in the Earth and space sciences. It acknowledges Fellows for their remarkable contributions to their research fields, exceptional knowledge, and visionary leadership. Only 0.1% of AGU membership receives this recognition in any given year.

On behalf of AGU's Honors and Recognition Committee, our Union Fellows Committee, our section and focus group Fellows committees, and AGU leaders and staff, we are very pleased to present the 2016 AGU Class of Fellows.

We thank all who provided support and commitment to AGU's honors program to help select these Fellows, including all members of section and focus group Fellows selection committees and of the Union Fellows Committee. These generous and devoted volunteers gave valuable time and energy to evaluating and selecting this year's Fellows. We also thank all the nominators and supporters who made all this possible through their dedicated efforts to nominate and recognize their colleagues.

Celebrate These Eminent Colleagues at Fall Meeting

We look forward to applauding the exceptional achievements, talents, and inspirations of these new Fellows at the annual Honors Tribute, to be held on 14 December at the 2016 AGU Fall Meeting in San Francisco.

Please join us in congratulating our 2016 AGU Class of Fellows!

This year's class of 60 elected Fellows is listed in alphabetical order below:

Hajime Akimoto, National Institute for Environmental Studies
Marc F. P. Bierkens, Utrecht University
Julie Brigham-Grette, University of Massachusetts Amherst
Thure E. Cerling, University of Utah
John T. Clarke, Boston University
Martyn P. Clark, National Center for Atmospheric Research
Robert W. Clayton, California Institute of Technology
James E. Cloern, U.S. Geological Survey
Steven Constable, University of California, San Diego
Steven A. Cummer, Duke University
Jon Davidson, Durham University
Paolo D'Odorico, University of Virginia
Linda T. Elkins-Tanton, Arizona State University
Robert W. Embley, Pacific Marine Environmental Laboratory, National Oceanic and Atmospheric Administration
Matthew H. England, University of New South Wales
Charles C. Eriksen, University of Washington
Mary K. Firestone, University of California, Berkeley
Nat Gopalswamy, NASA Goddard Space Flight Center
Michael Goulden, University of California, Irvine
Gordon E. Grant, Pacific Northwest Research Station, Forest Service, U.S. Department of Agriculture
Peter K. Haff, Duke University
Judson W. Harvey, U.S. Geological Survey
Gabriele C. Hegerl, University of Edinburgh
Harry Hendon, Collaboration for Australian Weather and Climate Research
Mary C. Hill, University of Kansas
Brent N. Holben, NASA Goddard Space Flight Center
Masahiro Hoshino, University of Tokyo
Satoshi Ide, University of Tokyo
Trevor R. Ireland, Australian National University
Anthony John Jakeman, Australian National University
Timothy D. Jickells, University of East Anglia
Fei-Fei Jin, University of Hawai'i at Mānoa
Robert W. Kay, Cornell University
Deborah S. Kelley, University of Washington
Lynn M. Kistler, University of New Hampshire
Shaun Lovejoy, McGill University
Yiqi Luo, University of Oklahoma
Paul R. Mahaffy, NASA Goddard Space Flight Center
David Mohrig, University of Texas at Austin
Mark Pagani, Yale University
Claire L. Parkinson, NASA Goddard Space Flight Center
Tai Phan, University of California, Berkeley
André Revil, Institut des Sciences de la Terre, Centre National de la Recherche Scientifique
Dar A. Roberts, University of California, Santa Barbara
Susan Y. Schwartz, University of California, Santa Cruz
Thomas W. Sisson, Volcano Science Center, California Volcano Observatory, U.S. Geological Survey
Peter K. Swart, University of Miami
Eiichi Takahashi, Tokyo Institute of Technology
Uri S. Ten Brink, Woods Hole Coastal and Marine Science Center, U.S. Geological Survey
Andréa Tommasi, Université de Montpellier
Paul J. Treguer, Université de Bretagne Occidentale
Jeffrey D. Vervoort, Washington State University
Thomas H. Vonder Haar, Colorado State University
Kelin Wang, Geological Survey of Canada
Stephen G. Warren, University of Washington
Robert S. White, Bullard Laboratories
Sean Willett, ETH Zurich
Shang-Ping Xie, Scripps Institution of Oceanography
Howard A. Zebker, Stanford University
Weijian Zhou, Institute of Earth Environment, Chinese Academy of Sciences

By **Margaret Leinen,** AGU President; and **Sam Mukasa,** Chair, Honors and Recognition Committee; email: unionfellows@agu.org

New *Geophysical Research Letters* Editorial and Revisions Policies

AGU

Covers of some recent issues of the journal Geophysical Research Letters.

Because significant advances in the geosciences can have an immediate impact on members of the AGU community, rapid publication is an essential service of AGU Publications. The mission of *Geophysical Research Letters* (*GRL*) is to publish "high-impact, innovative, and timely research on major scientific advances in all the major geoscience disciplines."

Papers accepted for *GRL* are communications-length articles with broad and immediate implications in their discipline or across the geosciences. *GRL* maintains the fastest turnaround of all high-impact publications in the geosciences and works closely with authors to ensure broad visibility of top papers.

The *GRL* Editorial Board continues to work hard to fulfill this mandate while serving the broad and growing community through a fair and transparent editorial and peer-review process. Submissions to *GRL* show just how much this community is growing and diversifying: Submissions grew 16% in 2015 (to a total of 4057), and year-to-date submissions are up an additional 15% in 2016 (to a total of 2783 through 31 July 2016).

Throughout this time, *GRL* has maintained a record of returning first decisions to authors in less than 30 days (on average) for papers that have gone to review and in less than 7 days (on average) for papers that are returned without review.

Over the past several months a number of changes have been implemented that help *GRL* to continue to fulfill its mandate within the context of the rapid growth in submissions.

A Return to Major Revisions

After a decade of using a "no major revisions" policy, *GRL* has recently resumed the use of a "major revisions" editorial decision. For these decisions, the manuscript number is maintained, and authors are required to submit their revisions within 30 days of the decision.

