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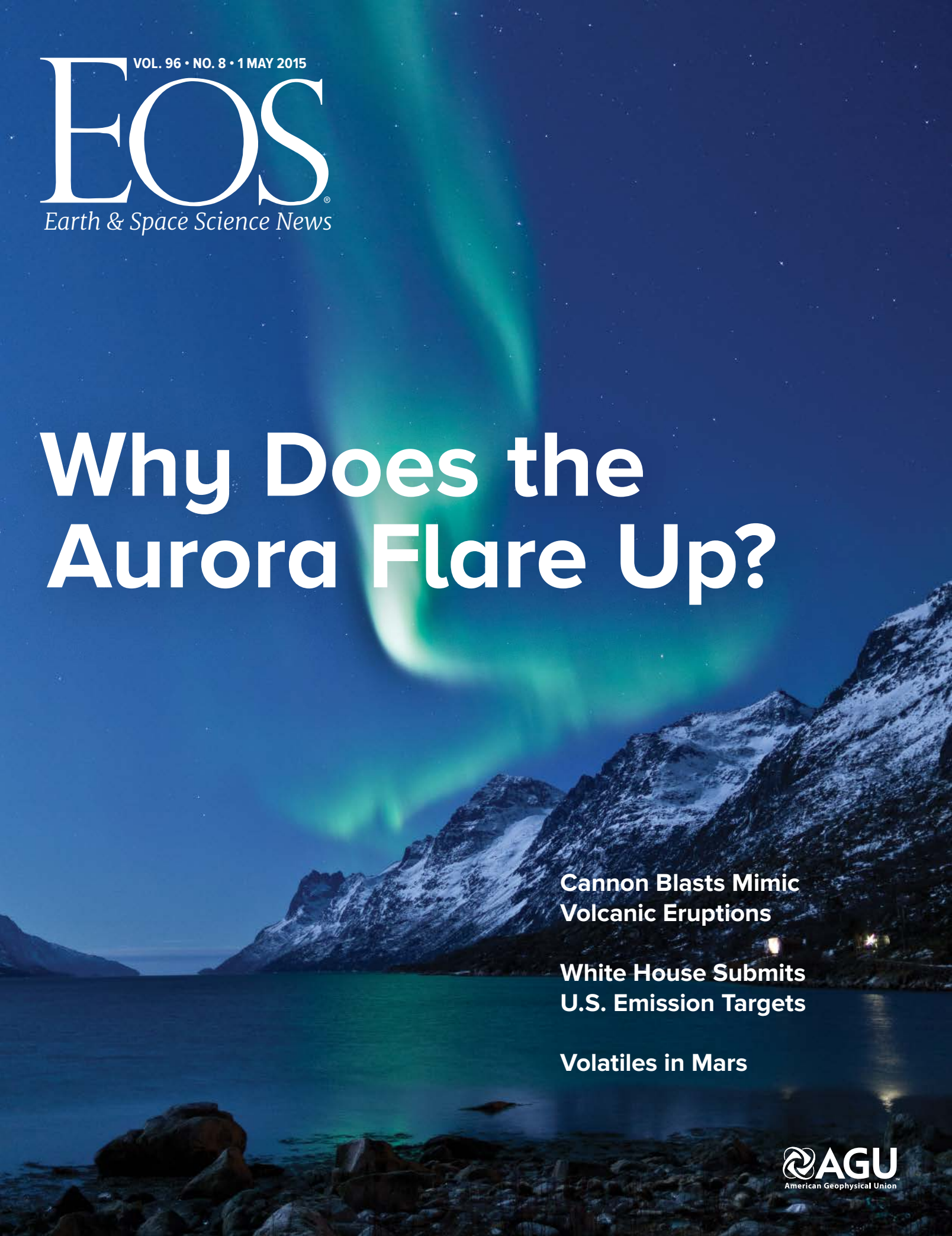
EOS

Earth & Space Science News



Why Does the Aurora Flare Up?

Cannon Blasts Mimic Volcanic Eruptions

White House Submits U.S. Emission Targets

Volatiles in Mars

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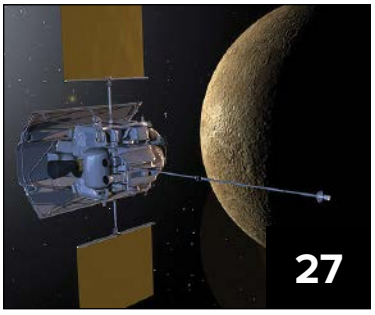

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EOS.

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NASA Hopes to Find Strong Indications of Life Beyond Earth Soon

NASA's search for water and for habitable planets and moons in our solar system and galaxy could be on the verge of something big, agency scientists say.

"I think we are going to have strong indications of life beyond Earth within a decade, and I think we are going to have definitive evidence within 10 to 20 to 30 years," NASA chief scientist Ellen Stofan said at a 7 April briefing about the agency's investigation of water and habitable bodies. "We know where to look. We know how to look. In most cases, we have the technology, and we are on a path to implementing it."

"We are on the verge of things that people have wondered about for millennia: Are we alone? And here we are on the verge of finding that out," Stofan said. She noted that scientists now know of many other planetary bodies that could merit further investigation. "I will be quite surprised if we go interrogate these environments and don't find evidence of life. To me, that would be a really surprising scientific result. Finding life, to me, is not the surprising result. It would be the absence of life that would be the surprising result."

> "We are going to have strong indications of life beyond Earth within a decade."

"We are not talking about little green men. We're talking about little microbes," she added. "We are looking for the building blocks of life, organic material that might tell us that some process is going on."

Looking Within and Outside the Solar System

The search for water and habitable bodies has accelerated with numerous recent missions and findings.

For instance, within our Solar System, NASA scientists suggested in March that Mars once had as much water as the Arctic Ocean. The water could have covered almost half of the planet's northern hemisphere at more than 1.6 kilometers in depth in some locations, according to the scientists, who analyzed data from ground-based observatories. In addition, NASA's Curiosity rover discovered an ancient streambed, among other findings.

Jupiter's icy moons Ganymede, Europa, and Callisto show evidence of oceans beneath their surfaces, as do Saturn's moons Enceladus and Titan. The Obama administration's fiscal year 2016 budget request to Congress supports the formulation and development of a Europa mission.

Outside of our solar system, the Kepler space observatory mission's search for habitable planets has detected 4633 candidate planets and has confirmed 1019 as of early April. The Transiting Exoplanet Survey Satellite, scheduled to launch in 2017; the James Webb

NASA

Panelists (left to right) John Grunsfeld, associate administrator for NASA's Science Mission Directorate; Jim Green, director of NASA's Planetary Science Division; Jeffery Newmark, interim director of NASA's Heliophysics Division; Paul Hertz, director of NASA's Astrophysics Division; and Ellen Stofan, NASA chief scientist.

Space Telescope, on target for a 2018 launch; and the planned Wide-Field Infrared Survey Telescope (WFIRST) mission could advance the discovery of more extrasolar planets.

"Where Is Everybody?"

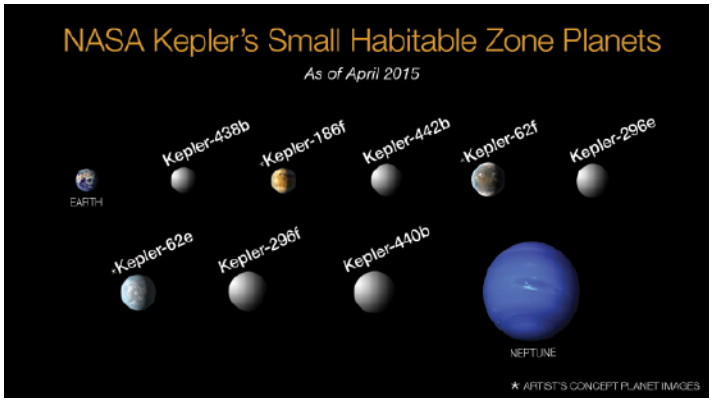
John Grunsfeld, associate administrator for NASA's Science Mission Directorate, said that Kepler has led to the understanding that we live in a galaxy and a universe filled with solar systems. Within these, he explained, many planets may resemble Earth: rocky planets in a potentially habitable zone.

"We are finding somewhat surprisingly that our universe [and] our galaxy are filled with habitable environments," Grunsfeld said. "It really does beg the question, 'If there are so many places that life could exist, where is everybody?' That's part of the question of are we alone. Of course, we have only been a spacefaring world for little over 50 years. I think it is amazing that we have made so much progress in such a short period of time," he added.

"In our own solar system, we have a chance of finding that there might have been past life on Mars, or evidence of current microbial life, sometime in the next generation of explorers," he said. Looking beyond our solar system, Grunsfeld said that the generation of telescopes after Webb could provide a high-precision spectrum from the atmosphere of a planet orbiting a nearby star "that would provide solid evidence that there is some sign of life out there."

Galaxy Is "a Soggy Place"

Paul Hertz, director of NASA's Astrophysics Division, said that our galaxy is "a soggy place," as is our solar system. He said that water has been detected in many locations, including in interstellar clouds in which planetary and star systems form. "But the place that we are most interested in looking is at worlds in 'habitable zones' around stars other than our Sun," Hertz said.



NASA

Small planets within habitable zones, identified by the Kepler mission.

The habitable zone, Hertz said, is "a fuzzy concept" that scientists argue about. Generally, the zone is considered to be a region of space around a star where one would expect to find liquid water on the surface of a planetary body, he said. However, within our solar system, Venus and Mars each arguably fall within the habitable zone, but neither currently has liquid water on its surface, he said. Some of the icy moons of Jupiter and Saturn, which fall outside of the traditional definition of the habitable zone, may have liquid water.

> "You can't write down a formula for [the habitable zone], but you know it when you see it."

Regarding the habitable zone, Hertz concluded, "You can't write down a formula for it, but you know it when you see it."

The Solar Wind

A number of factors could help to determine whether a planet or moon might be habitable, including the body's atmosphere and whether it has a magnetic field. Jeffery Newmark, interim director of NASA's Heliophysics Division, said the interaction of the solar wind with planets "is crucial for our understanding of the lifecycle of water on these planets and indeed the habitability throughout the universe."

He said that although Mars may have been covered by water 3–4 billion years ago, the absence of a significant Martian magnetic field may have allowed the solar wind to interact directly with Mars's upper atmosphere and "strip away the atmosphere and water" from the planet.

An Exciting Time

Jim Green, director of NASA's Planetary Science Division, said the study of the magnetic field and its interaction with the solar wind is an important element for understanding how Earth's magnetic field might have protected our home planet over the millennia. "We are now understanding how complicated yet connected the kinds of phenomena—like gravity, like rocky bodies, like magnetic fields, and like water—are playing in developing an environment for life and also maintaining it for long periods of time."

Green said this is an exciting time for the search for water and habitable planetary bodies, with the scientific community making enormous progress on many fronts. Green noted, for instance, a series of findings about icy moons around Jupiter and Saturn that "changes our perspective of where habitable zones are completely" because they can be around giant planets in addition to being around stars.

He also focused on Mars rovers. The Curiosity rover is poised to make more discoveries on Mars, Green said, adding that the next Mars rover, equipped with ground-penetrating radar and other instrumentation, is set to launch in 2020. That new rover would rigorously investigate another potentially habitable region on that planet. "Man, I don't know what we're going to find there," he said.

By **Randy Showstack,** Staff Writer

Supreme Court Hears Case About Regulating Power Plants

The U.S. Supreme Court heard sharply contrasting arguments on 25 March about whether the U.S. Environmental Protection Agency (EPA) properly interpreted a rule that regulates airborne mercury and other emissions from coal- and oil-fired power plants. Cost-benefit analyses also differed significantly.

Exposure to mercury at sufficient levels can affect the human nervous system and other parts of the body. According to EPA, coal-burning power plants are the largest human-caused source of airborne mercury emissions in the United States.

> "All we have to find is a plausible reading to uphold the EPA's interpretation."

The court's decision, expected by the end of the current term in June, could have significant regulatory, financial, and public health ramifications.

The case, *Michigan v. Environmental Protection Agency*, revolves around the interpretation of the word "appropriate" in a section of the 1990 amendments to the federal Clean Air Act (CAA) that calls for EPA to conduct a study of public health hazards that could reasonably be anticipated to occur because of emissions from electric utility steam generating units. The final sentence of the section states, "The Administrator shall regulate electric utility steam generating units under this section, if the Administrator finds such regulation is appropriate and necessary after considering the results of the study required by this subparagraph."

The Supreme Court granted a hearing on the case limited to the question of whether EPA "unreasonably refused to consider costs in determining whether it is appropriate to regulate hazardous air pollutants emitted by electric utilities." The current case also incorporates two similar cases: *Utility Air Regulatory Group v. EPA* and *National Mining Association v. EPA.*

What Is Meant by "Appropriate"?

EPA argued in its written court filing that costs do not come into play in the first part of its regulatory process. The agency "concluded that costs are not relevant to the decision whether to regulate such emissions, but that costs should instead be taken into account when setting emission standards," according to the agency's written arguments. EPA also concluded that quantifiable annual benefits of those standards to regulate mercury and other emissions would exceed costs by $27 billion to $80 billion, in 2007 dollars.

The petitioners, who represent the state of Michigan and 20 other states, argued in their written position that the word "appropriate" is ambiguous and that it renders EPA "free to find it appropriate to regulate without any regard for the regulation's cost." The petitioners stated that all relevant context "confirms that Congress did not intend for EPA to act with deliberate indifference to cost when answering the basic regulatory question whether it is appropriate to regulate."

They also stated that it would achieve just $4 million to $6 million in annual health benefits by reducing hazardous air pollutants at an annual cost of $9.6 billion to industry. The petitioners argued that the regulation's costs "are wholly disproportionate to their benefits." They stated that airborne mercury regulation cobenefits of lower emissions of particulate matter, which EPA estimated, "are not relevant benefits for the purpose of deciding whether it is appropriate to regulate [hazardous air pollutant] emissions from electric utilities."

Oral Arguments

During oral arguments, several justices pushed Michigan solicitor general Aaron Lindstrom about the meaning of "appropriate." Justice Ruth Bader Ginsburg said, "The word 'appropriate,' I think, is commonly used to indicate that the expert agency will do what it finds fit based on its expertise." Justice Sonia Sotomayor noted, "All we have to find is a plausible reading to uphold the EPA's interpretation."

