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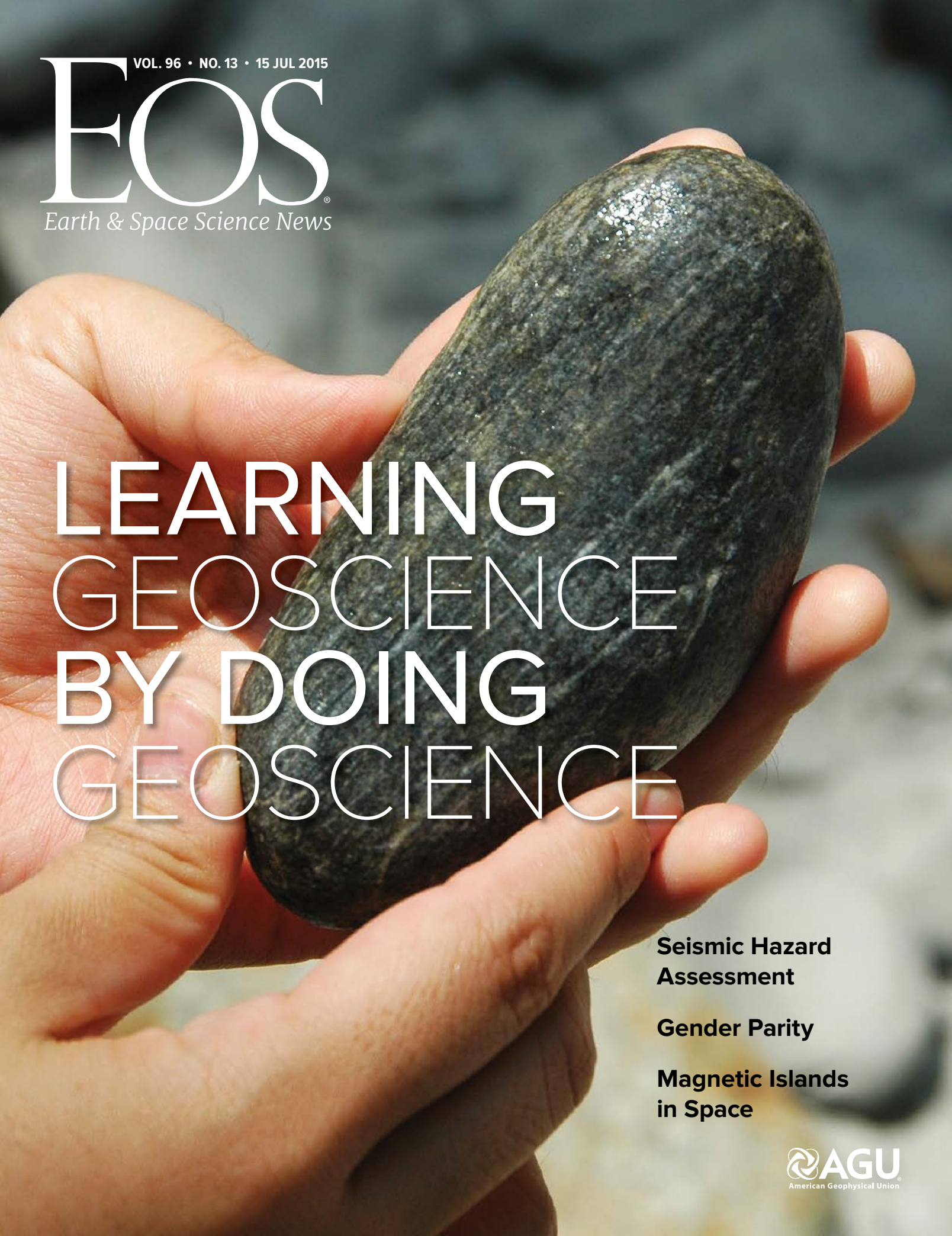
EOS

Earth & Space Science News



LEARNING GEOSCIENCE BY DOING GEOSCIENCE

Seismic Hazard Assessment

Gender Parity

Magnetic Islands in Space

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15 JULY 2015
VOLUME 96, ISSUE 13