Once the revision is received, the editor may make a decision based on the revisions or may send the revised manuscript for re-review. For any manuscript sent for re-review, the editor may choose to use the previous reviewers and/or one or more new reviewers. This deliberation depends on reviewer availability and on the nature of the previous reviews, the authors' responses, and the authors' revisions.

This new major revisions decision type does not replace other decision types used at *GRL* but merely adds to them.

Retention of Original Submission Date

When appropriate, an article's original submission date can now be preserved, even if a manuscript has received a new manuscript number through previous rounds of review and resubmission. This enhancement, which has been implemented across all AGU journals, was made possible by an update implemented in the GEMS online manuscript submission system.

The intention behind this change is to use it for manuscripts in which the primary body of scientific results has remained intact throughout the resubmission and revision process and for which the resubmission occurs promptly. This new policy recognizes that in some cases authors may provide convincing evidence that substantial additions to a paper are not necessary.

Mobility Between Journals

Another update implemented in GEMS allows manuscripts to be transferred between AGU journals. In some cases, a recommendation for a transfer may be based on a communica-

tion between the editors of the respective journals.

Because this enhancement allows the transfer of reviews and revisions between journals, it can substantially speed up the review and decision process at the receiving journal by allowing the authors to transfer a revised version that responds to the original reviews. Manuscripts may be transferred from *GRL* without being sent for peer review, or they may be transferred after the peer-review stage.

After the *GRL* decision has been made, the authors decide whether to finalize the transfer of the manuscript. Should the authors choose to finalize the transfer, any decision to accept the paper or to consider further review and revisions is up to the editors of the new journal.

Accessing All of the Data

In December 2013, the AGU Council adopted a new comprehensive data policy. This policy states that all data necessary to understand, evaluate, and replicate the reported research must be accessibly archived whenever possible, with information for how to access the data included either in the main text or in the acknowledgments. The policy applies to all data used in the analysis, including data from numerical models.

Further, the policy includes not only the underlying source data but also "derived data products reported or described in a paper." As is stated in the data policy, "AGU reserves the right to refuse publication when authors are unwilling to make the underlying data available or otherwise refuse to comply with this Data Policy." For further discussion of the policy, please see the AGU Publications Data Policy web page (http://bit.ly/agu-data-policy).

Ensuring Originality

For several years, AGU has used the CrossCheck text comparison service to detect overlap between submitted manuscripts and previously published works. *GRL* continues to return without review manuscripts that exhibit excessive overlap between the main manuscript text and previously published works, including works written by the authors of the submitted manuscript.

This decision is made on the basis of the overlap in the main text and captions and not on overlap in the author affiliations, acknowledgments, reference list, or common data set names. Authors are asked to revise the manuscript to address the instances of overlapping text and submit the revised version. Additional information is available on AGU's Scientific Ethics for Authors and Reviewers web page (http://bit.ly/ethics-page) and Dual Publication Policy web page (http://bit.ly/dual-pub-page).

Recognition for Reviewers

As an acknowledgment of the significant contributions of our reviewer community, AGU allows reviewers to receive credit for a review through their Open Researcher and Contributor Identifier (ORCID) records. In addition, GEMS now sends notification emails to reviewers once a final decision on a manuscript is made. This notification acknowledges each individual reviewer for his or her input and describes the outcome of the editor's final decision.

Increased Visibility

Finally, to ensure broad visibility of top papers, *GRL* and AGU staff have implemented a suite of journal content enrichments:

- *GRL* editors' highlights
- *GRL* commentary pieces
- *Eos* research spotlights
- *Eos Editors' Vox* blog posts
- AGU press releases
- AGU social media promotion

This enriched content makes *GRL*-published research more accessible to broader audiences and is centrally collected on the *GRL* website's Highlights tab. Articles selected for enriched content also feature that content on the article web page.

We are honored by the trust that the AGU community places in us as editors of *GRL*, and we take very seriously our responsibility to fulfill both the *GRL* mandate and the high standards of AGU Publications. We hope that these enhancements will help *GRL* to continue to serve the AGU community through rapid, transparent, and fair review and publication of cutting-edge Earth and space science research.

Editors of *Geophysical Research Letters* take very seriously our responsibility to fulfill both the *GRL* mandate and the high standards of AGU Publications.

By **Noah Diffenbaugh,** Editor in Chief, *Geophysical Research Letters;* email: diffenbaugh@stanford.edu; and **Lisa Beal, M. Bayani Cardenas, Kim Cobb, Meghan Cronin, Andrew Dombard, Tatiana Ilyina, Benoit Lavraud, Andrew V. Newman, W. K. "Bill" Peterson, Jeroen Ritsema, Julienne Stroeve, Joel A. Thornton,** and **Paul D. Williams,** Editors, *Geophysical Research Letters*

What Caused Record Water Level Rise in the Great Lakes?

NASA/GSFC/METI/ERSDAC/JAROS and U.S./Japan ASTER Science Team

In 2013 and 2014, outflow from Lake Superior to Lake Michigan-Huron through the St. Marys River, pictured here, was very high in response to abundant regional water supplies. The rate of water level rise on the Great Lakes during this period was the highest ever recorded.

Following a 15-year period of consistently below-average levels of water in Lakes Superior and Michigan-Huron—the planet's two largest lakes by surface area—their shorelines rose dramatically during 2013–2014. In 24 months, the water level in Superior rose almost two thirds of a meter, and the Michigan-Huron level rose 1 meter, the fastest rates ever recorded there during a period of 2 calendar years.

Despite speculation that these changes occurred in response to anomalous weather patterns, including below-average air temperatures across the region, no studies to date have confirmed this link, and previous attempts to understand the basins' water budgets have been stymied by the lack of consistent historical data. Now *Gronewold et al.* have developed a new water balance model to overcome this deficiency.

Using a statistical modeling framework, the researchers pooled all available data to generate estimates of the major monthly inputs and outputs to Lakes Superior and Michigan-Huron from 2005 to 2014. The estimates were then used to determine each system's main hydrological drivers. In contrast to earlier studies, this approach can combine data from multiple sources and incorporate multiple estimates of each component while also quantifying the uncertainty associated with each source of information.