Justice Elena Kagan commented that it is a stretch to say that silence on the part of Congress about cost means that consideration of cost is required. "Congress knows how to require consideration of costs. To get from silence to this notion of a requirement seems to be a pretty big jump," she said.

Lindstrom maintained that "agencies are supposed to not ignore an essential part of the problem as they engage in reasoned decision-making." He added, "I don't think [Congress] is silent when it tells the agency to look at all of the circumstances."

Justice Antonin Scalia weighed in: "I'm not even sure I agree with the premise that when

The Supreme Court

Congress says nothing about cost, the agency is entitled to disregard costs. I would think it is classic arbitrary and capricious agency action for an agency to command something that is outrageously expensive and in which the expense vastly exceeds whatever public benefit can be achieved." He added, "Sure, [EPA has] to consider the results of the study. It doesn't say they can't consider everything else. And the word 'appropriate' seems to suggest that they may consider other stuff."

Different Classes of Power Plants

Lawyers and justices also jousted over EPA's ability to establish different classes of power plants and regulate them differently.

Solicitor General Donald Verrilli Jr. pointed to a section of the CAA amendments that affirms the "Administrator's authority to establish subcategories under this section, as appropriate."

Verrilli said, "If there is such a vast difference in the technologies that the group of [power plant] entities is using that there would be a vast difference in cost, that might be a basis to treat them as a different subcategory."

Sotomayor said that minimum emissions standards "can vary dramatically depending upon how the categories and subcategories are set up" by EPA for various power plants.

Lindstrom rebutted, "Any subcategorization that was going to happen has already occurred, because we are talking about the rule that's been promulgated, and despite any subcategorization that happened, there is still $9.6 billion in costs that are being imposed on an annual basis."

Questions About Cost

Lawyer Paul Smith, representing industry respondents in support of EPA, said that his clients agree with the government that the EPA was not required to engage in a cost-benefit analysis before making the initial listing decision to regulate hazardous pollutants emitted by power plants.

He added that about 90% of the $9.6 billion capital cost to industry already has been spent and that the electric power industry has not experienced dramatic upheavals because of that expenditure. "The rule takes effect in the middle of April, and so the idea that the result here was somehow ludicrous or outlandishly expensive is belied by the fact that the industry is bringing itself into full compliance."

Scalia commented, "Instead of going to jail? Is that it?"

Smith reiterated that industry already has taken significant steps, "and the situation now is, we are ready to finally have national standards."

By **Randy Showstack,** Staff Writer

White House Submits Greenhouse Gas Emission Targets

The White House on 31 March formalized its goal to reduce U.S. greenhouse gas emissions by 26%–28% below 2005 levels by 2025, stating it would make "best efforts" to achieve a 28% reduction.

The target is included in a 31 March document submitted to the United Nations Framework Convention on Climate Change (UNFCCC) in advance of a climate summit in Paris, France, from 30 November to 11 December. The document, known as the Intended Nationally Determined Contribution (INDC), formalizes the U.S. target set last November in a joint announcement with China.

> "We can achieve this goal using laws that are already on the books," a White House adviser said.

More than 30 countries have submitted their climate action plans, including Russia, Mexico, Norway, Switzerland, and members of the European Union.

"According to UNFCCC, two-thirds of industrialized countries covering 65 percent of greenhouse gas emissions from the industrialized part of the world have now set out their ambition for the new [Paris climate change] agreement, which comes into effect in 2020," said UNFCCC executive secretary Christiana Figueres. "Many of these contributions also speak to longer-term aims representative of progressively increasing ambition over time." Figueres added that many more nations are expected to file their plans over the coming months.

The U.S. Emissions Target

"The U.S. target will roughly double the pace of carbon pollution reduction in the United States from 1.2 percent per year on average during the 2005–2020 period to 2.3–2.8 percent per year on average between 2020 and 2025," according to the White House. "This ambitious target is grounded in intensive analysis of cost-effective carbon pollution reductions achievable under existing law and will keep the United States on the pathway to achieve deep economy-wide reductions of 80 percent or more by 2050."

The White House stated in a note accompanying the UNFCCC submission that "substantial global emission reductions are needed to keep the global temperature rise below 2 degrees Celsius, and the 2025 target is consistent with a path to deep decarbonization."

The administration pointed to a list of laws and existing regulations that are relevant for implementing the target emission reductions. These include vehicle fuel economy standards and measures to address building sector emissions. The administration also cited as relevant several proposed regulations, including energy efficiency standards; standards for heavy-duty engines and vehicles; and the Clean Power Plan guidelines proposed by the U.S. Environmental Protection Agency (EPA) to cut carbon pollution from power plants (http://bit.ly/CPPEPA), which could be finalized by the summer.

An Ambitious and Achievable Goal

During a 31 March briefing, administration spokespeople noted the importance of the emission targets, underscored that combating climate change can go hand in hand with having a flourishing economy, and stressed the legal grounds to work to achieve the targets.

The UNFCCC submission "is ambitious and achievable within existing legal authority," White House senior adviser Brian Deese said. "Over the last 8 years, we in the United States have already cut carbon pollution more than any other country. By formalizing this goal, we are committing to build on that progress and to pick up the pace."

"We can achieve this goal using laws that are already on the books," Deese said. He added that the structure of the INDC "is grounded in an assessment of the potential to reduce emissions through our obligation under existing laws. Those are laws already passed by Congress and therefore no new legislation is necessary to realize the [emission] reductions we propose."

He said the Clean Power Plan "is an important component" of the administration's overall climate strategy. "We feel quite

Traffic and smog in Denver, Colo.

confident that the approach that EPA has laid out is not only consistent with long-standing legal authority under the [federal] Clean Air Act, but is also designed to provide states maximum flexibility to achieve [emission] targets."

Opposition to the Administration's Plan

Several prominent Republican senators castigated the White House emission targets. The administration's pledge to cut U.S. greenhouse gas emissions up to 28% "will not see the light of day with the 114th Congress," said Sen. Jim Inhofe (R-Okla.), chairman of the Senate Environment and Public Works Committee. "As the Obama administration continues to pursue a radical agenda on global warming, it's clear Americans are beginning to question if the cost of billions of dollars to our economy and tens of thousands of lost job opportunities is really worth it for potentially no gain."

"When a treaty comes before the Senate," Inhofe continued, "I fully expect for a majority of my colleagues to stand with the rest of Americans who want affordable energy and more economic opportunity, neither of which will be obtainable with the president's current climate deal."

Senate Majority Leader Mitch McConnell (R-Ky.) opposes EPA's Clean Power Plan to reduce carbon emissions from existing power plants, a key White House climate item. "Even if the job-killing and likely illegal Clean Power Plan were fully implemented, the United States could not meet the targets laid out in this proposed new plan," he stated. "Considering that two-thirds of the U.S. federal government hasn't even signed off on the Clean Power Plan and 13 states have already pledged to fight it, our international partners should proceed with caution before entering into a binding, unattainable deal."

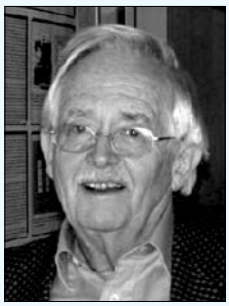
Support from Environmental Groups

Jennifer Morgan, global director for the World Resources Institute's Climate Change Program, stated that the U.S. proposal is "a serious and achievable commitment." Morgan said that "additional opportunities for deeper reductions will be increasingly available as technology trends make clean power and other low-carbon solutions more affordable. The United States' acknowledgement of the need for 'deep decarbonization' sends a positive signal."

"To win the fight against climate change, the world first needs to turn the corner on global greenhouse gas emissions, so that they stop rising and start falling," said Nathaniel Keohane, the Environmental Defense Fund's vice president for international climate. "Ultimately, the science is clear that the U.S. and other major emitters will need to do more to reduce emissions. The test for Paris is whether the emission reductions commitments that countries make are enough to ensure that the world makes that turn. The U.S. target, along with the pledges made by the EU, China, and others, means that for the first time we can see that turn happening."

By **Randy Showstack,** Staff Writer

Rolf Meissner (1925–2014)



Institute of Geosciences

Rolf Meissner

Rolf Meissner was one of the most influential Earth scientists in crustal and lithospheric research. He passed away on 4 June 2014, shortly before his 89th birthday.

Early Career

Rolf was born on 15 June 1925, in Dortmund, Germany, where he grew up and attended school, graduating from high school in 1943. After a period in the air force during World War II and a 3-year intermezzo as a musician after the war, Rolf studied meteorology and geophysics at the University of Frankfurt in Germany. He completed his Ph.D. in 1955 and then worked for 6 years managing a seismic surveying party and supervising a hydrocarbon exploration team in Europe and Africa.

Returning to academia in 1961, he became an assistant professor at the University of Frankfurt and completed a habilitation (postdoctoral university degree with lecturer qualification) on the structure of Earth's crust in 1966. In the following years, he worked as a lecturer at the universities of Mainz and Frankfurt.

> Rolf emphasized that the transfer of enthusiasm is as important as the transfer of knowledge to students studying science.

A Focus on the Moon

While he was a lecturer, Rolf wrote his first book, *The Moon*, a popular science review of the state of moon research before the Apollo program. The book was published in 1969, just before NASA's first Moon landing.

Rolf then became a visiting professor at the University of Hawai`i, where he worked on seismic data gathered by the first Apollo missions to the Moon. He belonged to the team that identified moonquakes. At this time, he was appointed professor of geophysics at the University of Kiel in Germany.

Leadership at Kiel

Rolf served as head of the Institute of Geophysics (now the Institute of Geosciences) at the University of Kiel from 1971 to 1995. By this stage of his career, he had developed pioneering concepts for investigating Earth's crust, was well rooted in the lunar research program of NASA, and was well known and highly respected within industry circles.

Through Rolf's leadership, the institute became internationally recognized as a leading science research facility. He succeeded in establishing geophysics in the educational program of the University of Kiel, covering an unprecedented breadth from near-surface prospecting to planetary science. His success was founded not only on his exceptional scientific capabilities and his international standing but also on his passion and enthusiasm for science, which he was able to share with his students, coworkers, and the scientific community at large.

Work on Deep Seismic Reflection

Many major national and international research programs that developed fundamentally new knowledge on the structure and evolution of the continents were initiated in the 1980s and 1990s. Many of these projects are closely tied, directly or indirectly, to Rolf's work.

The backbone of these projects was (and is) deep seismic reflection imaging. Since the late 1960s, Rolf had repeatedly demonstrated, in pilot projects and conceptual papers, that deep seismic reflection measurements were feasible and capable of providing a wealth of geological information. He developed integrative concepts for the interpretation of these measurements and underlined the importance of petrology and rheology for understanding the seismic data and the underlying geodynamic processes. In this context, he coined such terms as seismic lamellae and crocodile tectonics, which spread throughout the community.

Three of the numerous scientific projects in which Rolf was involved are worth noting. The German Continental Reflection Seismic Program (DEKORP) was the first project to investigate the deep structure and tectonics of the Variscan crystalline crust in high resolution and in a large-scale regional context in Germany. It led to a new understanding of basic deep geological processes. The Baltic and Bothnian Echoes of the Lithosphere (BABEL) project deciphered Caledonian-Proterozoic terrane tectonics and craton formation in the Baltic Sea area. Finally, the Chinese-American-German traverse through the Tibetan Plateau, called the joint International Deep Profiling of Tibet and the Himalaya/German Depth Profiling of Tibet and the Himalayas (INDEPTH/GEDEPTH) project, carried out deep seismic research of fundamental global importance. Rolf was heavily involved with INDEPTH/GEDEPTH even after his official retirement.

Writing Textbooks

Besides his numerous, frequently cited scientific articles, Rolf's textbooks also deserve mention. His *Praxis of Seismic Field Measurements and Interpretation*, coauthored by his friend Lajos Stegena and published in 1977 (in German), was the "seismic bible" for many generations of students. *The Continental Crust: A Geophysical Approach*, published in 1986, presented comprehensive knowledge on the continental crust and became internationally influential.

In 1999, Rolf published another popular science book, *The Little Book of Planet Earth*, which was translated into Chinese. Rolf's last scientific article, published with Irina Artemieva in late 2012, was a study of the relation of crustal thickness to plate tectonics.

Leadership and Honors

Rolf's scientific achievements were honored with many distinctions, two of which are especially worthy of mention. From 1985 to 1987, he was president of the European Geophysical Society, a predecessor of the European Geophysical Union. In this position, he promoted closer links between the American Geophysical Union and the European geoscience community.

In 1992, he was appointed honorary member of the German Geophysical Society. On this occasion, asked by a journalist for his life motto, Rolf quoted the German poet Goethe: "Tages Arbeit! Abends Gäste! Saure Wochen! Frohe Feste!" ("Daytime work! Evening guests! Hard weeks! Joyous feasts!")

A Passion for Teaching

In a speech at an honorary colloquium for his 80th birthday, Rolf emphasized that the transfer of enthusiasm is as important as the transfer of knowledge to students studying science. This philosophy, along with his scientific accomplishments, musical talent as a pianist and an accordion player, liberal thinking, humor, and charm, brought Rolf adoration from his students and from scientists around the world.

In memory of Rolf, an international scientific symposium—From Crustal Seismology to Geodynamics—will be held at the University of Kiel on 5–6 June 2015. It will highlight present and future concepts in lithospheric research. For details, visit the symposium's Web page (http://bit.ly/IfGMeissner).

By **Wolfgang Rabbel,** Institute of Geosciences, University of Kiel, Kiel, Germany; email:wrabbel@geophysik.uni-kiel.de

White House Science Fair Features Top Student Projects

U.S. president Barack Obama delivered an encouraging message to young scientists and a pointed message to Congress to support science in remarks at the fifth annual White House Science Fair on 23 March.

"Hello, scientists," said Obama to the students, from 6 years old and up, who had assembled in the East Room for the fair. The event featured 36 science projects.

Among the students was Sophia Sánchez-Maes, a 16-year-old from Las Cruces, N.M., who is having promising results with converting an extremophile algae into a renewable biofuel. She "is crazy about algae," Obama said about Sánchez-Maes. Other students featured at the science fair had sent an experiment to the International Space Station (ISS), developed a method to use agricultural waste to remove water pollutants, and experimented with construction materials that could make buildings more structurally sound to withstand earthquakes.

The student scientists and engineers "teach us something beyond the specific topics that they're exploring," Obama said. "They remind us that there's always something more to learn, and to try, and to discover, and to imagine—and that it's never too early or too late to create or discover something new."

> "It was such a transformative moment within my life to be able to say I got to this place."