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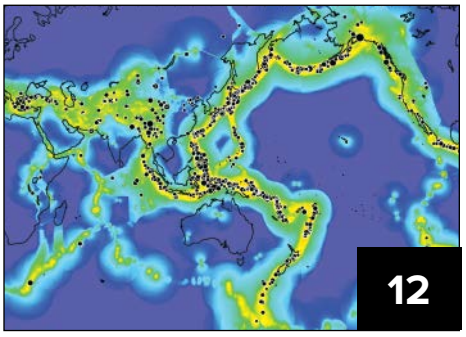
Learning Geoscience By Doing Geoscience

A pilot project helps teachers bring scientific practice into the classroom.

PROJECT UPDATE



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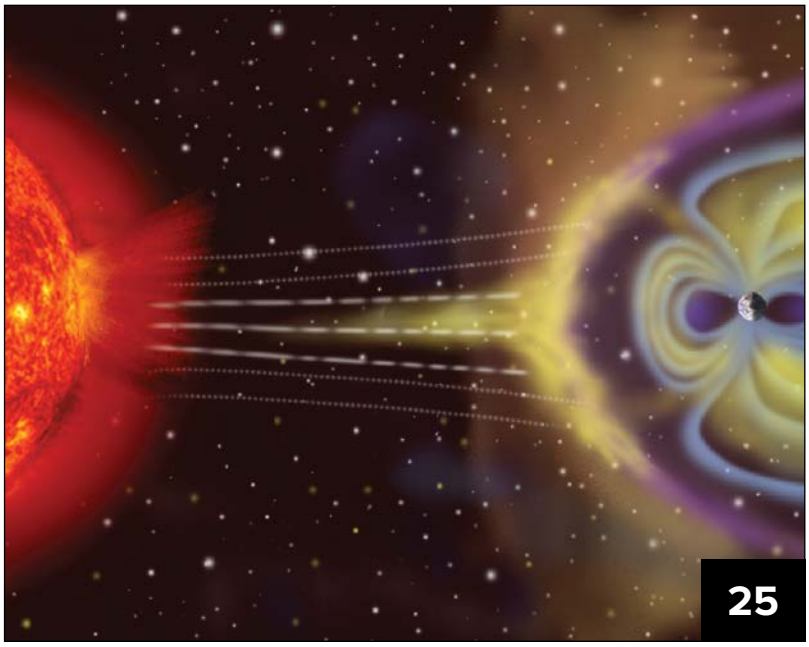

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Christine W. McEntee, Executive Director/CEO

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Initiative to Assist Developing Nations with Climate Resilience

A new international public-private partnership promises to provide developing nations with data, information, tools, and training to help them become more resilient to climate change. That assistance could help developing nations better prepare for floods, droughts, sea level rise, and other issues.

The Climate Services for Resilient Development partnership (http://bit.ly/Eos_CSRD), announced by the White House on 9 June, launched with a commitment of $34 million in financial and in-kind contributions from the United States, the United Kingdom, two international development banks, and several nongovernmental organizations and businesses.

The partnership "will enable the U.S. government to apply the technologies, scientific expertise, and capacities it has developed under President Barack Obama's Climate Action Plan to support resilience efforts in developing nations," according to the White House. The partnership will target services to countries in subregions of Latin America, Africa, and Asia, with an initial focus on Colombia, Ethiopia, and Bangladesh.

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Officials Cite Benefits of Climate Resilience Help

The assistance can't come soon enough, according to officials from those countries who spoke at the launch event.

"We are one of the front line countries" experiencing climate change, said Mohammad Ziauddin, Bangladesh's ambassador to the United States.

"In most cases, we are unable to assess our vulnerability with facts and figures due to a lack of data and the absence of adequate monitoring infrastructure and research. Therefore we need help in collecting climate-related data and improving our early warning systems for flood and drought." He added, "We also need help in increasing our capacity and expertise for generating more localized information to strengthen resilience of our local communities against climate change."