Their analysis indicates that the rapid rise in water levels in both lakes in 2013 was largely driven by increased spring runoff and precipitation over the lakes. By contrast, in 2014 the rise in Superior was predominantly due to reduced evaporation above it, whereas the increase in the Michigan-Huron system was due to a combination of all three of these factors, plus high inflow from Lake Superior via the St. Marys River, which links the two water bodies.

In the future, the authors hope to apply this new modeling framework to other large, freshwater lakes around the globe to better understand how their water levels may respond to both short- and long-term climate trends, information that will be crucial to guiding future water resource management decisions. (*Water Resources Research*, doi:10.1002/2015WR018209, 2016) **—Terri Cook, Freelance Writer**

A New Tool to Better Forecast Volcanic Unrest

Dmitri Rouwet

The sulfuric lake of Kawah Ijen, where researchers studied volcanic activity over a 12-year period to create a new statistical tool to predict volcanic eruptions.

On 27 September 2014, Japan's Mount Ontake erupted and killed 57 people. Unlike other deadly volcanoes, magma didn't roll down its slopes, but the eruption spewed huge plumes of ash and stones into the sky. Although these so-called phreatic eruptions can be just as dangerous as their magmatic counterparts, they often give fewer warnings and are therefore much harder to predict.

Here *Tonini et al.* present a new model that includes indicators of nonmagmatic unrest that might help forecast when a phreatic eruption is soon to occur. The model is the Bayesian Event Tree, a probabilistic tool that synthesizes information from multiple sources—historical records, geological data, and analytical modeling—into one complete analysis that helps scientists forecast that an eruption may happen soon.

The researchers built the new model using data from Indonesia's Kawah Ijen, an active crater lake underlain by a degassing volcano and the perfect example of a system likely to experience phreatic eruptions. Local sulfur miners are often killed by fumes of hydrogen sulfide and sulfur dioxide that vent without warning from fissures in rock. Even in less dramatic events, these poisonous gases are still concentrated enough to burn the miners' eyes and throats and eventually dissolve their teeth.

The team used data from 2000 to 2010 to establish a historical baseline of activity at Kawah Ijen and then analyzed the unrest events that occurred throughout the following 2 years. The model captured a swarm of earthquakes in May 2011 that suggested that Kawah Ijen was about to enter a long period of unrest. Indeed, further earthquakes in October 2011 indicated that both magmatic and hydrothermal unrest was on the rise. The model retrospectively picked up on the rising probability of an eruption roughly 2 months before local authorities increased the alert level, suggesting that the model could improve the management of volcanic unrest.

With this in mind, the team has also created a software program that allows anyone to explore the event tree and visualize the results. The authors hope the program will reduce the gap between the scientific community and decision makers. (*Geochemistry, Geophysics, Geosystems*, doi:10.1002/2016GC006327, 2016) **—Shannon Hall, Freelance Writer**

Venus's Unexpected, Electrifying Water Loss

Billions of years ago, when the solar system was young, you might have mistaken Venus for Earth at a glance—both planets were home to life-sustaining water.

Venus lost that water long ago, and scientists generally place the blame on the solar wind. The electric field carried by the solar wind penetrated Venus's ionosphere, stripping away its ions, including water group species like oxygen and hydrogen.

However, this isn't the only way that Venus might have dried out. A different mechanism involves how an electric field could be generated from the movement of electrons, even while gravity pulls the ions downward. The field could make it easier for water's constituent atoms to be lost to space: It could fling hydrogen ions away from the planet at escape velocity, and it might give a considerable boost to the heavier oxygen ions as well.

Now *Collinson et al.* have made the first definitive measurement of this electric field, and their results show it may indeed have played a larger role than previously thought. The results may even force scientists to downgrade prospects for water on exoplanets thought to be habitable.

The researchers used data from the European Space Agency's Venus Express probe, which arrived at the planet in 2006 and operated until it ran out of propellant and sank into the atmosphere in 2014. The team chose orbits where the satellite flew over Venus's north pole on every orbit. This allowed the probe to measure the strength of the electric field associated with the planet's magnetic field lines.

The authors were surprised to find just how much potential the electric field had: roughly 10 volts, strong enough to fling not only hydrogen ions but also oxygen atoms into space. For context, that's at least 5 times stronger than the equivalent field in Earth's ionosphere. The team suspects this could be because Venus is closer to the Sun and receives more ionizing radiation, and some preliminary modeling supports that conclusion.

If true, the discovery could be bad news for the dozens of potentially habitable exoplanets that NASA's Kepler satellite has discovered. Although these planets are in the "Goldilocks zone"—situated at the right distance from their star to support water—in Kepler's sample of systems, that zone tends to be closer to their stars because those planets are easier to detect. If they too have strong electric winds like Venus, they may be more likely to share its bone-dry, lifeless fate. (*Geophysical Research Letters*, doi:10.1002/2016GL068327, 2016) **—Mark Zastrow, Freelance Writer**

ATMOSPHERIC SCIENCES

POST DOCTORAL FELLOWSHIP IN AEROSOL FORCING OF CLIMATE

Applications are sought for a Post Doc to participate in a NASA-funded project designed to (i) quantify the scales of coherence of different aerosol properties over the contiguous US, (ii) quantify the scales, intensity and causes of extreme aerosol events over the contiguous US and (iii) document changes in event frequency and/or characteristics over time.

The selected applicant will lead the numerical modeling using WRF-Chem and participate in statistical analyses of reanalysis and remote sensing data. The successful applicant will hold a Ph.D. in atmospheric science, engineering or related subject. Experience with aerosol research and WRF-Chem is highly desirable, familiarity with geospatial analysis of large data sets, and programming in Fortran and Matlab is desirable.

The preferred start date is 1 October 2016 and the initial appointment will be for 1 year with the possibility of renewal for 2 additional years.

Salary will be commensurate with experience.

For full consideration, please send a letter of application, a current curriculum vitae, and the names and contact information of three references to: Professor S.C. Pryor (sp2279@cornell.edu).

Applications will be processed until position is filled but those received by 1 September 2016 will receive full consideration. Cornell University is an Equal Employment Opportunity/Affirmative Action Employer and we strongly encourage applications from women and minorities.