Federal Commitment to Research

In his remarks, Obama focused on the need to increase the diversity of students in science, technology, engineering, and mathematics (STEM) programs. He also stressed that science needs support and funding. Innovative minds, he said, "are going to need the capacity to get research positions and fellowships and grants. And that, particularly when it comes to basic research, has typically been funded by the federal government. And my federal budget promotes a significant increase in the kinds of research that need to happen. Unfortunately, some of the budgets coming out of Congress don't make those same commitments."

"So it's not enough for us to just lift up young people and say, great job, way to go," Obama continued. "You also have to have labs to go to, and you've got to be able to support yourself while you're doing this amazing research. And that involves us as a society making the kind of investments that are going to be necessary for us to continue to innovate for many, many years to come."

In conjunction with the science fair, the White House announced a number of initiatives, including more than $240 million in private sector commitments to science education and new ways to engage students in citizen science efforts (see http://bit.ly/2015WHScienceFair).

Randy Showstack

President Obama speaks at the fifth annual White House Science Fair.

Student Projects

Among the student scientists were Kalista Ybarra, 12, and Madelyn Hickman, 11, from the Hobby Middle School in San Antonio, Texas, who shared their "Crystal Tetris" experiment. Designed to compare the growth of ice crystals onboard the ISS with that of crystals grown concurrently on Earth, the project was supposed to have been delivered to the space station on 28 October 2014. The original delivery rocket crashed, but the student project hitched a ride on a subsequent launch in January. The girls told *Eos* that they were glad the experiment made it to the ISS the second time.

NASA administrator Charles Bolden attended the science fair and met with a number of the students, including the Crystal Tetris team. "Talking to a group of kids that had actually flown something on the International Space Station already, to me, that is mind-boggling," he told *Eos*.

Bolden had three pieces of advice for children: Study hard, work hard, and don't be afraid of failure. The Crystal Tetris team members "epitomize the lack of any fear of failure. They faced failure and then picked themselves up and went back in again. And I think that's an incredible lesson."

A Transformative Moment

Sánchez-Maes told *Eos* she has "been into algae" for a long time. "Lots of efforts for biofuel revolve around corn, but I heard algae can produce 10 times as much without interfering with the agricultural supply," said Sánchez-Maes, who has been working to optimize the process.

About meeting President Obama, Sánchez-Maes said she was nervous and excited. "He was in the room next to mine talking to some Girl Scouts. And I was just jumping up and down quietly so I could get [my nerves] all out before he came in." She said that when she saw him enter the room, "I sombered up and got ready to keep my cool and focus on what was really important, just getting this information out." She said that the president is interested in renewable energy and asked a lot of good questions.

Sánchez-Maes brought her proud grandfather, Albert Sánchez of Las Cruces, with her to the White House. She recalled that when she was younger, she told her grandfather that she would take him to Washington, D. C., one day. "So when I finally got to call him up about 2 weeks ago and say, 'Hey, Grandpa, I'm taking you to D. C.,' it was such a transformative moment within my life to be able to say I got to this place."

By **Randy Showstack,** Staff Writer

Volatiles in Mars: Constraints, Questions, and Future Directions

Workshop on Volatiles in the Martian Interior
Houston, Texas, 3–4 November 2014

Scientists from diverse disciplines met in November 2014 at the Lunar and Planetary Institute (LPI) in Houston to discuss the state of knowledge of volatiles in the interior of Mars. Participants focused on studies of meteorites, observations from remote sensing, laboratory experimental investigations, in situ surface investigations, astrobiological implications, and geophysical and geochemical modeling.

The goals of the workshop were to examine the latest developments in the field; where data are lacking; and which observations, instruments, or experiments are needed to make progress on understanding the origin, roles, and evolution of volatiles in the interior of Mars. Ultimately, participants sought to synthesize knowledge from diverse scientific fields and focus the primary scientific questions that still need to be addressed.

The workshop sessions, organized by volatile components, focused on the current and ancient atmosphere, chlorine in the interior and interactions with a crustal reservoir, the amount of water in the interior and the effect of water on mantle melting, degassing of magmatic sulfur to the atmosphere, and carbon and the potential for habitability. The main approach used to understand the volatile content of Martian magmas, and thereby the interior, has been the study of Martian meteorites; the investigations discussed at the meeting focused on analyses of hydrous minerals (apatite and amphibole) in the meteorites and their bulk elemental and isotopic chemistry. Some presentations focused on cosmochemical constraints to understanding the Martian interior. Additional talks focused on laboratory experimental simulations, geophysical modeling, and remote sensing (orbiter and rover analyses) to understand the volatile content of the Martian interior and the roles volatiles played in the evolution of Mars.


Juliane Gross

Martian meteorite NWA 5789, packed with olivine crystals.

Workshop participants discussed three general processes that have determined the history and present state of volatiles in the Martian interior: accretion of volatile-bearing planetary material from the planetary nebula; catastrophic outgassing due to magma ocean solidification; and degassing by secondary volcanism, with trapping and release of volatiles by crustal processes potentially overprinting the primary information. Discussion focused on the differences among subclasses of Martian meteorites, between Martian meteorites and the chemistry and mineralogy of the surface, and between Mars and Earth.

> Which observations, instruments, or experiments are needed to make progress on understanding the origin, roles, and evolution of volatiles in the interior of Mars?

Some of the questions that arose from the meeting include the following: What is the concentration and heterogeneity of volatiles in the Martian mantle? How has degassing of the mantle through magma ocean crystallization and secondary basalt genesis depleted the volatile content of the mantle and contributed to an early greenhouse atmosphere? How has interaction with crustal and atmospheric fluids overprinted the volatile element and isotopic composition of the Martian meteorites? Participants agreed that to fully characterize the concentration and, importantly, heterogeneity of the volatile content of the Martian interior, it is vital to increase the diversity of the sample collection (in composition, age, petrologic classification, etc.) with meteorites, surface and orbital missions, and, eventually, sample return.

The workshop featured strong international participation, especially from Europe. LPI, the Universities Space Research Association, and NASA's Mars Exploration Program provided financial support. The Mars Exploration Program contributed travel grants to two graduate students.

By **Justin Filiberto,** Geology Department, Southern Illinois University, Carbondale; email: filiberto@siu.edu; **David Beaty,** Mars Program Office, Jet Propulsion Laboratory, California Institute of Technology, Pasadena; and **Walter Kiefer,** Lunar and Planetary Institute, Houston, Texas

Coastal Altimetry Challenges Our Understanding of Short Scales in the Ocean

8th Coastal Altimetry Workshop
Konstanz, Germany, 23–24 October 2014

Space-based observations of sea level, ocean dynamics, and sea state via radar altimetry are undergoing a revolution, thanks to the advent of technological improvements such as synthetic aperture radar (SAR) altimetry and to advances in methods to extract geophysical measurements from the raw radar data.

In the coastal zone those enhancements can bring large dividends, helping to elucidate the effects of changes in the oceans on the coastal environments. These applications include observations of coastal currents and the nearshore wave field, detection of storm surges, and monitoring of the rate of sea level rise at the coast. Scientists discussed technical advances and applications last fall at a workshop held in Konstanz, Germany.

Participants lauded how improvements in processing SAR (also known as delay-Doppler) altimetry echoes approach the instrumental precision limit expected from theory. This limit, finer than for conventional altimetry, is critical for coastal applications. Featured talks focused on CryoSat-2, which has pioneered the generation of SAR data and is a precursor to Sentinel-3, scheduled for launch in late 2015.

Other talks reported that Ka band (35-GHz) measurements from the Indo-French mission Satellite with Argos and AltiKa (SARAL) are of very good quality and are particularly suited to observing small-scale oceanic features in the coastal zone. Applications presented at the meeting showed where data on coastal currents and sea level, gleaned from altimetry, compared well with information from buoys, gauges, and high-frequency radars.

These improvements now challenge our understanding of how phenomena that occur on shorter scales influence the open oceans. Submesoscale features (sized at 1–10 kilometers) do not balance with the Coriolis effect, yet they account for a good share of the ocean mixing. Workshop participants agreed that these features need to be accurately characterized and modeled.

In addition, attendees found that experiments comparing high-resolution, high-precision altimetry with models are particularly relevant to broad research goals, such as the aims of the Global Ocean Data Assimilation Experiment (GODAE), and to the exploitation of future altimetry mapping missions, such as NASA's Surface Water and Ocean Topography (SWOT), planned for 2020.

> Participants lauded how data processed with new waveform models and improvements in processing SAR altimetry echoes approach the instrumental precision limit expected from theory.

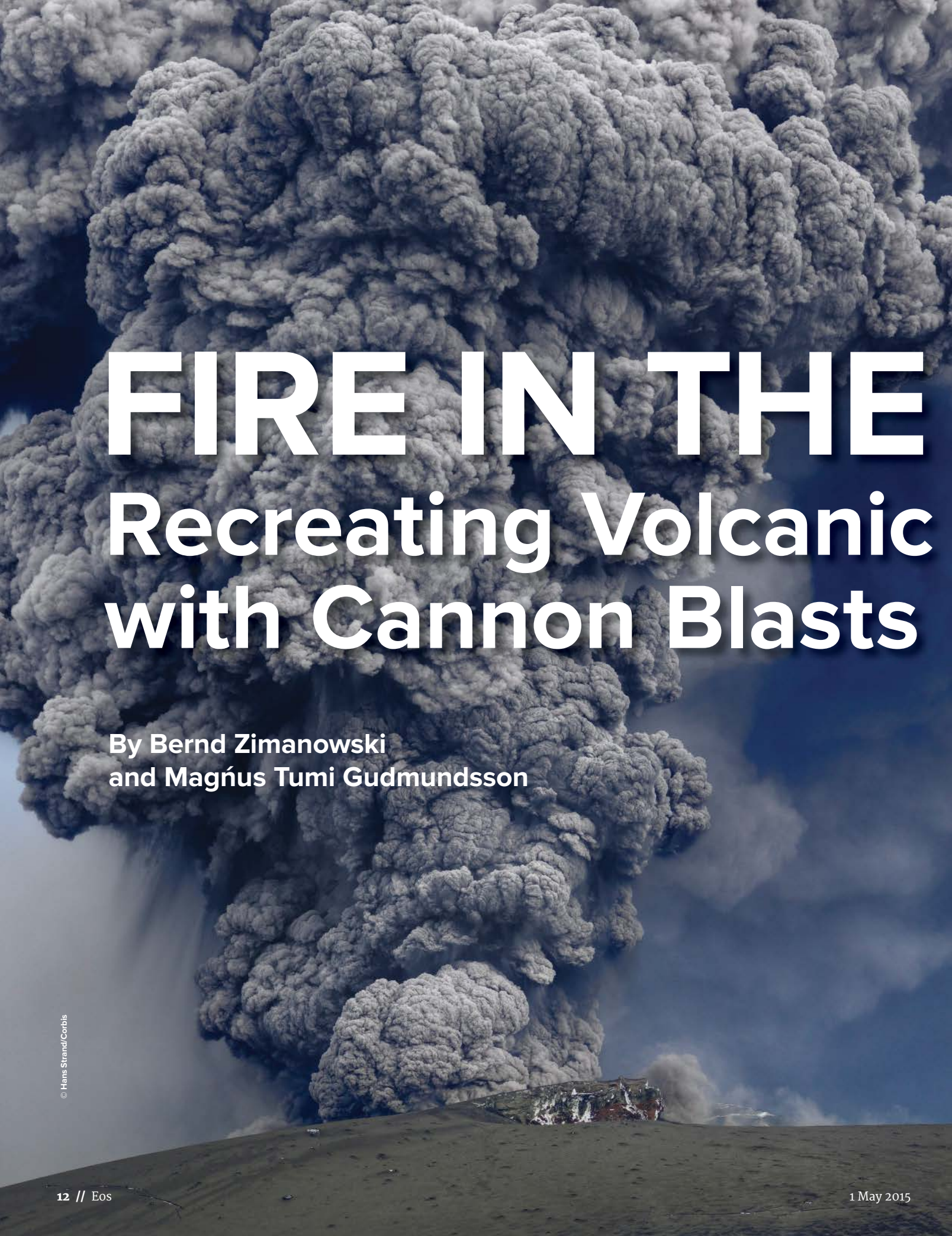
Finally, workshop participants agreed that a new generation of researchers needs to be educated to exploit SAR altimetry data sets. Promising initiatives include a training course organized by the European Space Agency before the workshop to help scientists understand the research potential of data from CryoSat-2 and Sentinel-3.

The 8th Coastal Altimetry Workshop, with 56 contributions and 80 participants from 19 countries, confirmed that this research community continues to incubate ideas that stimulate better exploitation of altimetry over the entire ocean. Participants noted that the coastal zone is a challenging test bed for new instruments, data retrieval techniques, and applications. Nonetheless, altimetry in the coastal zone has the potential to generate a wealth of data on how coastal environments continue to evolve as climate changes.

All the presentations from this workshop, as well as the previous ones in the Coastal Altimetry series, are available on the International Coastal Altimetry Community website (http://www.coastalt.eu/community). The workshop's training material can be found on the European Space Agency's coastal altimetry pages (http://www.coastalaltimetry.org).

By **Paolo Cipollini,** National Oceanography Centre, Southampton, UK; email: cipo@noc.ac.uk; **Stefano Vignudelli,** Consiglio Nazionale delle Ricerche, Pisa, Italy; and **Jérôme Benveniste,** European Space Agency, Frascati, Italy

An artist's impression of coastal altimetry observation featuring the soon-to-be launched Sentinel-3.



FIRE IN THE
Recreating Volcanic with Cannon Blasts

By Bernd Zimanowski
and Magńus Tumi Gudmundsson

HOLE Eruptions

As the volcano Eyjafjallajökull erupted from beneath the glacial ice cap of southern Iceland in April and May 2010, it burst through 200 meters of ice and spewed 270 million cubic meters of ash into the stratosphere. Thanks to an unusually stable jet stream, this moderate-sized eruption darkened the skies of Europe with glass-rich ash, grounding flights in one of history's biggest disruptions to air travel [*Gudmundsson et al.*, 2012].

The threat from such ash plumes has not gone away. A much stronger eruption of Grímsvötn volcano in 2011 raised the alarm again, but fortunately, the weather kept Europe's skies mostly clear.