Girma Birru Geda, Ethiopia's ambassador to the United States, said that there is "no doubt that improved climate information services would help countries such as Ethiopia in better adapting to the effects of climate change and enhancing [our] resilience."

Pablo Vieira, Colombia's vice minister of environment, added that the benefit of early warning services can far outweigh the required upfront investments.

Commitment to Climate Resilience

The U.S. commitment to the partnership includes $10 million in financial support from the U.S. Agency for International Development (USAID) for regional, country, and end user needs assessments and to implement activities and products to help developing nations strengthen their climate resilience. Other components are high-resolution elevation data from the U.S. Geological Survey through its Earth Explorer website; and the leveraging of ongoing governmental efforts, such as the National Oceanic and Atmospheric Administration's International Research and Applications Project, as well as SERVIR. This latter initiative involves key support from NASA and USAID in assisting developing nations with satellite-based Earth observation data and science applications. SERVIR comes from the Spanish acronym for the Regional Visualization and Monitoring System for Mesoamerica.

The United States "is deeply committed to helping the poorest and most vulnerable nations become more resilient to the growing impacts of climate change," John Holdren, assistant to the president for science and technology, said at the launch of the partnership.

U.S. science and technology agencies "can provide as global public goods useful climate data tools and models to decision makers in other nations just as they provide them to U.S. citizens, businesses, farmers, and planners," Holdren said. "We can think of these products as climate services much like we think of weather services to allow individuals and decision makers to be better informed about what is coming."

Roots of the Partnership

"The partnership is a key component of the president's broader vision" about how to deal with climate change, explained Brian Deese, senior adviser to the president for climate change and other issues. President Obama highlighted the need for the partnership in comments he made (http://bit.ly/ObamaTellsSummit) at the September 2014 Climate Summit at the United Nations and in an executive order.

"You have our commitment that the United States will continue to use every tool that we have available to us to help try to tackle this [climate change] challenge head on," Deese said. "We will look to build partnerships wherever we can constructively do so." He added that the plan is for the partnership to grow in coming months with more countries participating. Moreover, the president's trip to Africa this month is "a specific opportunity to deepen the impact of this partnership."

USAID acting administrator Ambassador Alfonso Lenhardt said that "climate-resilient development is essential to [the agency's] goal to end poverty around the world." He said that "through lessons learned from the scale-up of these efforts, we will help tens of millions of people who are vulnerable to the impacts of climate change by the end of 2016."

NASA Data Set

Beyond the partnership, but timed with its launch, NASA released a new data set that provides downscaled climate model outputs for every country in the world. The Earth Exchange Global Daily Downscaled Projections

Randy Showstack

Brian Deese, senior adviser to the president for climate change and other issues, speaking at the launch of the Climate Services for Resilient Development partnership.

> The United States "is deeply committed to helping the poorest and most vulnerable nations become more resilient to the growing impacts of climate change."

data set shows how temperature and rainfall patterns worldwide may change through the year 2100 because of growing concentrations of greenhouse gases in Earth's atmosphere, explained NASA chief scientist Ellen Stofan.

Additional Support for the Partnership

The United Kingdom's Department for International Development and the UK Met Office also are partners in the initiative. Dame Julia Slingo, chief scientist with the UK Met Office, told *Eos*, "My science of weather and climate science has always been about saving lives and livelihoods, protecting infrastructure, helping people to be better prepared, more resilient. And what's so great here is that this [partnership] is, I think, a germ of a new way of doing that, in a public and private partnership and using the private sector to open a lot of doors that we can't normally reach."

Other commitments to the partnership include support for the dissemination of climate services and products from the Inter-American Development Bank and the Asian Development Bank. "The information and data that are available through this partnership is unbelievable," Samuel Tumiwa, deputy representative of the North American Representative Office of the Asian Development Bank, told *Eos*. "The real question is, How do we get it out to the users?" He suggested pushing information—including early storm warning messages—out to end users through cell phones.

Additional founding partners include the American Red Cross, Esri, Google, and the Skoll Global Threats Fund.

By **Randy Showstack,** Staff Writer

White House Focuses on Drought and Wildfire Threats

With much of the drought-stricken western United States facing a potentially harsh fire season, the White House has allocated more than $110 million to deal with these hazards and their economic impacts.