CRYOSPHERE SCIENCES

Snow Lidar and Spectrometer Remote Sensing Scientist

The Jet Propulsion Laboratory (JPL), located in Pasadena, CA is a Federally-Funded Research and Development Center operated by the California Institute of Technology for NASA. We invite applications for a full-time scientist position to conduct research on the snow component of the water cycle. The successful applicant will use distributed snow modeling and snow density modeling with airborne and spaceborne snow remote sensing data to quantify snow/water cycling. The successful candidate will also support scientific and operational analysis of data from the Airborne Snow Observatory, MODIS, VIIRS, GLISTIN-A, UAVSAR, and NISAR. The selected individual will be expected to work with other scientists within the Surface Hydrology group and elsewhere on lab in a highly collaborative flight project and research environment. The selected candidate will analyze and interpret data from an array of instruments, present their research at conferences and in journal articles, develop proposals for NASA ROSES solicitations and other funding opportunities, and participate in establishing the science foundation and requirements for future science missions.

Requires a Ph.D in Geography, Cryospheric Science, or related scientific field. An additional two years of postdoctoral experience is highly desired. We are particularly looking for someone with a strong understanding of snow distribution, snow densification processes, and physical process controls on snowmelt. Applicant must have an established reputation as a researcher in the water cycle science as evidenced by a strong record of peer-reviewed publications and presentations at major international scientific meetings and conferences.

JPL/Caltech offers a competitive salary and impressive benefits. To view the full job description and apply, visit: http://Careerlaunch.jpl.nasa.gov/ (Job ID #2016-6948). Applications will be reviewed as they are received, and should include a curriculum vitae, a career statement with research objectives, and contact information for three professional references. JPL/Caltech is an equal opportunity/affirmative action employer.

EARTH AND SPACE SCIENCE INFORMATICS

Assistant Professor of Earth and Planetary Sciences

The Department of Earth and Planetary Sciences at Washington University in St. Louis invites applications for a tenure-track Assistant Professor position in the fields of climate, carbon cycling, or paleoclimatology. The ideal candidate will study climate or the effects of climate change in modern systems and/or over Cenozoic Earth history. Areas of interest include but are not limited to: paleoclimatology and records of consequent environmental change; elemental cycling and associated climate feedbacks; the response of terrestrial, marine, and/or freshwater systems to climate change. The candidate is expected to employ quantitative tools and ideally will integrate field observations with laboratory measurements.

The successful candidate is also expected to develop a vigorous, externally funded research program, maintain a strong publication record, teach a range of undergraduate and graduate courses, advise students, and be active in university service. We are seeking candidates who will complement our research programs in biogeochemistry and environmental geology as well as foster collaboration with environmental scientists across the Washington University community.

Candidates must have a Ph.D. with a focus in environmental Earth science, or a related field, at the time of appointment, and should send a letter

Tenure Track Faculty - Sedimentary Geology

PennState

The Department of Geosciences at The Pennsylvania State University invites applications for a tenure-track faculty position at the Assistant Professor level in Sedimentary Geology, broadly defined. We seek a colleague working to understand the chemical, physical or biological evolution of modern or ancient sedimentary systems. We are especially interested in applicants who integrate a combination of field, laboratory, and modeling techniques, and who complement our existing departmental strengths in geobiology, geochemistry, and geophysics. Successful applicants will be expected to contribute to a diverse research and teaching community in the Department of Geosciences through the development of a vigorous, internationally recognized and externally funded research program, and through teaching courses in their discipline at the undergraduate and graduate levels. The Department of Geosciences is part of the College of Earth and Mineral Sciences, and houses research programs spanning a broad spectrum of Earth Science disciplines (further information is available at: http://www.geosc.psu.edu). Applicants must have a Ph.D. in geosciences or a related field at the time of appointment. Applicants should submit a cover letter, curriculum vitae, a statement outlining research and teaching interests, and the names and contact information of three references. All materials must be submitted online. Review of applications will begin on November 1, 2016 and continue until the position is filled. Appointment may begin as early as July 1, 2017. For further information or questions, please contact Mark Patzkowsky, Chair of the Search Committee at mep12@psu.edu.

Apply online at **http://apptrkr.com/841651**

CAMPUS SECURITY CRIME STATISTICS: For more about safety at Penn State, and to review the Annual Security Report which contains information about crime statistics and other safety and security matters, please go to http://www.police.psu.edu/clery/, which will also provide you with detail on how to request a hard copy of the Annual Security Report.

Penn State is an equal opportunity, affirmative action employer, and is committed to providing employment opportunities to all qualified applicants without regard to race, color, religion, age, sex, sexual orientation, gender identity, national origin, disability or protected veteran status.

of application, curriculum vitae, statements of teaching and research interests, and names and contact information of at least four references as a single PDF to Alex Bradley, Climate Search Committee Chair, Department of Earth and Planetary Sciences, Washington University, Campus Box 1169, 1 Brookings Drive, St. Louis, MO 63130, or via e-mail: ClimateFacSearch@eps.wustl.edu. The Department seeks an exceptionally qualified and diverse faculty; women, minorities, protected veterans and candidates with disabilities are strongly encouraged to apply. Washington University in St. Louis is committed to the principles and practices of equal employment opportunity and affirmative action. It is the University's policy to recruit, hire, train, and promote persons in all job titles without regard to race, color, age, religion, gender, sexual orientation, gender identity or expression, national origin, veteran status, disability, or genetic information. Applications should be received by November 1, 2016 to ensure full consideration.

GEOCHEMISTRY

Tenure-Track Faculty Position

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

GLOBAL ENVIRONMENTAL CHANGE

Landsat and Land Change Scientist

ASRC Federal–InuTeq, LLC invites applications for three Earth Research Scientist positions. The successful candidates will work among hundreds of scientists and engineers at the USGS Earth Resources Observation and Science (EROS) Center (http://eros.usgs.gov/) in Sioux Falls, South Dakota participating on teams conducting dozens of projects and studies addressing significant remote sensing and earth science challenges. EROS is a national center of Earth science remote sensing and geospatial research, Landsat program management and data reception, geospatial data management, and systems development that coordinates with multiple Federal and International agencies on a broad scope of global, national, and regional scaled Earth science projects.