The much larger effusive lava eruption in the vicinity of the ice-covered volcano Barðarbunga

Physikalisch Vulkanologisches Labor, Uni-Wuerzburg

lasted for 6 months (from September 2014 to February 2015). Scientists closely monitored the eruption for signs whether the volcanic fissure would migrate under a nearby ice cap, which would have turned it into a major explosive, ash-forming event. Fortunately this did not happen, but the area is still under close surveillance for possible renewed activity.

To address this threat, a new project is testing high-resolution ash monitoring systems in an unconventional way: by firing cannons packed with ash collected from the Eyjafjallajökull eruption and monitoring how the artificial ash clouds evolve over time.

Wanted: The Volcano's Mass Eruption Rate

Since October 2012, the European Union has funded the FUTUREVOLC project, charged with developing a comprehensive system to monitor future eruptions in Iceland. A main goal of this project involves better understanding the amount of ash such ice-bound volcanoes produce and push into the atmosphere per unit time—also known as the mass eruption rate.

A variety of ground-based instruments could be used to estimate mass eruption rates in explosive eruptions. However, they need better calibration to obtain reliable data that can fulfill scientific and operational needs.

The FUTUREVOLC consortium decided to use the well-documented 2010 eruption of Eyjafjallajökull as a case study for benchmarking purposes. Eruptions of this type typically eject ash in explosive pulses, merging into a continuous plume about 100 meters above the volcano [*Dellino et al.*, 2012]. The consortium posed the question, What if the rough dynamics of the eruption could be replicated on a small scale?

What if the rough dynamics of the eruption could be replicated on a small scale?

As part of the FUTREVOLC effort, scientists on the campus of Universität Würzburg in Germany have succeeded in doing just that in a remote area well apart from traffic and power lines.

The goal was to observe miniaturized volcanic blasts with known mass eruption rates and then observe details of artificial plumes to determine whether their properties could allow scientists to work backward to estimate these rates. If the mass eruption rate can be estimated this way, scientists can, in theory, quickly assess eruption patterns as the plume develops and potentially warn downwind communities of the amount of ash coming their way.

Fine Ash and Big Cannons

Scientists collected the ash for their experiments a few weeks after the Eyjafjallajökull eruption, a few kilometers

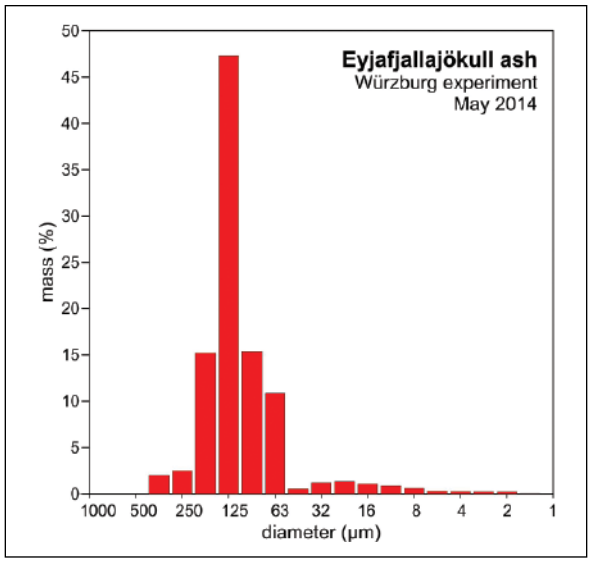


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Fig. 1. Grain size distribution of the ash used in the experiments.

to the east of the volcano's vents. Thus, the ash contains material from both of the main explosive phases of the eruption. The experiments only used particles smaller than 500 micrometers across. Thus, the grain size distribution of the ash used (Figure 1) was broadly similar to that sampled 20–60 kilometers away from the vents in the first explosive phase of the eruption (14–18 April 2010) [*Gudmundsson et al.*, 2012], making it more representative of the eruption clouds threatening aircraft.

A joint team from Universität Würzburg, Bari University in Italy, and the University of Iceland conducted the experiments at Universität Würzburg in May and August 2014. To recreate the explosive volcanic plumes, the team developed three specially designed gas impulse cannons. In each one, pressurized gas rushes through nozzles into a bed of ash particles at the bottom of a tube roughly 1.5 meters high. The tube serves as the artificial vent [see *Dellino et al.*, 2010].

FUTUREVOLC utilized a three-cannon setup (Figure 1). Each cannon was charged with 5 kilograms of ash, of which about 3.2 kilograms went into the plumes, which rose as high as 20 meters.

In the first runs, all three guns fired simultaneously, creating the first volcanic ash plume ever seen in Bavaria. Then, the guns were fired with equal time intervals between the shots to represent the explosive pulses seen during the 2010 eruption [*Dürig et al.*, 2014]. Finally, the amount of ash was varied to simulate different mass eruption rates.

Monitoring the "Eruptions"

Several research groups from across Europe monitored the eruptions, each using various methods [e.g., *Mather and Harrison*, 2006; *Prata and Bernardo*, 2009; *Vöge and Hort*, 2009; *Ripepe et al.*, 2013]. Some used high-resolution cameras, with a few operating in the infrared or at very high frame rates. Some also included Doppler radar, acoustic measurements from microphones detecting rumbling frequencies lower than humans can hear, and measurements of the plumes' electric field. By running

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Fig. 2. Getting ready for the first experimental run: Scientists check the impulse cannons (left side in the foreground). An electrical field sensor is prepared by the team from the UK Met Office and National Centre for Atmospheric Science (right side in the background).

these systems simultaneously, the teams were able to test and intercalibrate them so that measurements of the next explosive eruption in Iceland will be more accurate.

The teams also came away from the collaboration with a better understanding of the methodologies and technical aspects of each other's techniques. The consortium created a joint database of the results and presented the results obtained from individual sensors in a joint workshop immediately following the experiments.

Scientists are now poring over the data to see if they can tease out any patterns from the plumes that hint at the known mass eruption rates. If they succeed, they could help improve real-time observations of mass eruption rates and provide much better predictions of how volcanic plumes rise and disperse. Both may help reduce the disruption to air travel the next time an Icelandic volcano pumps ash into the skies over Europe.

Acknowledgments

This work was conducted by the FUTUREVOLC project (http://futurevolc.hi.is), partly funded by the European Union under the Seventh Framework Programme for Research and Technological Development. Specific groups at various institutions conducted monitoring experiments. These include Norway's Nicarnica Aviation, which worked with high-resolution infrared cameras; the National Centre for Atmospheric Science at the United Kingdom's University of Leeds, the UK Met Office, and Physikalisch Vulkanologisches Labor at Universität Würzburg, which conducted electrical field measurements and used high-speed cameras; the Institut für Geophysik at Germany's Universität Hamburg, which worked with Doppler radar; the Dipartimento di Scienze della Terra at Italy's Universitá di Firenze and the Departement de Sciences de la Terre at Switzerland's Université Geneve, which deployed a small infrasound array as well as high-speed cameras; and Germany's Geoforschungszentrum Potsdam, which took optical density measurements and observed with high-speed cameras.

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Why Does the Aurora Flare Up?

By Syun-Ichi Akasofu

The spectacular auroras that circle Earth's geomagnetic poles and burst with colorful displays during geomagnetic storms have mystified humanity for millennia. Now scientists are uncovering their secrets.

The aurora is one of the most magnificent natural phenomena on Earth. Many early polar explorers described its beauty, or attempted to. "I have no words in which to convey any adequate idea of the beauty and splendor of the scene," wrote one participant in the First Polar Year, the international exploration campaign of 1882–1883. "It was a continuous change from arch to streamers, from streamers to patches and ribbons, and back again to arches" [*Greely*, 1894, p. 139].

Viewed from space during intense geomagnetic storms as Earth suffers an onslaught of particles from solar eruptions, this wonder is an explosive, widespread event, during which violent movements

spread rapidly from the midnight sector along a belt that surrounds the geomagnetic pole. Such activity, called an auroral substorm, occurs several times during a geomagnetic storm [*Akasofu,* 1964] (Figure 1).

The most spectacular part of these displays happens during the expansion phase, which lasts for, at most, 1 hour of the 3–4 hours of a substorm's average duration. The expansion phase is preceded by a mysterious delay during which Earth's magnetic field begins to respond to the gathering storm but displays little auroral activity—the so-called growth phase.

What drives this expansion phase? The question has long perplexed auroral scientists, and remains one of the most challenging issues in space physics.

The Aurora: Electrical Currents on a Circuit

Using a great variety of ground- and satellite-based observations and computer simulations, space physicists have made great progress in understanding the aurora. Scientists can now think about the aurora in terms of electrical discharge, with currents flowing through the magnetosphere, the region of space dominated by Earth's magnetic field. Viewing auroras as the product of electric currents on a circuit allows scientists to understand and thus describe the physics of substorms [*Alfven*, 1967, 1977, 1986].

Specifically, the solar wind (streams of plasma from the Sun) generates a dynamo, which acts as a power supply. Auroral substorms are how the magnetosphere dissipates that energy, directing it downward to the ionosphere, where current-carrying electrons collide with atmospheric atoms and molecules and make them glow.

However, crucial questions still remain unanswered about the physics of auroral substorms and the specific mechanisms that drive them. Most controversial of all is the issue of where this energy is stored and how it is converted.

What Powers Auroral Substorms?

The solar wind blows across the boundary of the magnetosphere, called the magnetopause, where the interplanetary magnetic field (IMF) and Earth's magnetic field merge. As it blows across this merged magnetic field, it induces an electric current, converting the kinetic energy of the solar wind to electric power. This creates the so-called solar wind–magnetosphere dynamo (S-M dynamo). When the intensity of the southward oriented component of the IMF is large and the solar wind blows more strongly, the power increases.

When the power becomes strong enough (at about 10^{11} watts, roughly equivalent to the total power of the thousand largest power plants in the world), the Earth's magnetosphere responds. The voltage across the boundary of the magnetosphere rises to 100 kilovolts or more, creating an electric current in the magnetosphere-ionosphere coupling system. This current, called the directly driven (DD) current, grows and decays along with the S-M dynamo that drives it (Figure 2).

Active auroral displays (the expansion phase) begin about 1 hour after the S-M power is increased. This delay occurs because, although the ionosphere is the main sink of auroral energies, the ionization and conductivity are too low to dissipate the power as heat before expansion onset. Therefore, the magnetosphere accumulates the increasing power produced by the S-M dynamo

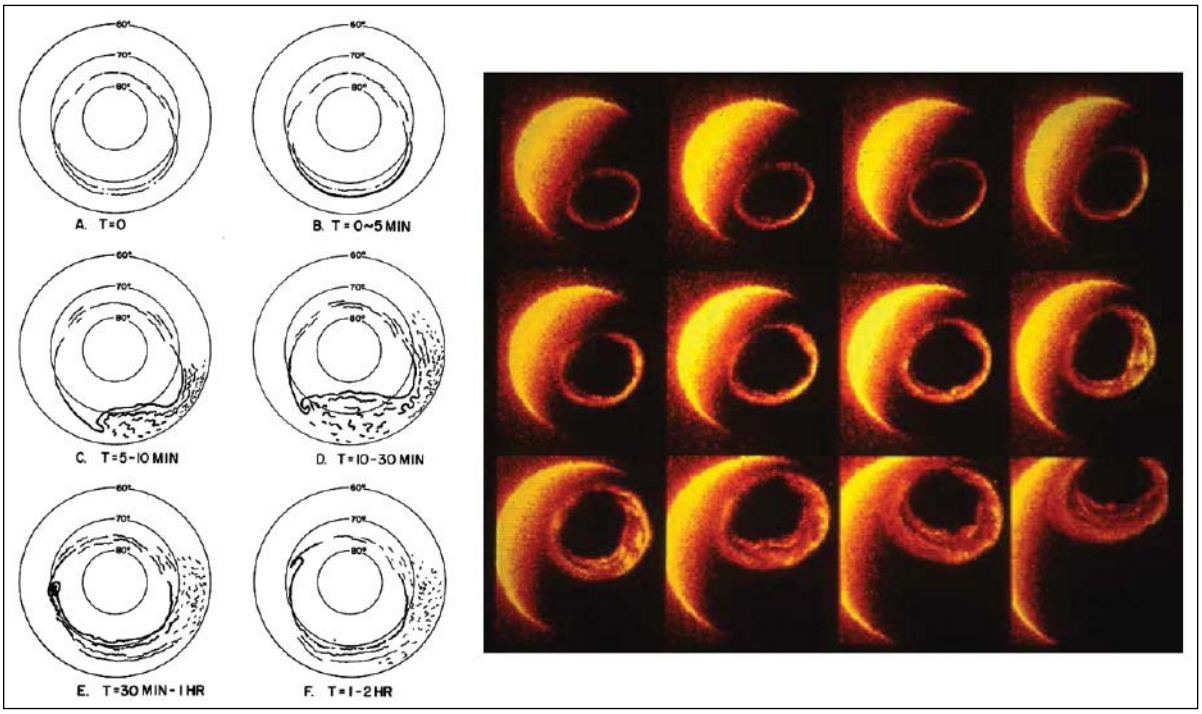

Fig. 1. (left) The development of the auroral substorm during the expansion and recovery phases is shown schematically. From Akasofu *[1964]. (right) The first series of global images of an auroral substorm observed by the Dynamics Explorer satellite. From* Frank et al. *[1982].*

during the growth phase until a threshold is reached, which sets off auroral displays.

A Tale of Two Buckets

At this threshold, the growth phase ends and the expansion phase begins. The expansion phase is triggered by the spontaneous formation of an unloading (UL) current system [*Bostrom*, 1964], which develops in the coupled magnetosphere–ionosphere and lasts for only about 1 hour (as shown in the two good examples of Figure 2). This current drives most auroral phenomena in the polar region during the expansion phase.

However, unlike the DD current, the UL current cannot simply be explained by an increase in S-M dynamo power. At its strongest, the UL current can be larger than the DD current peak. This is because the energy used in the expansion phase was previously stored up throughout the growth phase and then unloaded through auroral displays.

Therefore, a process other than the S-M dynamo must generate the UL current. If the magnetosphere is like a bucket with a spout that steadily overflows when overfilled (corresponding to the DD current), the UL current is like a "tippy bucket" that dumps all of its energy at once, thus powering the expansion phase. These facts have long been speculated on and suggested by many researchers, but they are now quantitatively understood [*Akasofu*, 2013].

How Much Energy Can the Magnetosphere Store—and Where?

Scientists now have a good understanding of some aspects of the UL's bucket of energy—namely, its total capacity and the rate at which it empties (and powers the auroral substorm). The total heat production is estimated to be up to 10^{16} joules, which is dissipated at a rate of about 5×10^{11} watts during the expansion phase.