The White House also has called for improving the way that the U.S. Forest Service (USFS) funds forest fire–fighting efforts so that the money is not diverted from other agency priorities.

"We are focused on and concerned about the impact of drought on economic and social conditions across the western United States," said White House Senior Advisor Brian Deese at a 12 June briefing. The very dry conditions, which federal forecasts indicate will likely intensify, also mean that the wildfire season is expected to be "acute" in large parts of the West, he noted. The briefing took place following a meeting between President Barack Obama and governors of western states earlier in the day.

Don DeBold, CC BY 2.0 (http://bit.ly/ccby2-0)

In this March 2014 photo, the bottom of the Uvas Reservoir, about 120 kilometers south of San Francisco, lies exposed by California's drought.

Funding Details

Funding announced 12 June includes $6.5 million for the Bureau of Reclamation to support water management improvement programs, $10 million for the Department of the Interior (DOI) to fund 10 Wildland Fire Resilient Landscapes projects (http://bit.ly/Eos_wildfire), and $30 million for the U.S. Department of Agriculture (USDA) to expand crop insurance relief.

The money also will provide up to $18 million for the Department of Labor to award to California, allowing the state to provide jobs for people who have been dislocated by the drought. Californians will lose about 18,000 jobs due to the 2015 drought, according to a June 2015 study by the University of California, Davis, Center for Watershed Sciences, cited by the White House.

Thirty-five percent of the landscape in the West is in severe or exceptional drought, Deese said. The newly announced funding adds to $190 million the federal government already has invested this year to address the water crisis.

The White House also anticipates that USDA could spend at least $1.2 billion to compensate farmers and ranchers for grazing losses in 2015 through its Livestock Forage Disaster Program (http://bit.ly/LivestockDisaster). That program paid out more than $4 billion over the past 3 years.

Deese characterized the new funding as "just a next step in an ongoing, very aggressive, all-of-government effort" to respond to drought and related wildfire risk.

Reforms Proposed to Fund Wildfire Management

Currently, USFS makes intra-agency transfers of funds to cover expenses for wildfire management. Although Congress usually repays these funds within several months, the transfer hinders other USFS efforts to manage forests.

"We have a budgeting system that is self-defeating and is undermining our federal government's ability not just to fight fires but reduce the likelihood of fires in the future," Deese said.

Robert Bonnie, under secretary for Natural Resources and the Environment at USDA, said that legislation introduced in both houses of Congress—the Wildfire Disaster Funding Act (House Resolution 167 and Senate Bill 235)—would create a fund that USFS and DOI can draw on during particularly bad years. The White House's proposed fiscal year 2016 budget also includes a funding fix modeled after the congressional proposals.

The legislation would ensure "that we don't take resource[s] from the nonfire portion of the budget, the very portion of the budget that allows us to do the work to reduce fire hazard in the first place," Bonnie said. The new funding approach would enable "investments in forest restoration in order to reduce the threat of catastrophic fire over the long term," he added, noting that the legislation has broad bipartisan support in Congress. It also has received support from the timber industry, the environmental and outdoor recreation communities, and others, he said.

USDA anticipates an above-average fire season, particularly in California and the Pacific Northwest, in August and September. Bonnie said that the fire season today is about 60–80 days longer than it was a few decades ago, the number of acres that burn has doubled over the same time frame, and there are now bigger and more catastrophic fires.

By **Randy Showstack,** Staff Writer

Pope Calls for Action on Climate Change, Environmental Degradation

REUTERS/Max Ross

Pope Francis issued an encyclical regarding climate change on 18 June.

Pope Francis has issued a long-anticipated papal letter that warns about the risks of climate change and other environmental degradation, urges protection of the Earth and of the poor, and calls for "a new dialogue about how we are shaping the future of our planet."

"If present trends continue, this century may well witness extraordinary climate change and an unprecedented destruction of ecosystems, with serious consequences for all of us," the pope states in the encyclical letter, *Laudato Si': On Care for Our Common Home* (http://bit.ly/Popeletter), which the Vatican distributed on 18 June.