Landsat Science Team Scientist (Req #16001359). The Landsat Science Team Scientist will extensively network and communicate with members of the Landsat Science Team and the USGS EROS land change science community to originate, gather, and share information and knowledge concerning the Landsat program. Primary objectives will include:

1. Support the activities of the Landsat Science Team, including coordination, planning, and communications.
2. Provide general science support to Landsat users by evaluating technical issues associated with Landsat characteristics and products.
3. Contribute to research on Landsat topics affecting science and applications.
4. Contribute to the development of a focused EROS land change science capability.

Land Change Scientist I (Req #16001353). The Land Change Scientist I will focus on land cover classification and the geography of change, as part of an InuTeq and USGS interdisciplinary team of scientists and engineers working to meet EROS LCMAP goals. Primary objectives will include:

1. Provide a systematic evaluation of how well continuous monitoring outputs are performing.
2. Determine whether change agents are being correctly identified.
3. Define circumstances under which outputs do or do not characterize change.
4. Suggest improvements for classification and change attribution results.
5. Evaluate accuracy of timing and types of change and change agents.

Land Change Scientist II (Req #16001351). As a participant in an InuTeq and USGS interdisciplinary

team of scientists and engineers working to meet EROS LCMAP goals, the Land Change Scientist II will:

1. Provide a near-term systematic evaluation of products such as change magnitude, EVI slope, and other current and/or future derivatives from the continuous-monitoring algorithm.

2. Describe geographic and technical circumstances under which independent variables perform well or poorly for continuous monitoring and assemble examples as evidence.

3. Provided recommendations on variables to include as part of a set of operational products from continuous land cover monitoring.

4. Provide recommendations for continued LCMAP product improvement.

Tenure Track Assistant Professor of Applied Geophysics

The Department of Earth and Atmospheric Sciences at Central Michigan University invites applications for a tenure-track position in applied geophysics at the Assistant Professor level, beginning Fall 2017. We seek candidates who use a combination of field-based geophysical methods and quantitative methods to examine crustal or lithosphere dynamics; earthquake processes; petroleum or metal exploration geophysics; subsurface fracturing and fluid flow; or environmental geophysics. The selected candidate will support the departmentís programs through engaging, student-centered teaching, develop an externally-funded research program that involves students, and actively contribute to service initiatives that advance the department, college, and university.

The Department of Earth and Atmospheric Sciences, housed in the College of Science and Engineering, offers B.S. degrees in Geology, Environmental Science, and Meteorology, and participates in an interdisciplinary Ph.D. program in Earth and Ecosystems Science. The expertise of faculty members spans research areas across the geosciences, including hydrogeology, environmental modeling, Earth surface processes, climatology, and geochemistry. Further information about the department can be found at http://www.eas.cmich.edu.

Candidates must hold a Ph.D. in geophysics, geological sciences, or a related field. In addition, candidates must demonstrate (1) the potential for outstanding teaching, (2) the potential to develop a vigorous research program that involves students and attracts external funding, and (3) strong oral and written communication skills. Preference will be given to candidates who have postdoctoral experience (academic or industry), a demonstrated record of receiving external funding, and teaching experience.

Review of applications will begin October 15th, and continue until the position is filled. Applicants should submit a CV, cover letter, statement of research interests, statement of teaching philosophy, and the names and contact information for 3 referees through an online process at http://www.jobs.cmich.edu. Requests for further information may be addressed to Dr. Lawrence Lemke at L.D.Lemke@cmich.edu.

Classified by the Carnegie Foundation as a research high (R2) doctoral university, CMU is recognized for strong undergraduate education and a range of focused graduate and research programs. CMU is a student-focused university with opportunities for leadership, internships, and off-campus volunteer programs. CMU, an AA/EO institution, strongly and actively strives to increase diversity within its community (see www.cmich.edu/aaeo/).

HYDROLOGY

2 PhD scholarships studying impacts of drought in New Zealand native forest

The project involves exploring the threat of seasonal drought to kauri and associated southern conifers using a field-based drought experiment. There are two scholarships on offer. The first involves measurement of sap flow and other plant water relations parameters. This PhD project will concentrate on native tree species including kauri at the University of Auckland Huapai scientific reserve where the drought experiment will be established. The other project will explore drought mortality mechanisms in southern conifers using field and glasshouse studies. There will be opportunity to work with a mechanistic model of the soil-plant-atmosphere pathway subject to student interest. The full scope of each project is negotiable for the right candidates, subject to fitting into the theme of drought in native forest.

Associate or Full Professor of Geology

The West Virginia University (WVU) Department of Geology and Geography invites applications for a tenured faculty position in the area of hydrogeoscience at either the Associate Professor or Full Professor level. Applicants with exceptional qualifications will be nominated for the Eberly Family Distinguished Professorship in Geology. The successful candidate is expected to bring a vigorous program of innovative, externally-funded research; build effective collaborations; and teach at the graduate and undergraduate levels.

Research on fresh water resources is currently an area of strategic growth at WVU (http://research.wvu.edu/about) including a new interdisciplinary water research institute. We invite applications from individuals with interests in basic and applied aspects of groundwater flow. Relevant specialties might include physical hydrogeology; fluid flow modeling; hyporheic or vadose zone processes; groundwater-surface water interaction; flow in fractured media; hydrogeology of energy-related

NOTICE OF VACANCY
WASHINGTON STATE UNIVERSITY
Laboratory for Atmospheric Research
Department of Civil and Environmental Engineering
Voiland College of Engineering and Architecture
Position 55848

Washington State University, Department of Civil and Environmental Engineering and the Laboratory for Atmospheric Research (LAR) invite applications for a permanent 9-month tenure-track faculty position at the assistant to associate professor level on the Pullman campus with an effective start date from January 1, 2017 to August 16, 2017. This position is part of WSU's priority to build a diverse faculty; thus, female and minority candidates are strongly encouraged to apply.