This dissipation rate is crucial in understanding substorms, because it relates to the question of how much energy the magnetosphere can hold when it acquires excess energy from the solar wind—that is, how much energy the tippy bucket can store before it tips over.

What is unclear—and very controversial—is where the magnetosphere can stably store as much as 10^{16} joules.

Scientists have long thought that magnetic energy is accumulated mainly in the region of the magnetotail, where solar wind drags the magnetopause back into a comet-like shape on the Earth's nightside across the equatorial plane. There, the magnetic field lines are nearly parallel, but half of them are oppositely oriented across the equatorial plane. Many researchers believe that these lines can cross at a certain point in the tail and reconnect, releasing a large amount of magnetic energy in the process, which shoots plasma toward Earth.

However, there are crucial questions about that premise. The first is whether or not the magnetotail within a distance of 10–20 Earth radii (R_E) has enough magnetic energy to power a substorm. Although magnetic reconnection has been observed at a distance of within 20 R_E [*Angelopoulos et al.*, 2008], it can be shown that even the total magnetic energy there is insufficient

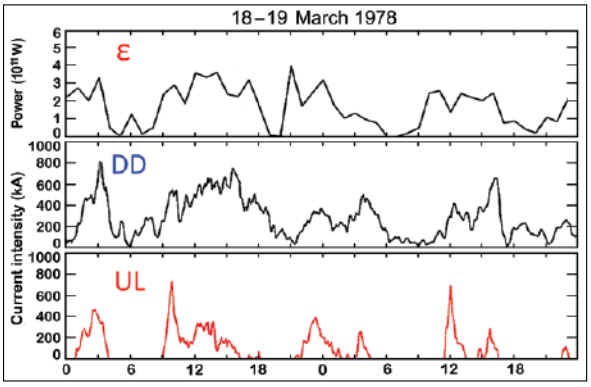

Fig. 2. (top) The solar wind–magnetosphere dynamo power (ε), (middle) the directly driven (DD) currents, and (bottom) the unloading (UL) currents are shown over the course of 48 hours (2 days). Note that although both ε and DD vary in a similar way, unlike DD, UL variations are impulsive during two typical substorms. Modified from Sun et al. *[1998].*

for a single substorm [*Akasofu*, 2013]. Further, observations of the bursty flows of plasma are inconclusive in terms of their duration and the amount of energy they carry for individual substorms; they may trigger some substorms when other conditions make the magnetosphere ready.

Second, the tail-wide flows predicted by magnetic reconnection can explain the DD current, but not the UL current—which, as mentioned above, is necessary for electrical discharge processes associated with the expansion phase. This is a critical requirement for considering the magnetic energy conversion.

Where Else Could the Energy Be?

If the magnetotail does not have sufficient magnetic energy for the expansion phase, scientists might consider the main body of the magnetosphere (within 10 R_E) as a potential storage place. This is because the stronger any ambient magnetic field is, the more it can hold magnetic energy. Thus, the main body of the magnetosphere could potentially store excess amounts of energy.

In the past, such a proposal seemed unthinkable. The field lines in the main body of the magnetosphere are not like those in the magnetotail, and thus, magnetic reconnection is rare [*Ge and Russell*, 2006]. In fact, it is likely that the main body may not even be able to store more than 10^{16} joules; the magnetosphere may become unstable before the stored energy reaches this threshold. Indeed, this instability may be the cause of substorms. Thus, if magnetic energy conversion takes place chiefly in the main body of the magnetosphere, a whole new theory of the conversion process of stored magnetic energy is necessary.

One possibility is that deflation processes (as a result of the unloading) of the main body of the magnetosphere, which inflated during the growth phase, might cause charge separation. Electrons tightly bound around the contracting magnetic field lines shift earthward, but not protons (thus not plasma as a whole), generating an earthward electric field.

Deflation processes (as a result of unloading) of the main body of the magnetosphere, which inflated during the growth phase, might cause charge separation.

This field, however it is created, is needed to generate the UL current [*Lui and Kamide*, 2003]. Such a hypothetical charge separation process is called the "thawing" (or breakdown) of "frozen-in field lines" predicted by *Alfven* [1977]. In theory, this process could produce an earthward electric field of 10 millivolts per meter.

One crucial satellite observation at a distance of 8.1 R_E may support the idea of deflation. The satellite observed a sudden current reduction in the UL (unloading the stored energy), plasma instabilities, and an earthward electric field of as high as 20 millivolts per meter (together with the breakdown of the frozen-in field lines condition), all simultaneous with an onset of the expansion phase [*Lui*, 2011].

Correction

In the 1 April 2015 issue of *Eos* magazine, part b of Figure 1 was misprinted in the article "A Suite of Software Analyzes Data on the Sphere" by C. Harig, K. W. Lewis, A. Plattner, and F. J. Simons. The correct figure is shown below.

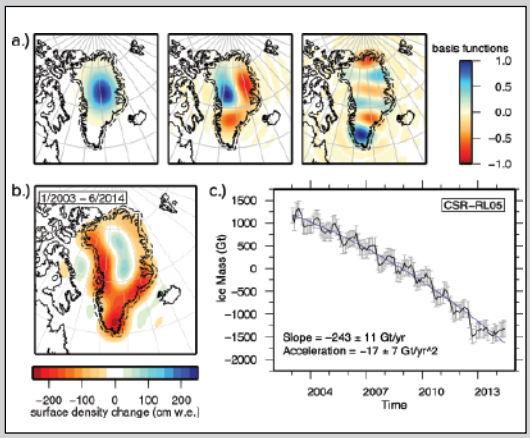

Fig. 1. (a) Three Slepian functions for the dashed region around Greenland, complete to spherical harmonic degree and order 60. Each of the mathematical functions (shown from left to right are the first, fifth, and ninth functions from the complete set) is a "template" map pattern for the ice mass loss that we recover from the data. The full set of 20 such functions, with the proper weightings derived from the data, yields the modeled ice mass loss pattern shown in Figure 1b. (b) Greenland's total ice mass change from Gravity Recovery and Climate Experiment (GRACE) data collected between January 2003 and June 2014, in centimeters of water equivalent per meter squared. The total mass loss integrated over the region for this time period is 2412 gigatons. (c) Greenland's ice mass loss, shown in monthly continent-wide averages over the past decade, in gigatons. Error bars show plus and minus twice the standard deviation and the best fit quadratic function that describes the accelerating behavior.

The Next Question to Ponder

During the last 50 years, through a great variety of approaches, we have learned much about how the solar wind–magnetosphere–ionosphere system can generate auroral substorms. In addressing the question of why the aurora flares up, a more focused question arises: How can the accumulated magnetic energy get unloaded such that it generates the earthward electric fields needed to produce auroras?

Acknowledgments

The author thanks all the magnetospheric physicists of the past and present for their efforts toward great progress in substorm research over the last 50 years. The joint 30-year effort by Y. Kamide, Sun Wei, B.-H. Ahn, A. T. Y. Lui, and C.-I. Meng is crystallized in Figure 2. The author would also like to dedicate this article to the late Lou Frank in honor of the successful imaging of auroral substorms.

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Editor's Note: In the printed 1 May issue of Eos *magazine, a formatting error caused numbers that should have been represented in scientific notation not to have superscripts. The numbers in this pdf have been corrected from the printed version.*

AGU Sections and Focus Groups Announce 2014 Awardees

Mariotti Receives 2014 Luna B. Leopold Young Scientist Award

Giulio Mariotti received the 2014 Luna B. Leopold Young Scientist Award at the 2014 AGU Fall Meeting, held 15–19 December in San Francisco, Calif. The award recognizes "a young scientist for making a significant and outstanding contribution that advances the field of Earth and planetary surface processes."

Giulio Mariotti

Citation

We are pleased to honor Giulio Mariotti with the Luna B. Leopold Young Scientist Award for groundbreaking experimental and theoretical work at the intersection of physical and biotic processes in coastal landscapes. Giulio is a geomorphologist who applies his considerable quantitative and observational skills to improve our understanding of Earth surface processes. While keeping a firm grasp on the detailed fluid and sediment dynamics of coastal systems, Giulio has been able to step back from the details and consider how best to pare a problem down to the simplest possible representations and/or observations to get at the underlying system controls and responses.

Through work in the field, the lab, and numerical modeling, Giulio has provided key insights into the interactions of coastal hydrodynamics, morphodynamics, and ecological processes. For example, with a simple dynamic model Giulio showed the existence of a threshold width for tidal flats bordering salt marshes. Once this threshold is exceeded, irreversible marsh erosion takes place even in the absence of sea level rise. He also determined through a series of laboratory experiments how wrinkle structures in siliciclastic deposits can be microbially induced, shedding light on the feedbacks between flow, sediment motion, and microbial growth.

Giulio's creativity, quantitative skills, and productivity place him in the very top tier of young scientists in Earth and planetary surface processes who have followed in the footsteps of Luna Leopold.

—P. L. Wiberg, *University of Virginia, Charlottesville*

Response

I would like to thank the Earth and Planetary Surface Processes focus group for this award and for the trust they put in my capabilities. My academic achievements were made possible by my adviser, Sergio Fagherazzi, who distilled in me the art of observing processes and landforms in the field and translating them into mathematical models. I am also in debt to Taylor Perron and Tanja Bosak, who followed me during my off-the-beaten-path adventure in experimental microbial sedimentology.

I confess that when I started working on ecogeomorphology, I thought about biotic processes as an obstacle to the quantitative understanding of geomorphology. This was the view of a freshly graduated engineering student, with a lot of mathematical tools in his bag but with a quite narrow vision of nature. Luckily, interactions with scientists from different backgrounds—biologists, ecologists, paleontologists, and biochemists—taught me to look at life not as an inconvenience, but rather as an opportunity to give purpose to my geomorphology-based research. Such a change of view led my interest toward questions about the origin and evolution of life and the functioning and fate of modern coastal ecosystems.

There are plenty of biotic-driven questions relevant to society that can be addressed using the tools of geomorphology. My wish is to continue along this road, working with old and new colleagues who are the true catalysts for my work. Thanks to all of you.

—G. Mariotti, *Massachusetts Institute of Technology, Cambridge*

Parker Receives 2014 G. K. Gilbert Award

Gary Parker received the 2014 G. K. Gilbert Award at the 2014 AGU Fall Meeting, held 15–19 December in San Francisco, Calif. The award recognizes "a scientist who has either made a single significant advance or sustained significant contributions to the field of Earth and planetary surface processes, and who has in addition promoted an environment of unselfish cooperation in research and the inclusion of young scientists into the field."

Gary Parker

Citation

"For visionary research on Earth surface processes, advancing the fields of sediment transport and morphodynamics and inspiring a generation of Earth surface scientists."

—Marcelo H. Garcia, *University of Illinois at Urbana-Champaign, Urbana*

Response

I express my deep thanks to those who supported me in regard to the G. K. Gilbert Award. They are but a subset of a world of fascinating colleagues with whom I have coevolved over my career. The collective phenomena of subaerial and submarine morphodynamics remain irresistibly appealing to me. After all, are there many more beautiful things than a meandering or braided stream, animated using Google Engine? I want to see progress. I want to know more. I want to leave the scene knowing that more progress will be made. Maybe I can continue to contribute by the Method of Inadvertently Littering the Literature with Mistakes. See, he's wrong again! (Well, I thought I was right at the time…) And may we get closer and closer in our rationality to that which strums so hard on our strings of spiritual aesthetics.

—Gary Parker, *University of Illinois at Urbana-Champaign, Urbana*

Bruyninx Receives 2014 Ivan I. Mueller Award for Service and Leadership

Carine Bruyninx received the 2014 Ivan I. Mueller Award for Service and Leadership at the 2014 AGU Fall Meeting, held 15–19 December in San Francisco, Calif. The award recognizes "major achievements in service and/or leadership to the geodesy community."

Carine Bruyninx

Citation

The Ivan I. Mueller Award for Distinguished Service and Leadership recognizes major achievements in service to and leadership of the geodesy community that go beyond scientific and research contributions. Inspired by the role model of Ivan I. Mueller, an American Geophysical Union (AGU) Fellow and Waldo E. Smith Medalist, the award is intended to recognize a body of work that enhances the visibility of geodesy within AGU as well as within the international associated bodies.

We are honored to be invited to write the citation for this year's recipient of the award, our distinguished colleague Carine Bruyninx of the Royal Observatory of Belgium. Carine was chosen by the international geodetic community to take on the role of network coordinator of the Reference Frame Sub-Commission for Europe (EUREF) Permanent Network (EPN) in 1996. She is broadly recognized for her vision in transforming Global Navigation Satellite System (GNSS) networks for scientific applications. Today, she continues her tireless and skillful service as head of the EPN Central Bureau. By employing rigorous scientific principles, Carine has shown the world how one can develop and actively stimulate the use of common guidelines in a GNSS network

involving more than 30 countries. In large part owing to Carine's efforts, the EPN became a shining example for other networks to follow, and a preeminent pillar in the International GNSS Service (IGS), which has its roots in the vision and leadership of Ivan I. Mueller. The community recognizes Carine's dedicated service to geodesy through her appointment to the IGS Governing Board, and to other leadership roles within the International Association of Geodesy.

To quote one of the supporting letters, "Dr. Bruyninx has played a major role in enabling and promoting the GNSS transformation. In so doing, she has exemplified *par excellence all the qualities of leadership and service that the Mueller Award is intended to recognize.*"

—Geoff Blewitt, *University of Nevada, Reno;* **Véronique Dehant,** *Royal Observatory of Belgium, Brussels, Belgium; and* **Zuheir Altamimi,** *Institut Géographique National, Paris, France*

Response

Thank you for your kind words. I am extremely honored to receive this award and would like to thank all of those involved in the process.

After finishing my studies in astrophysics at the University of Leuven, faith drove me in the direction of GPS when I was hired at the Royal Observatory of Belgium (ROB) to "integrate Belgium in international terrestrial reference frames." We installed permanent GPS stations and integrated one of them in the International GPS (now GNSS) Service (IGS). I started to attend the meetings of the International Association of Geodesy subcommission for the European Reference frame (EUREF), and when EUREF decided to set up a regional densification of the IGS, I was asked, at the end of 1995, to become the network coordinator. Without fully realizing the consequences, I answered positively. Since that time, my team and I have been responsible for the daily management of the EUREF Permanent Network (EPN). This position has given me the opportunity to interact with a lot of colleagues, to learn from them, and to have interesting discussions on how to upgrade the EPN in response to evolving technological developments, such as real-time data streaming, multi-GNSS, and individual antenna calibrations while maintaining reliable station metadata (my battle horse for many years). I am fortunate to have worked with numerous colleagues over the years. I would like especially to thank the former director of ROB, Professor P. Pâquet, my mentor in the early years, who will always have my full respect. The discussions with the members of the EUREF Technical Working Group, with whom I've worked closely together for 2 decades, were constructive and challenging. Finally, I would like to thank my colleagues within the GNSS research group at ROB: we complement each other, and it is a joy every day again to work with each of you.