Candidates are sought with expertise in numerical modeling related to air quality, atmospheric chemistry, and climate change at urban to regional scales. The successful applicant will help lead and grow the WSU AIRPACT air quality forecast system operation. The selected applicant will teach graduate and undergraduate air quality and environmental engineering courses, direct graduate student research, and develop a strong extramurally funded research program. The position requirements include:
1) expertise with urban to regional scale atmospheric chemistry models with applications to air quality, atmospheric chemistry, and/or climate change, 2) a record of research accomplishments demonstrated by peer reviewed publications and/or extramural grants, 3) demonstrated ability to work with diverse, interdisciplinary teams in a collaborative manner, 4) a record of outreach, mentoring, or teaching to diverse student populations, and 5) an earned Ph.D. or equivalent degree in a relevant engineering or science field. In addition, experience using remote sensing and in situ observations to evaluate and improve models and participation in the design and implementation of field campaigns is desirable.

Applicants should apply online at https://www.wsujobs.com by submitting the following: a cover letter, a detailed resume, a statement of research and teaching interests, and a list of five references with contact information. Screening of candidates will begin September 1, 2016, but applications will be accepted until the position is filled.

WASHINGTON STATE UNIVERSITY IS AN EQUAL OPPORTUNITY/AFFIRMATIVE ACTION EDUCATOR AND EMPLOYER.

activities; groundwater supply and sustainability; contaminant transport; ecohydrology; multiscale hydrologic modeling; critical zone processes; and/or karst hydrogeology.

To apply, please visit http://jobs.wvu.edu and navigate to the position title listed above as Job Number 03733. Upload (1) a single PDF file including a statement of research interests, a statement of teaching philosophy, and a curriculum vitae; and (2) pdf files of up to 4 publications. Please also arrange for three letters of reference to be sent to search chair Joseph J. Donovan at jdonovan@mail.wvu.edu. Review of applications will commence on October 15, 2016 and continue until a successful candidate is identified. For additional information, please see http://geology.wvu.edu.

WVU is an EEO/Affirmative Action Employer and welcomes applications from all qualified individuals, including minorities, females, individuals with disabilities, and veterans.

University of Minnesota – Department of Earth Sciences

The Department of Earth Sciences in the College of Science and Engineering at the University of Minnesota – Twin Cities is soliciting applications for a tenure-track faculty position in hydrology/hydrogeology at the assistant professor level. Exceptional candidates at the associate professor level will also be considered. This position will carry with it additional resources from the Gibson Endowed Fund for research activities over the first five years of the appointment.

Areas of research for this position could include physical, chemical, and/or biological aspects of hydrology or hydrogeology. Frontier topics of interest in this field include, among others, research at non-traditional spatial scales, grand challenges in water resource sustainability and security, novel measurement techniques and datasets, and links between the study of hydrological systems and subsurface geology, other portions of the earth system, and/or other disciplines, as well as other topics. The successful candidate is expected to develop a vigorous research program, attract external funding, and contribute to the instruction, research, and service efforts of the department. A Ph.D. in earth sciences or a related field is required at the time of appointment.

The Department of Earth Sciences is a vibrant interdisciplinary department whose research ranges from geobiology to deep earth dynamics. Alongside our commitment to excellence in scholarship, we seek to further the University of Minnesota's land-grant mission through developing ties with industry and/or governmental agencies that benefit the needs of our students, the state of Minnesota, and the broader community. The Department is in the N.H. Winchell School of Earth Sciences (http://www.esci.umn.edu/), which also includes the Institute for Rock Magnetism, the Limnological Research Center/National Lacustrine Core Facility/Continental Scientific Drilling Coordination Office, the Minnesota Geological Survey, the National Center for Earth-surface Dynamics, and the Polar Geospatial Center. Other affiliated research units at the University include the Saint Anthony Falls Laboratory and the Institute on the Environment. The appointee will have access to large-scale computing facilities (Minnesota Supercomputer Institute, Digital Technology Center) and the interdisciplinary Water Resources graduate program.

Materials Required: A one-page letter of intent. A CV with a list of publications. A statement of research and teaching interests. Names and contact information of three referees who can

Postdoctoral Research in Space Physics at the University of Kansas

Applications are invited for a post-doctoral position in space physics at the University of Kansas Dept. of Physics & Astronomy beginning as early as Oct. 1, 2016. Ph.D. in physics, astronomy, or a related field associated with space physics by date of appointment and demonstrated experience in space physics or astrophysics or related field as evidenced by application materials. The initial appointment is for one year with possibility of renewal for another year subject to review and continued grant funding. For complete position announcement and to apply on-line go to https://employment.ku.edu/staff/6725BR .

Review of applications will begin Aug. 15, 2016, and continue as needed to ensure a large, high quality, and diverse applicant pool.

Inquiries: email to cravens@ku.edu with a copy to tizby@ku.edu.

KU is an EO/AAE; full policy at http://policy.ku.edu/IOA/nondiscrimination

Faculty Cluster Hire in Earth Surface Processes
University of California Santa Barbara
Tenure-Track Assistant Professor Positions

The University of California Santa Barbara announces a multidisciplinary cluster hire of four outstanding scientists, to further strengthen its world class Earth surface process teaching and research mission. We seek dynamic researchers who are at the forefront of advancing theory, measurements and understanding in terrestrial Earth Surface Processes from disciplines including climatology, geochemistry, geology, geomorphology, hydrology and soil science. The cluster hire will build on UC Santa Barbara's foundation strengths in physical geography and Earth and environmental sciences. Successful hires will contribute to improving our understanding of the characteristics and functioning of the entire planet, and especially its terrestrial surface through the study of the complex interactions among atmosphere, geosphere, hydrosphere, biosphere, cryosphere, including their alteration by, and impact on, human activity. We will give preference to candidates with demonstrated expertise in one or more quantitative techniques including field measurement, remote sensing, modeling, and theory and candidates who, based on research and teaching proficiency, would fit into one of the following: the Bren School of Environmental Science and Management, the Department of Earth Science, and the Department of Geography. Applications will be reviewed starting October 31, 2016 with expected appointments on July 1, 2017. Please see the following website for a more complete description of the positions http://www.eri.ucsb.edu/escluster. To be considered for one of the four available positions, apply electronically at: https://recruit.ap.ucsb.edu/. Applications completed by October 31st, 2016 will receive fullest consideration, but each department will continue reviewing applicant files until that position is filled.

The Department is especially interested in candidates who can contribute to the diversity and excellence of the academic community through research, teaching and service.

The University of California is an Equal Opportunity/Affirmative Action 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.

address the candidate's research and teaching potential.

Applications must be completed online at: http://www1.umn.edu/ohr/employment/ – search for Job Opening ID: 311335

The review of applications will begin October 14, 2016. Applications will continue to be accepted until the position is filled. Questions may be directed to Prof. Jake Bailey (baileyj@umn.edu).

The University of Minnesota provides equal access to and opportunity in its programs, facilities, and employment without regard to race, color, creed, religion, national origin, gender, age, marital status, disability, public assistance status, veteran status, sexual orientation, gender identity, or gender expression. The University supports the work-life balance of its faculty.

INTERDISCIPLINARY/OTHER

NASA/LIBRARY OF CONGRESS CHAIR IN ASTROBIOLOGY

The John W. Kluge Center at the Library of Congress invites applications from all disciplines for the Baruch S. Blumberg NASA/Library of Congress Chair in Astrobiology, a senior research position in astrobiology and its implications for humanity and society.

The applicant will be in residence at the Library of Congress for up to 12 months and will conduct independent research using the Library's collections that explores the intersection of the science of astrobiology with its humanistic and societal implications. The applicant will also convene related public programs that ensure the subject of astrobiology's role in culture and society receives considered treatment each year in Washington, D.C., and be expected to participate in the intellectual community at the Kluge Center.

The Chair is open to scholars and leading thinkers in the fields of astrobiology, astronomy, planetary science, history of science, philosophy, religion, sociology, anthropology, ethics, literature, the arts, paleontology, Earth and atmospheric sciences, geological sciences or other fields. The Chair may undertake research on a wide range of issues related to how life begins and evolves, or examine the social, religious, ethical, legal, and cultural concerns that arise from researching the origins, evolution, and nature of life in the universe.

The possibilities for research subjects are many. The following are meant to inspire, not to limit creativity: legal issues related to governance of planets and space; ethical implications of cross-contamination; scientific and philosophical definitions of life; conceptions of the origins of life in theistic and non-theistic religions; comparison of the discussion of these issues in multiple nations and cultures; life's collective future—for humans and other life, on Earth and beyond, examining the impacts on life and future evolutionary trajectories that may result from both natural events and human-directed activities; or other subjects that involve astrobiology and its effects on humanity and society.

Proposals should be submitted via the Kluge Center's online application system by close of business on December 1, 2016. Applicants must include a completed application form, a C.V., a complete project proposal, and three references. Applicants should also include as part of their proposal detailed plans and a budget (no more than three pages) for such auxiliary activities as workshops, symposia, or small conferences, explaining how these activities would support the research and/or contribute to any public presentation of the human implications of astrobiology.

The Chair holder will be appointed by the Librarian of Congress on the recommendation of a selection committee consisting of representatives from the academic community jointly selected by NASA and the Library of Congress.

For more information, please visit http://www.loc.gov/loc/kluge/fellowships/NASA-astrobiology.html.

The John W. Kluge Center was established at the Library of Congress in 2000 to foster a mutually enriching relationship between the world of ideas and the world of action, between scholars and political leaders. The Center attracts outstanding scholarly figures to Washington, D.C., facilitates their access to the Library's remarkable collections, and helps them engage in conversation with policymakers and the public. Learn more at: http://www.loc.gov/kluge.

Tenure-Track Faculty Position

The Department of Earth and Environmental Sciences at Boston College invites applications for a tenure-track Assistant Professor with an expertise in quantitative/computational modeling of integrated earth systems: a geodynamic and/or hydrologic modeler who explores the physical, chemical, and/or biological interrelationships among diverse environmental and earth systems at the regional to global scale. The candidate should have broad research interests compatible with those of the current faculty in our Department of Earth and Environmental Sciences and potentially with faculty in the Biology, Chemistry, Physics, Computer Science and/or Mathematics departments. Areas of research expertise could include (but are not limited to): modeling of the interactions of ice-sheet dynamics, sea-level rise and climate change; modeling the exchange of water, carbon, energy, or pollutants between the terrestrial hydrosphere, cryosphere, ocean, atmosphere, and lithosphere; and modeling crustal deformation and mantle flow as it influences surface topography and climate. The successful candidate will be expected to develop a vigorous externally funded research program integrated with excellence in teaching within the Earth and Environmental

Science curriculum at both the undergraduate and graduate levels.

Information on the department, its faculty and research strengths can be viewed at http://www.bc.edu/eesciences.

Applicants should send a curriculum vita, statements of teaching and research interests, and the names and contact information of at least three references to https://apply.interfolio.com/36250. Review of applications will begin on November 1, 2016. Inquiries may be directed to Prof. Noah Snyder, Search Committee Chair (noah.snyder@bc.edu).

SEISMOLOGY

Director of the Southern California Earthquake Center and Professor of Earth Sciences, University of Southern California

The Dana and David Dornsife College of Letters, Arts and Sciences of the University of Southern California in Los Angeles, California, seeks a senior earthquake scientist to lead the Southern California Earthquake Center (SCEC) as its director and principal investigator. The appointment will be made at the tenured faculty level (Associate Professor or Professor) in the Department of Earth Sciences (http://dornsife.usc.edu/earth/). The SCEC director will oversee a world-leading program in earthquake system science that currently involves over 1000 earthquake experts at more than 70 universities and research institutions. The successful candidate will have a strong record of federally funded earthquake research, innovative ideas about the future of earthquake science, and the ability to articulate scientific results to end-users and the general public. She or he will be knowledgeable about the application of advanced computational methods to solve system-level problems, including the use of physics-based methods for earthquake forecasting. Doctoral degree and teaching experience is required.