—Carine Bruyninx, *Royal Observatory of Belgium, Brussels*

Swanson-Hysell Receives 2014 William Gilbert Award

Nicholas Swanson-Hysell received the 2014 William Gilbert Award at the 2014 AGU Fall Meeting, held 15–19 December in San Francisco, Calif. The award recognizes outstanding and unselfish work in magnetism of Earth materials and of the Earth and planets.

Nicholas Swanson-Hysell

Citation

I take a lot of pleasure in presenting Nicholas Swanson-Hysell with the 2014 William Gilbert Award for his impactful, rigorous, and original research in paleomagnetism and its applications to tectonics, paleoclimate, and fundamental rock magnetic studies.

Nick's dissertation work revisited the basalts of the North American Midcontinent Rift, which were long thought to show evidence of asymmetric reversals. Through meticulous field mapping, Nick was able to place the reversal history within a detailed stratigraphic context and showed that Laurentia was moving rapidly southward toward the equator during the rifting process and that each successive reversal within the sequence was largely symmetric, thereby resolving a decades-old mystery and demonstrating that the geocentric axial dipole (GAD) hypothesis could be extended back in time 1.1 billion years.

Since his Ph.D., Nick has leveraged an incredible scientific tool set that includes rock and paleomagnetism, isotope geochemistry, and sedimentology and stratigraphy to make similarly major contributions to paleogeographic studies, paleoclimatology, impact magnetization, and pure fundamental rock magnetism. This unusual combination of geophysical and geochemical research skills has allowed Nick to improve our understanding of major events in Earth history ranging from Neoproterozoic glaciations to the Paleocene–Eocene Thermal Maximum.

The thing about Nick that stands out to all who work with him is his generosity of spirit. Whether he's helping teach the Summer School in Rock Magnetism at the Institute for Rock Magnetism or contributing to the PmagPy code that is the foundation for the MagIC database, Nick makes a genuine effort to give back to our community. In short, he's an inspiring fellow to be around, and in a field where there are always fewer honors than people who deserve them, I am exceptionally happy that we can recognize Nick's past and future scientific work with the William Gilbert Award.

—Joshua M. Feinberg, *University of Minnesota, Twin Cities, Minneapolis*

Response

I am truly honored to have been chosen to receive the 2014 William Gilbert Award from the American Geophysical Union (AGU). As an early career scientist, I have received so much mentorship and intellectual invigoration from the members of the Geomagnetism and Paleomagnetism section of the Union. It is with great thanks that I accept this recognition from them.

I got started on this path as an undergraduate due to the mentorship of Dave Bice, who sent me off to the North American Midcontinent Rift to obtain samples for a tectonics course at Carleton College. Guided by Mike Jackson, I made my first measurements on a magnetometer at the Institute for Rock Magnetism (IRM). These measurements revealed the asymmetric normal and reversed directions that Josh wrote of above. As I soon discovered in the literature, I had stumbled upon the problem of Keweenawan reversal asymmetry. Around this time, Adam Maloof came through Carleton to give a talk. He had been thinking about ways to more firmly constrain the magnitude of the asymmetry. Talking about the problem with Adam led me to begin geologic and paleomagnetic inquiry as a graduate student at Princeton, where I benefited immeasurably from his mentorship. That period revealed to me the true generosity of this community as I conducted appreciable lab work during my Ph.D. research in five different paleomagnetism labs. I am deeply grateful to Dave Evans, Joe Kirschvink, Ben Weiss, Dennis Kent, and their students for welcoming me into their labs, enabling the collection of data, and providing mentorship and inspiration.

My time during graduate school as an informal visitor and visiting fellow at the IRM further opened my eyes to rock magnetism. Josh Feinberg and Mike Jackson were unfailingly generous with their time and expertise in helping me craft ways to get at some particularly vexing rock magnetic puzzles. I feel very lucky to have gotten the opportunity to be at the IRM as a National Science Foundation postdoctoral fellow, where interactions with members of the IRM, including Bruce Moskowitz, Julie Bowles, Peat Solheid, and others, as well as the many visiting fellows, made for a quite stimulating environment. And now I have the good fortune of being a part of the geomagnetism and paleomagnetism (GP) community here at the University of California, where I have particularly benefited from recent interactions with Rob Coe and Lisa Tauxe. Lisa's open source approach to sharing knowledge, expertise, and software has been inspirational.

Again, thank you to the GP community and AGU for this recognition and for the support you all have given to me and other young scientists.

—Nicholas L. Swanson-Hysell, *University of California, Berkeley*

Visit http://eos.org/agu-news to read more announcements of AGU section and focus group awards.

Manzoni Receives 2014 Early Career Hydrologic Science Award

Stefano Manzoni received the 2014 Early Career Hydrologic Science Award at the 2014 AGU Fall Meeting, held 15–19 December in San Francisco, Calif. The award is for significant early career contributions to hydrologic science.

Stefano Manzoni

Citation

I am thrilled to announce Stefano Manzoni as the successful recipient of the 2014 American Geophysical Union (AGU) Early Career Hydrologic Science Award for developing new theories of soil water–biota interactions that unfolded the role of soil moisture fluctuations on plant-microbial structure and function. I have known Stefano since he first arrived at Duke University from Polytechnic of Turin (Italy) in 2003 while working as an undergraduate researcher with Professor Amilcare Porporato. Stefano's Ph.D. work with Amilcare Porporato began in 2004 with a focus on the coupled water/carbon and nutrient cycling in soils. Stefano presented his first results from global-scale litter decomposition data sets that suggest terrestrial decomposers may react to nutrient shortage by respiring more, a response accurately predicted by his stoichiometric theories for these systems. These results appeared in *Science* the same day Stefano defended his Ph.D. dissertation.

My own interactions with Stefano commenced when he initiated work on stomatal optimality theory that successfully described leaf gas exchange under different environmental conditions, including highly intermittent light and leaf nitrogen levels. This is the first major theory that bridges water use strategy to stomatal movement in response to its immediate environment. It is quite likely that this theory will be eminently employed in large-scale climate models, where greening of the biosphere continues to resist complete theoretical treatment.

More broadly, Stefano's research style combines rigor, generality, completeness, and simplicity in ways never attempted before in this interdisciplinary field. He is able to "digest" cutting-edge knowledge from soil science, hydrology, ecology, plant physiology, atmospheric sciences, dynamical systems theory, and stochastic processes so as to provide a comprehensive view of water-material cycling in ecosystems. All his letter writers agree that he should be awarded the Early Career Hydrologic Science Award for moving ecohydrology from its empirical roots to a field that accommodates many of its spatiotemporal dimensions, thereby allowing this field to address pressing societal problems.

—Gabriel Katul, *Duke University, Durham, N.C.*

Response

Thank you, Gaby, for your kind words. I am deeply honored to be here and receive the Early Career Hydrologic Science Award, and I would like to thank AGU, the Hydrology section, and Eric Wood for this recognition. Sometimes I think back to the moment that set in motion the personal and professional trajectory that led me here today. As is often the case, it all started with a simple yes.

I was finishing my master's at Polytechnic of Turin, and looking for a thesis supervisor, I knocked on Amilcare Porporato's office door. His answer was positive, but he was moving to Duke University and asked me if I would join him. So I finished my thesis at Duke, thinking that a thesis abroad would not change my life, but it did. I started my Ph.D. with Amilcare, and since then, he has been an adviser, a mentor, and a role model. His contagious enthusiasm, independent way of thinking, and effortless jumping across disciplinary boundaries have all contributed to shaping me as a researcher as well as a person.

While at Duke University, I was fortunate to meet Gabriel Katul. He has been a generous and ever-present supervisor, mentor, and friend. Gaby's approach is inspiringly pragmatic and focused toward sharply defined objectives—an approach that left a strong mark in my contribution to the field of ecohydrology.

Many other colleagues always supported and encouraged me, in particular Rob Jackson, Josh Schimel, Alberto Montanari, and, more recently, Martin Weih. Finally, my most sincere thanks to Giulia Vico, my wife and among my most supportive research collaborators. As some of you probably know, sharing your life with a scientist is an opportunity and a challenge in its own right—with Giulia it is a fun and engaging adventure. In closing, I hope I will have a chance to continue working in and giving my contribution to the Hydrology section and the wider AGU.

—Stefano Manzoni, *Stockholm University, Stockholm, Sweden*

McKnight Receives 2014 Hydrologic Sciences Award

Diane McKnight received the 2014 Hydrologic Sciences Award at the 2014 AGU Fall Meeting, held 15–19 December in San Francisco, Calif. The award is for outstanding contributions to the science of hydrology.

Diane McKnight

Citation

Diane is a visionary scientist. One example is her study of the links between natural organic matter and metals in acid mine drainage streams. Her work on the photoreduction of iron in natural streams, published in *Science* in 1988, remains influential to this date.

Another breakthrough came in 2001 when she demonstrated the use of fluorescence spectroscopy to characterize dissolved natural organic matter, work that has influenced essentially the whole field. There obviously is much more—Diane has published about 200 papers in archival journals over her career, and they represent a tremendously substantive body of scientific work.

Diane also is persistent. An anecdote is illustrative. Years ago Diane, Ken Bencala, and I wanted to inject enough dissolved organic carbon in a Colorado stream to trace its fate and transport. After figuring out that it would take about 95 years to leach enough material from leaves, it would have been easy to give up. But Diane had other ideas. She flew to Georgia where she met a tanker truck driver at the Suwannee River. I only wish I had a tape of the conversation that must have occurred. "Let me get this straight. You want me to pump my tank full of swamp water?" Answer: "yes, please." Suffice it to say that we did the experiment.

Diane also has an enviable record of service; she was president of the American Geophysical Union's Biogeosciences section and was the founding editor of *Journal of Geophysical Research: Biogeosciences*.

The Hydrologic Sciences Award for 2014 is conferred to Diane "for her major contributions to fundamental knowledge of linked hydrologic-biogeochemical processes."

—George Hornberger, *Vanderbuilt University, Nashville, Tenn.*

Response

I thank George for his generous comments and my family for their support, especially my husband for his friendship and advice. I am grateful for my association with three institutions with strong commitments to hydrology, the Parsons Laboratory at the Massachusetts Institute of Technology (MIT), the U.S. Geological Survey (USGS), and the University of Colorado. At MIT I benefited from advice from my thesis advisers, Francois Morel and Penny Chisolm, as I planned a study of the CuSO4 treatment of a drinking water reservoir. At the USGS, my career was influenced by a singular event, the eruption of Mount St. Helens. While studying Spirit Lake, I observed how research by USGS scientists had protected the public and advanced understanding the volcano. Since then, I have been fortunate to work with colleagues on continuing, site-based research projects: the USGS's Toxics Substances Hydrology Program, the McMurdo Dry Valleys and Niwot Ridge Long-Term Ecological Research projects, and the Boulder Creek Critical Zone Observatory. Within these projects, we have conducted stream-scale experiments to probe underlying processes, and I am indebted to many colleagues for the success of this research. Intersecting with these projects has been a quest with environmental chemists to understand the biogeochemistry of dissolved organic matter in streams and lakes.

Finally, I would like to look ahead by considering the past. I am a descendant of James Buchanan Eads, a famous civil engineer who in 1874 built the first steel arched bridge across the Mississippi River. Eads was a national hero. Since that time, we have reshaped the river and changed its chemistry while also changing the climate that will drive the river's future. Certainly, advances in hydrology will contribute to the security of communities worldwide, but challenges are heroic in scale. I applaud the young scientists of the Hydrology section who will carry the hydrologic sciences forward.

—Diane McKnight, *University of Colorado, Boulder*

Gleason Receives 2014 Mineral and Rock Physics Early Career Award

Arianna Gleason received the 2014 Mineral and Rock Physics Early Career Award at the 2014 American Geophysical Union Fall Meeting, held 15–19 December in San Francisco, Calif. The award is for promising young scientists (current Ph.D. students and individuals who have completed the degree requirements for a Ph.D. or highest equivalent terminal degree up to 12 months prior to the nomination deadline) in recognition of outstanding contributions achieved during their Ph.D. research.

Arianna E. Gleason

Citation

The American Geophysical Union (AGU) Mineral and Rock Physics Focus Group is pleased to present the first Early Career Award to Arianna Gleason. Following her undergraduate years at the University of Arizona, she was a Consortium for Materials Properties Research in Earth Sciences (COMPRES) intern at the Advanced Light Source of the Lawrence Berkeley National Laboratory in 2004–2005. She received her Ph.D. in 2010 from the University of California at Berkeley under the supervision of Professor Raymond Jeanloz. From 2010 to 2013, Arianna was a postdoctoral scholar at Stanford University working in the research group of Professor Wendy Mao. She is now a research associate at Stanford and the Los Alamos National Laboratory.

Arianna Gleason is an exceptionally bright young researcher working at the cutting edge of multidisciplinary mineral physics. She is making seminal contributions to two frontiers of high-pressure experimentation: static compression diamond-anvil cell and dynamic compression laser shock measurements. She is conducting pioneering high-pressure mineral physics research using shock compression performed at the Linac Coherent Light Source at the Stanford Linear Accelerator Center, the Jupiter Laser Facility at Livermore National Laboratory, and facilities at Los Alamos National Laboratory. Congratulations, Arianna!

—Bob C. Liebermann, *Mineral Physics Institute, Stony Brook University, Stony Brook, N. Y.*

Response

I am extremely honored to receive this award and grateful to the Mineral and Rock Physics section of AGU for its recognition of my efforts and accomplishments. My interest in mineral physics sprang from an X-ray diffraction project with Professor Bob Downs at the University of Arizona (U of A) on chalcopyrite during my undergraduate studies, and I cultivated a commitment to careful scientific research and discovery with the Spacewatch Project at the Lunar and Planetary Laboratory, U of A. I feel fortunate to have found a field that I am truly excited about and am proud to contribute to planetary sciences and mineral physics.