Applications should include a curriculum vitae, publication list, statement of teaching and research interests, and three names of individuals familiar with the applicant's work who could be contacted for letters of reference. It should also include a vision statement on how, as SCEC director, the applicant would move forward the Center's research program. In order to be considered for this position, applicants are required to submit an electronic USC application through the following link: http://jobs.usc.edu/postings/68664.

Inquiries may be directed to: Chair, Search Committee, c/o Karen Young (kayoung@usc.edu). Review of complete applications will begin November 1, 2016, and will continue until the position is filled.

USC is an equal-opportunity educator and employer, proudly pluralistic and firmly committed to providing equal opportunity for outstanding persons of every race, gender, creed and background. The University particularly encourages women, members of underrepresented groups, veterans and individuals with disabilities to apply. USC will make reasonable accommodations for qualified individuals with known disabilities unless doing so would result in an undue hardship. Further information is available by contacting uschr@usc.edu.

Tenure Track Faculty Position in Global Geophysics, University of Southern California

The Department of Earth Sciences in the Dana and David Dornsife College of Letters, Arts and Sciences of the University of Southern California in Los Angeles, California, invites applications for a faculty position in global geophysics at the tenure-track Assistant Professor or tenured Associate Professor level. We seek candidates who will develop a program of fundamental research on the structure, deformation, and/or evolution of the lithosphere and its interactions with the Earth's deep mantle and fluid envelopes. The successful candidate will bring new approaches—observational, experimental, computational, and/or theoretical—to lithospheric studies and will demonstrate a strong commitment to both graduate and undergraduate teaching. We are particularly interested in candidates who can connect research on lithospheric problems to other areas of departmental interest, which include global environmental change, geobiology, and earthquake system science (http://dornsife.usc.edu/earth/). Applicants must have a PhD in a related field.

Applications should include a curriculum vitae, publication list, statement of teaching and research interests, and three or more names of individuals familiar with the applicant's work who could be contacted for letters of reference. In order to be considered for this position, applicants are required to submit an electronic USC application through the following link: http://jobs.usc.edu/postings/67388. Inquiries can be directed to: Chair, Search Committee, c/o Karen Young (kayoung@usc.edu). Review of complete applications will begin November 1, 2016.

USC is an equal-opportunity educator and employer, proudly pluralistic and firmly committed to providing equal opportunity for outstanding persons of every race, gender, creed and background. The University particularly encourages women, members of underrepresented groups, veterans and individuals with disabilities to apply. USC will make reasonable accommodations for qualified individuals with known disabilities unless doing so would result in an undue hardship. Further information is available by contacting uschr@usc.edu.

AGU

American Geophysical Union
Position Announcement

Education & Professional Development Coordinator

Currently, AGU has an excellent full time career opportunity in our dynamic Science department. Located in AGU head office in Washington, DC, the Education & Professional Development Coordinator will provide program administration, project management support, and project level coordination in support of the goals and objectives of the AGU Talent Pool Programs and overall AGU.

The incumbent will also serve as the primary administrator and customer support representative for students and judges participating in Virtual Poster Showcases (VPS); assist students and judges with VPS platform; work with platform provider to continually improve user experience; produce and maintain 'how to' documents; work with marketing staff to promote events; and track program metrics and evaluations. In addition, this role will coordinate and oversee AGU's Undergraduate Mentoring Program (UMP) and Career and Research Advice and Mentoring Session (CRAM Session) program for geoscience students; as well as organize and serve as primary coordinator for the annual GIFT (Geophysical Information For Teachers) workshops for high school teachers.

Requires 3–5 years with BS/BA; 2+ years with MS/MA; a science background (geoscience or allied sciences) is preferred.

For consideration, please submit your cover letter with your salary requirements and resume to jobs.agu.org

AGU is an Equal Opportunity/Affirmative Action employer. Minorities, women, veterans and individuals with disabilities are encouraged to apply.

ASSISTANT PROFESSOR OF PRACTICE,
DEPARTMENT OF EARTH AND ATMOSPHERIC SCIENCES
(non-tenure track, Atmospheric Sciences)

Applications are invited for a non-tenure track position as Assistant Professor of Practice in the Department of Earth and Atmospheric Sciences at the University of Nebraska-Lincoln. The successful candidate will be expected to teach multiple courses in atmospheric sciences, take a lead role in academic advising, participate in curricular development, and support recruiting and outreach activities. In addition, a fraction of the appointment will be devoted to research and service (details subject to negotiation). Demonstrated excellence in teaching courses in atmospheric science is required. Preference will be given to candidates who show evidence of the skills required for advising/mentoring undergraduate students and the engagement skills required to recruit majors. Applicants must hold a Ph.D. in meteorology, atmospheric sciences, or a related field at the time of appointment.

The Department of Earth and Atmospheric Sciences offers B.S. degrees in Meteorology-Climatology and Geology, as well as M.S. and Ph.D. degrees in Earth and Atmospheric Sciences. Research in atmospheric sciences focuses on meteorological hazards, climate change, and remote sensing. Additional information about the Department can be found at http://eas.unl.edu. The University of Nebraska-Lincoln is committed to a pluralistic campus community through affirmative action, equal opportunity, work-life balance, and dual careers. See http://www.unl.edu/equity/notice-nondiscrimination.

To apply, go to http://employment.unl.edu/postings/50670 and complete the "faculty/administrative form".Applicants must attach a cover letter, curriculum vitae, a statement of teaching philosophy, and names of at least three references via the above website. Review of applications will begin on Sept. 30, 2016. The preferred starting date for this position is January 2, 2017.

Postcards from the Field

Hi, Everyone.

Waking up in the foothills of the Absarokas in Wyoming at 5:00 a.m. to quantify the effect of flood irrigation gets a lot easier with a beautiful sunrise.

—Niels Claes, graduate student, Department of Ecosystem Science and Management, University of Wyoming

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

AGU LEADER

2016 ELECTIONS

Election is Open
Time to Vote

Your vote can influence the direction of AGU

Visit elections.agu.org to review the ballots and candidate bios

Polls are open through 27 September

elections.agu.org