For my accomplishments in high-pressure research, I owe much gratitude to a number of professors and scientists at the Advanced Light Source, Lawrence Berkeley National Laboratory, the University of California, Berkeley (UCB), and Stanford University for their guidance and support during my graduate and postdoctoral studies. In particular, I am indebted to my Ph.D. adviser, Raymond Jeanloz, at UCB for his invaluable teaching and my inspiring postdoctoral adviser, Wendy Mao, at Stanford University. Progress in mineral physics often relies on a multidisciplinary and collaborative approach; therefore, I am very fortunate to have so many great mentors and enthusiastic and experienced colleagues. In particular, I would like to thank Cindy Bolme at Los Alamos National Laboratory and collaborators in High Energy Density Physics at the Lawrence Livermore National Laboratory, the Matter in Extreme Conditions staff at the Linac Coherent Light Source, SLAC, and staff at the Advanced Photon Source, Argonne National Laboratory. The support from my family and friends has been invaluable to my journey as a scientist—I dedicate this award to my late mother and grandfather.

—Arianna E. Gleason, *Los Alamos National Laboratory and SLAC National Laboratory, Stanford University, Menlo Park, Calif.*

Fischer and Geballe Receive 2014 Mineral and Rock Physics Graduate Research Awards

Rebecca Fischer

Zack Geballe

Rebecca Fischer and Zack Geballe have been awarded the 2014 Mineral and Rock Physics Graduate Research Award. This award is given to one or more promising young scientists in recognition of outstanding contributions achieved during their Ph.D. research.

Fischer's thesis is entitled "Earth's accretion, core formation, and core composition." Geballe's thesis is entitled "Melting and freezing of metals under the high pressures of planetary interiors." They both were formally presented with the award at the 2014 American Geophysical Union Fall Meeting, held 15–19 December in San Francisco, Calif.

Rebecca Fischer received her B.A. in integrated science and Earth and planetary sciences from Northwestern University in 2009. She is currently working toward a Ph.D. in high-pressure mineral physics under the supervision of Andrew Campbell at the University of Chicago. Her research interests include the compositions of Earth and planetary cores and the physical and chemical processes that determine their compositions.

Zack Geballe received his B.S. in physics from the University of Michigan Ann Arbor in 2008. In Fall 2014 he completed his Ph.D. in high-pressure mineral physics under the supervision of Raymond Jeanloz at the University of California, Berkeley. His primary research interests are the thermal evolution of the Earth's core and the physics of melting, freezing, and amorphization.

Aubrecht Receives 2014 Natural Hazards Focus Group Award for Graduate Research

Christoph Aubrecht has been awarded the Natural Hazards Focus Group Award for Graduate Research. This award recognizes a promising young scientist engaged in studies of natural hazards and risks and is given in recognition of outstanding contributions achieved during their Ph.D. (or highest equivalent terminal degree) research. He was formally presented with the award at the 2014 American Geophysical Union Fall Meeting, held 15–19 December in San Francisco, Calif.

Christoph Aubrecht

Christoph Aubrecht has a Ph.D. in Integrated Geographic Information (GI) Science and Remote Sensing from Vienna University of Technology and a prior master's degree from the University of Vienna. He is affiliated as a senior scientific consultant with the AIT Austrian Institute of Technology as well as the World Bank's Disaster Risk Management team. He previously provided consultancy to the Global Facility for Disaster Reduction and Recovery and held various visiting scientist positions at the National Oceanic and Atmospheric Administration's National Geophysical Data Center, Columbia University's Consortium for International Earth Science Information Network, and the attached NASA Socioeconomic Data and Applications Center, as well as the University of Southern California. For several years Chris has been lecturing in GI science and remote sensing at the University of Vienna. He is on the editorial board of various international scientific journals, and his publications include more than 30 refereed articles in journals and books. Research interests focus on multidimensional spatiotemporal modeling as well as disaster risk management, exposure, and vulnerability.

Moon Receives 2014 Donald L. Turcotte Award

Woosok Moon

Woosok Moon was awarded the 2014 Donald L. Turcotte Award, given annually to recent Ph.D. recipients for outstanding dissertation research that contributes directly to the field of nonlinear geophysics. He gave an invited talk and was formally presented with the award at the 2014 American Geophysical Union Fall Meeting, held 15–19 December in San Francisco, Calif. Woosok received his B.S. in atmospheric science from Seoul National University in 2000 and a M.Sc. in meteorology from the Pennsylvania State University in 2008. He received a Ph.D. in geophysics under the supervision of J. S. Wettlaufer at Yale University. His research interests include Arctic sea ice thermodynamics, geophysical fluid dynamics, and stochastic dynamical systems applied to climate dynamics.

Daniel Griffin

Blue oak trees up to 500 years old thrive in California's drought-scorched foothills. Their rings provide a unique record of drought and wetness for the Golden State.

California's 2012–2014 Drought Unusual for Last Millennium

California's ongoing drought, which began in 2012, is severely straining the state's water resources, agriculture, and economy and is disrupting ecosystems. Although the drought is the worst on record since instruments began recording aridity levels about 120 years ago, scientists wonder how unusual it is over longer periods of time.

To learn more, *Griffin and Anchukaitis* analyzed two paleoclimatic records from tree rings to compare this drought with others from the last 1200 years. California's long-lived trees provide a record of hydroclimate history through their wide (wet) and narrow (dry) rings.

The first record estimates the Palmer drought severity index (PDSI), a metric of soil moisture based on precipitation and temperature, using tree ring data from a large number and wide variety of sites in the region. The second record, which extends back over 700 years, estimates simple precipitation using tree rings from blue oaks (*Quercus douglasii*) at four sites in central and Southern California. Collectively, these two records provide long-term context for the 2012–2014 drought in terms of both soil moisture and precipitation.

Using PDSI data dating back to 800 A.D., the authors found that dry-soil periods of 3 or more years occurred in California relatively frequently. However, soil moisture deficits accumulated from 2012 to 2014 were more severe than any other short-term period in the record.

However, the blue oak tree rings from 2012 to 2014 suggest that although precipitation has been low, it was lower in numerous earlier years. The researchers believe that record high temperatures explain the recent drought's severity, even though precipitation was not unprecedentedly low. (*Geophysical Research Letters*, doi:10.1002/2014GL062433, 2014) **—Puneet Kollipara, Freelance Writer**

Unusual Echo Signal in Atmospheric *E* Layer

Patchy layers of metallic ions in Earth's atmosphere, called sporadic *E* layers, are often observed during the night at midlatitudes across the globe. Recently, however, patchy *E* layers were observed at higher latitudes above Alaska and during the daytime.

Hysell et al. suggest that the high-latitude, daytime *E* layers they observed likely form when neutral waves in the atmosphere interact with Earth's ionospheric layer—between 90 and 125 kilometers above the surface. During their measurement, the scientists also discovered an unusual behavior of field-aligned plasma density irregularities (FAIs) at a certain radio frequency in the layers.

Metallic *E* layers are between 1 and 2 kilometers thick and cause radio waves to reflect, refract, diffract, or scatter off course. This can deter radio communication. Using the High Frequency Active Auroral Research Program facility in Gakona, Alaska, the researchers generated high-frequency radio emissions to measure instabilities in the patchy *E* layers. The authors compare this approach to the process of injecting dye into biological tissue to highlight functions that would otherwise be invisible.

The authors discovered that when the radio frequencies matched the critical frequency of the layers, they measured a characteristic quasiperiodic FAI echo. Above the third electron gyroharmonic frequency, however, the echo strength diminishes, they note. FAI echoes have been observed before in the *E* and higher-altitude *F* layers, but those echoes are unlike the ones the researchers observed at this frequency. The authors speculate on what causes echo strengths to diminish at this frequency but remain unsure of how to interpret this strange behavior. (*Geophysical Research Letters*, doi:10.1002/2014GL061691, 2014)

—Jessica Orwig, Freelance Writer

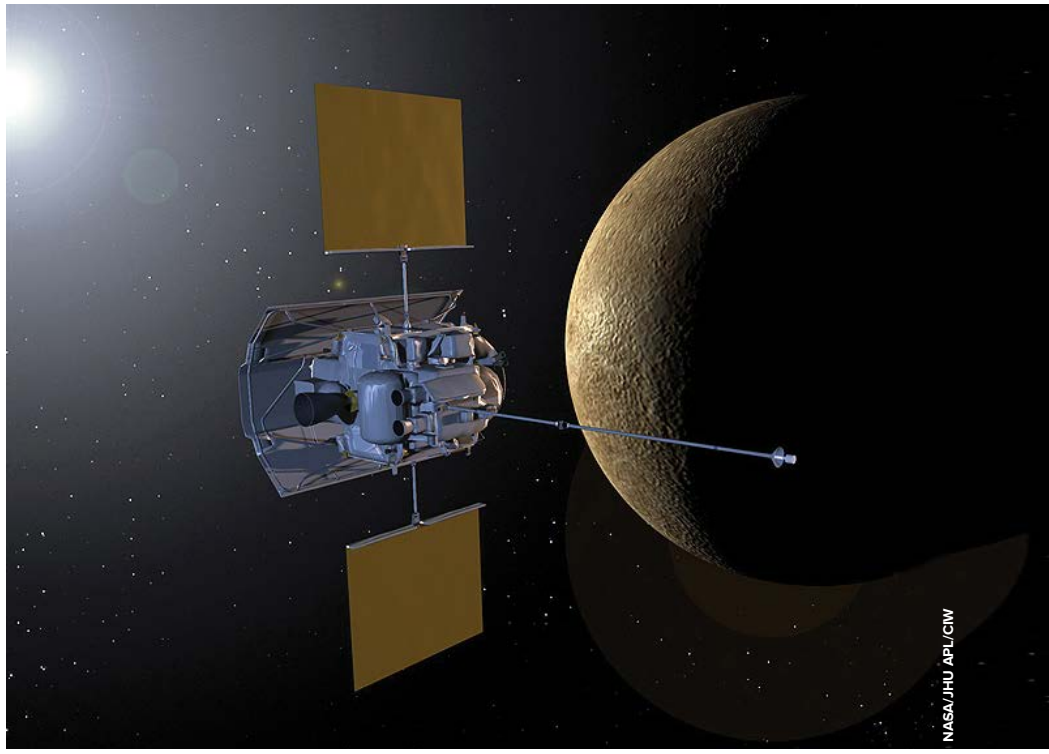
Scientists Watch Solar Winds Blast Mercury's Magnetic Field

Scientists working on NASA's Mercury orbiter, the Mercury Surface, Space Environment, Geochemistry, and Ranging (MESSENGER) spacecraft, have watched in recent years as coronal mass ejections from the Sun sent solar winds sailing toward the solar system's innermost planet during the recent peaks of the solar cycle. The team studied what the most extreme of these events do to the planet's magnetosphere—the region controlled by Mercury's weak magnetic field.

Since the spacecraft arrived in 2011, its observations have shown that Mercury's magnetic field closely aligns with the planet's rotation axis and carries a polarity similar to Earth's. The tiny planet packs a large iron core; however, its magnetic field reaches just one fifth of its radius beyond the surface and packs about 1% of the strength of Earth's.

Slavin et al. examined the solar wind's impact on reconnection, where magnetic field lines from the Sun connect with field lines at a planet, releasing both kinetic and thermal energy and accelerating particles to high speeds. The team identified three spacecraft passes where the planet's magnetic field exceeded 300 nanoteslas—roughly 3 times the strength typically seen. To hit those levels, the authors say that the pressure of solar wind hitting Mercury must have risen by some 4 to 9 times above normal in each instance.

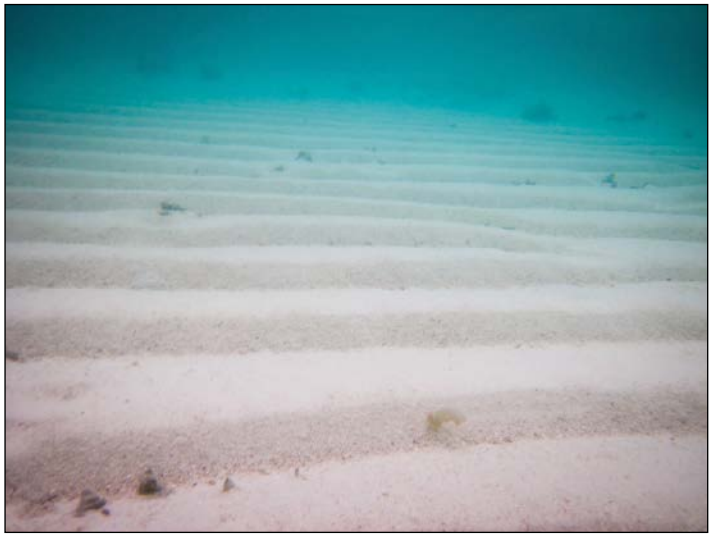
The team's results show that Mercury's magnetic reconnection is intense and that the magnetopause actually intersected the planet's surface at times in the southern hemisphere, where the magnetic field is weakest. The authors say their analysis shows that the edge of Mercury's magnetic field responds to increasing solar wind pressure very similarly to how Earth responds. (*Journal of Geophysical Research: Space Physics*, doi:10.1002/2014JA020319, 2014) **—Eric Betz, Freelance Writer**



Artist's impression of the Mercury Surface, Space Environment, Geochemistry, and Ranging (MESSENGER) spacecraft in orbit at Mercury.

Aquifers Spew More Pollution into Oceans Than Rivers

When it comes to oceanic pollution, underwater seepage from coastal aquifers trumps runoff from rivers, a new study says. Coastal aquifers are pockets of permeable earth—gravel, sand, or silt—that trap water. Much like rivers, these reservoirs absorb ground contaminants, such as fertilizer, subterranean carbon, and metals. These chemicals can subsequently leak from the seabed into the ocean, through a process known as submarine groundwater discharge (SGD), but the scale of this seepage remains in question.



Robertus B. Herdiyanto, CC BY-SA 2.0 (http://bit.ly/ccbysa2-0)

How much pollution leaks from coastal aquifer seabeds, through the seabed, and into the ocean? Much more than what gets brought to the ocean from rivers, a new study finds.

Kwon et al. created a mathematical model to estimate SGD of radium-228, a radioactive isotope that serves as a readout for terrestrial leaching. Prior models made indirect estimates of SGD by subtracting the recorded levels of radium-228 deposited by rivers, dust blown from land, and diffusive fluxes from coastal sediments from the steady state of radium-228 found in marine water. This earlier method is more accurate near shore, according to the authors, but becomes problematic for open seas, where accurate recordings at depth are sparse.

To circumvent this issue, the team posited a new model to get accurate recordings at depth based on tactics used to estimate the global mixing of ocean acidification. When combined with radium-228 data, this circulation model inferred SGD for the global ocean, excluding the polar seas because of insufficient available recordings of isotopes.

They estimate that SGD from coastal aquifers contributes 3 to 4 times more terrestrial contaminants to the ocean than river water. Also, the bulk—70%—of SGD occurs in the Indian and Pacific oceans, suggesting these regions are more susceptible to natural and man-made pollutants that are stored in coastal aquifers. The findings may also inform future research and policy decisions with regard to biogeochemical changes, pollution cycles, and ecosystem dynamics. (*Geophysical Research Letters,* doi:10.1002/2014GL061574, 2014) **—Nsikan Akpan, Freelance Writer**

Researchers Roll Clouds into Climate Modeling

Traditional global climate models have avoided directly simulating the role that clouds play in Earth's climate systems. The nebulous billows of water droplets are generally too dynamic and small for classic models to resolve. Instead, these models have relied on numerical simplifications called parameterizations to stand in for the clouds' aggregate effect.

Modern computational power is starting to change that. Now scientists can simulate, rather than approximate, cloud systems, and they are incorporating clouds into their regional and global climate models.

Hagos et al. set out to compare model simulations that included clouds with what played out in reality during observations as part of the Dynamics of the Madden-Julian Oscillation Experiment (AMIE/DYNAMO) field campaign. Their test bed was the Indian Ocean near Gan, one of the Maldives islands, where the researchers compared their model simulations to data collected by ships and ground-based radar instruments over the course of a month. The team found that their model was fairly accurate in predicting the observed relationship between cloud depth and size.

The study highlights the usefulness of directly comparing computational predictions to real data to validate simulations and elucidate biases, according to the authors. They add that when cloud models account for those biases in cloud and rain processes, weather forecasting and eventually climate modeling will become even more reliable. (*Journal of Geophysical Research: Atmospheres*, doi:10.1002/2014JD022143, 2014) **—Eric Betz, Freelance Writer**

STS41B-41-2347, NASA JSC

Large and small cloud structures in overlapping systems.

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Atmospheric Sciences

NGGPS Subseasonal Prediction at Princeton University

The Atmospheric and Oceanic Sciences Program at Princeton University, in association with NOAA's Geophysical Fluid Dynamics Laboratory (GFDL), seeks two postdoctoral or more senior scientists for subseasonal (14–30 day) prediction of extreme and disruptive weather events, with a focus on severe winter storms, warm-season severe weather outbreaks, and hurricanes. The successful candidates will aid development of diagnostics of high-impact events in sub-seasonal ensemble predictions from the convection-permitting GFDL HiRAM model, and carry out simulations in support of the seasonal forecast effort. This will include the automatic identification of tropical and extratropical cyclones, atmospheric rivers, cold air outbreaks, sudden stratospheric warmings, tropical waves, the MJO, and related phenomena important for subseasonal prediction. The candidates will also work to develop a database of observed severe weather events, both warm- and cold-season, against which verification of retrospective seasonal forecasts can be performed.

Each selected candidate must have a Ph.D. in meteorology, atmospheric sciences, or a closely related field. The candidates will have strong backgrounds in either tropical meteorology or synoptic-scale meteorology, and should have some experience using and analyzing weather and/or climate models. The positions are for one year renewable for up to three years pending satisfactory progress and continued funding.

Complete applications, including a CV, publication list, contact information for at least 3 references in order to solicit letters of recommendation, and a one-to-two page statement of research interests should be submitted by June 15, 2015 for full consideration. Applicants should apply online to http://jobs.princeton.edu, Requisition #1500226. For additional information contact Lucas Harris (lucas.harris@noaa.gov) and/or Shian-Jiann Lin (shian-jiann.lin@noaa.gov). This position is subject to the University's background check policy. Princeton University is an equal opportunity employer. All qualified applicants will receive consideration for employment without regard to race, color, religion, sex, national origin, disability status, protected veteran status, or any other characteristic protected by law.

Hydrology

A researcher is sought to conduct hydrologic studies in the Congo Basin.

This is a broadly defined position in terms of both the appointment type and specific research (note, however, that this is not a tenure-track faculty position). For example, a faculty member seeking a sabbatical would be considered and hired as a consultant, or a scientist several years beyond their Ph.D. who is seeking a new direction in their research could be hired as a consultant or a postdoctoral researcher. The successful candidate will study the hydrology of the Cuvette Centrale wetlands. However, the focus could instead be on the overall water balance of the basin, or involve wetland biogeochemistry, or be applications oriented, etc. Specifically, the researcher in this position will be expected to lead-author peer-reviewed papers on their Congo research and submit applications or proposals for funding on Congo related studies. The researcher is also expected to have demonstrated their research skills by having already published scientific papers. While not required, candidates who have a working ability in the French language are desired (not necessarily fluent, but passable). The position will be available at the Byrd Polar and Climate Research Center at The Ohio State University in Columbus Ohio. Contact Prof. Douglas Alsdorf (alsdorf.1@osu.edu) for more information. To submit an application, email a PDF of your CV and one relevant publication to Prof. Alsdorf. The position is open until filled. Ohio State is an equal opportunity employer. All final applications will have to complete a background check.

Millersville University

FULL-TIME, ONE-YEAR METEOROLOGY INSTRUCTOR/ASSISTANT PROFESSOR

Millersville University welcomes applications for a full-time, one-year, instructor/assistant professor of meteorology. The position is a sabbatical leave replacement. The primary teaching responsibilities will be in boundary layer meteorology and statistical methods applied to meteorology. Millersville University, highly regarded for its instructional quality and strong commitment to diversity, is a student-centered institution and one of 14 institutions of the Pennsylvania State System of Higher Education. The campus, located in historic Lancaster County, is within a short drive or train ride of Baltimore, Philadelphia, New York City, and Washington, DC. Millersville enrolls approximately 8,000 undergraduate and graduate students, and is nationally ranked as one of the top regional public colleges and universities by *U.S. News & World Report*. The Department of Earth Sciences offers a traditional BS-meteorology degree. Additional information about the department can be found at **www.millersville.edu/esci/**. To learn more about the position, and to apply, link to **http://jobs.millersville.edu/postings/1723**. Full consideration will be given to applications received by 03 May 2015.

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Ocean Dynamics and Prediction Research
Naval Research Laboratory

The Naval Research Laboratory is seeking postdoctoral and senior researchers to push forward the frontiers of ocean forecasting. Problems that must be addressed cover a wide scope of physics including surface waves, thermohaline circulation, ice, nearshore circulation, and ocean/atmosphere coupling from global to nearshore scales. This challenging work includes processing and analysis of satellite and in water observations, construction of numerical model systems and assimilation for predicting the ocean environment. This work is long term, with the goal to provide new technology for systems moving to operational forecast centers.

This is an excellent opportunity to work with some of the best modelers and data analysts in the ocean community. The Naval Research Laboratory has access to the major supercomputer sites as well as excellent local computer resources. The laboratory is collocated with the Naval Oceanographic Office, which is the largest national operational forecast center for oceanography.

For a quick overview of some of the research projects within the NRL Oceanography Division at Stennis Space Center, visit the web site:

http://www7320.nrlssc.navy.mil/projects.php

Applicants must be a US citizen or permanent resident at time of application. Applications will be accepted until positions are filled. Please mail or e-mail a resume and description of research interests, or phone:

Gregg Jacobs
NRL Code 7320
Stennis Space Center, MS 39529

via e-mail: jacobs@nrlssc.navy.mil
Phone: 228-688-4720

SIESD 2015 Summer Institute on Earth-surface Dynamics

Summer in the Swamp - Self-organization in landscapes and its residue in the stratigraphic record

This year's theme maintains our current focus on linking surface processes and subsurface records, but with a new flavor: it is field-centric and will be hosted at Tulane University to take advantage of the unique and fascinating Mississippi River Delta. The aims for 2015 are to develop a basic working knowledge of analysis tools that can help us make sense of complex surface systems and their depositional records, and begin to make predictions in both realms. We will focus on building connections: between surface and subsurface, between field and laboratory, and among physical biological and geochemical processes. SIESD will combine classical methods of process analysis, measurement and predication with methods related to emerfging ideas in areas such as reduced complexity, modeling, network analysis, pattern formation, and geostatistics. Students will participate in taught class-room sessions, hands-on work with computational tools, field work, and physical experiments that the course participants will help design and run.

Dates and Location:
July 27 - August 5, 2015
Tulane University, New Orleans

Eligibility:
The Summer Institute is directed towards graduate students in the final years of their PhD program, postdocs, or early career scientists (three years from PhD). Applications from women, monorities and individuals with disabilities are strongly encouraged.

Application Procedure:
Online application and instructions are available at: nced.umn.edu/siesd Applications are open now.

Application Deadline:
May 15, 2015

Contact:
Deb Pierzina (Email: pierz001@umn.edu)

For more information:
nced.umn.edu/siesd

The 7th Annual SIESD is organized by the National Center for Earth-surface Dynamics, a National Science Foundation Science and Technology Center funded by the Office of Integrated Activities under agreement EAR-1020914

Ocean Sciences

UConn Marine Sciences – Postdoctoral Fellow I

The Department of Marine Sciences at UConn is seeking a postdoctoral scholar to study the impact of evaporation and precipitation on the salinity structure of the upper ocean as part of the NASA SPURS-2 program. The candidate will work with Dr. James Edson to deploy systems capable of measuring heat, momentum, radiative and evaporative fluxes from a surface mooring and research vessels. The candidate will participate in the field program in the eastern tropical pacific and assist in the analysis and publication of the collected data. For details on the position, visit www.jobs.uconn.edu. The University of Connecticut is an EEO/AA employer. (Search # 2015122)

Solid Earth Geophysics

Colorado School of Mines Department of Geophysics Baker Hughes Chair

Colorado School of Mines invites applications for the position of the Baker Hughes Chair of Petrophysics and Borehole Geophysics, a regular academic faculty position in Geophysics, which is anticipated to be filled at the rank of Associate or Full Professor. The Department is seeking an individual with a distinguished international reputation in the study of rock properties (e.g., physical, chemical, electrical, mechanical) and their interactions with fluids, in the context of exploration for, and development of, natural resources. The successful candidate will be one who investigates poroelastic and fractured media with a multi-scale perspective that considers information obtained in lab, borehole and field environments.

Candidates must have earned a doctoral degree in geophysics or a related discipline and have demonstrated success in their career as an educator and researcher commensurate to receiving tenure at a research-active university like Mines. The successful candidate must demonstrate leadership in scholarship, service, and teaching at the undergraduate and graduate levels. Applicants for consideration at the Professor rank must also demonstrate national or international recognition in their discipline. Candidates must possess superb interpersonal and communication skills and a collaborative style of research and teaching, and must have experience in collaboration with industry. Preference will be given to candidates whose research interests hold potential for multidisciplinary collaboration.

For the complete job announcements and directions on how to apply, visit: http://inside.mines.edu/HR-Academic-Faculty

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Interdisciplinary/Other

CVV 682Assistant Professor: Pedologist/Soil Scientist

Oregon State University, Department of Crop and Soil Science, is seeking a full time Assistant Professor in Pedology/Soil Science who studies soil-forming processes and the importance of soils in earth system science. Research that incorporates collaboration with Critical Zone Observatories, is interdisciplinary in nature, and views soils as a complex system is especially encouraged. Possible areas of research could include soil-water dynamics, digital soil mapping and soil and landscape classification, energy based modeling of pedogenesis and ecosystem function, soil forming processes in the critical zone, pedology informing ecological and ecosystem dynamics, and human dimensions of land-use change. Tools could include remote sensing, dynamic or spatial modeling, experimental studies and observation, and geochemistry. The candidate should work in a field that can attract significant extramural funding. PhD required by start of employment in Soil Science, Earth Science or closely related field. The successful candidate will be expected to teach an advanced course in soil morphology and classification, an undergraduate course in soil science, and a course in the candidate's specialty. This position supports the department and university mission to develop and disseminate research-based information to practitioners and policy makers.

Required qualifications include PhD in Soil Science, Earth Science or closely related field with demonstrated experience in soil landscape studies as related to Pedology, with demonstrated teaching skills and a demonstrable commitment to promoting and enhancing diversity. Salary is commensurate with education and experience. To review posting and apply, go to http://oregonstate.edu/jobs. Apply to posting # 0014231. Review of the applications will begin on 20 April 2015 and continue until the position is filled. OSU is an AA/EOE/Vets/Disabled. Questions should be addressed to Dr. Kate Lajtha, Search Committee Chair, Department of Crop and Soil Science, Oregon State University, Corvallis, Oregon 97331, email: lajthak@science.oregonstate.edu.

Postcards from the Field

Hi, everyone!

I'm having a blast at Kawah Ijen volcano in East Java, Indonesia, studying the largest hyper-acidic volcanic lake in the world! The turquoise lake water may look enticing, but given that the brine has a pH hovering around zero from magmatic volatiles interacting with the lake water, it's not exactly a lake you'd want to swim in. At least the view's nice!

Cheers,
Sri Budhi Utami
MSc student at McGill University

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

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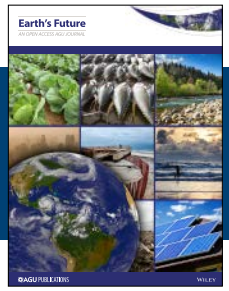

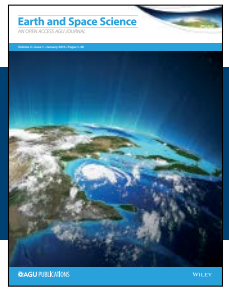

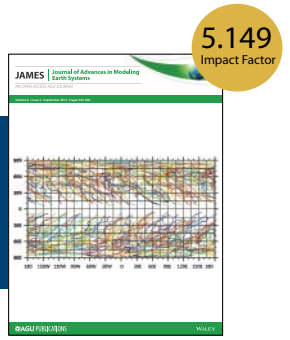

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Which Chapman Will You Be Attending in 2015?

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Santa Fe, New Mexico, USA
27–31 July

Magnetospheric Dynamics
Fairbanks, Alaska, USA
27 September–2 October

The MADE Challenge for Groundwater Transport in Highly Heterogeneous Aquifers: Insights from 30 Years of Modeling and Characterization at the Field Scale and Promising Future Directions
Valencia, Spain
5–8 October

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