"Climate change is a global problem with grave implications: environmental, social, economic, political and for the distribution of goods. It represents one of the principal challenges facing humanity in our day. Its worst impact will probably be felt by developing countries in coming decades," the encyclical says.

Although the document acknowledges multiple factors that can influence global climate, including volcanic activity and the solar cycle, it states that "a number of scientific studies indicate that most global warming in recent decades is due to the great concentration of greenhouse gases (carbon dioxide, methane, nitrogen oxides and others) released mainly as a result of human activity."

> The encyclical says, "Climate change… represents one of the principal challenges facing humanity in our day."

Other Environmental and Social Issues

Grounded in scientific and religious references, the encyclical also focuses on other environmental and social issues, including the depletion of natural resources, the quality of water available to the poor, and the loss of biodiversity. The document also calls for a change in attitude so that people care more for the planet and the poor and a change in consumption habits.

"Leaving an inhabitable planet to future generations is, first and foremost, up to us. The issue is one which dramatically affects us, for it has to do with the ultimate meaning of our earthly sojourn," the pope's letter states.

"Doomsday predictions can no longer be met with irony or disdain. We may well be leaving to coming generations debris, desolation and filth," the encyclical continues. "The pace of consumption, waste and environmental change has so stretched the planet's capacity that our contemporary lifestyle, unsustainable as it is, can only precipitate catastrophes, such as those which even now periodically occur in different areas of the world. The effects of the present imbalance can only be reduced by our decisive action, here and now. We need to reflect on our accountability before those who will have to endure the dire consequences."

Reminder of the Link Between Climate Change and Poverty

The pope expressed particular concern about disproportionate suffering of the poor from climate change and environmental declines. "Many of the poor live in areas particularly affected by phenomena related to warming, and their means of subsistence are largely dependent on natural reserves and ecosystemic services such as agriculture, fishing, and forestry," according to the document. The poor "have no other financial activities or resources which can enable them to adapt to climate change or to face natural disasters, and their access to social services and protection is very limited," the letter states.

The pope's words "should serve as a stark reminder to all of us of the intrinsic link between climate change and poverty," said World Bank Group president Jim Yong Kim in a statement welcoming "the Pope's emphasis on humanity's moral obligation to act." The document comes at a pivotal time leading up to the United Nations' climate change conference in Paris this fall, Kim added.

The encyclical criticizes weak international political responses to the environmental crisis and rejects as incorrect that human "dominion" over the Earth equates to unbridled exploitation of nature. In addition, the document states that attention needs to be paid to imbalances in population density but that demographic growth can be compatible with development. "To blame population growth instead of extreme and selective consumerism on the part of some,

is one way of refusing to face the issues," the document states.

"The Real Work Starts Now"

The papal letter could have a "transformational effect on the planet," atmospheric and climate scientist Veerabhadran Ramanathan told *Eos*. "The real work starts now. This is not the time for us to relax, thinking Pope Francis is going to take care of it. No, he just opened the door, and we have to go through the door," added Ramanathan, who is a professor at the Scripps Institution of Oceanography, University of California, San Diego.

The pope "has brought the moral dimension and has informed the people how we have to change our behavior. So now this is the time for scientists and policy makers to take up that message and start work on real solutions to the problem," explained Ramanathan, a council member of the Pontifical Academy of Sciences, who, in 2014, helped to coordinate a workshop (http://bit.ly/VaticanWorkshop) at the Vatican entitled "Sustainable Humanity, Sustainable Nature: Our Responsibility."

"We, as scientists, need to acknowledge that this is not just a science, technology, and policy issue," Ramanathan added. "It is a moral, ethical problem in the sense that there is intergenerational inequity." Noting that the planet will continue warming for the next several hundred years, he said, "We are leaving behind this horrible legacy for generations."

Papal Words Recall Rachel Carson

"When I saw the first draft of [the encyclical] 9 months ago, I said, 'My goodness, this is Rachel Carson speaking,'" Ramanathan said, referring to the author of *Silent Spring,* a 1962 book about the risks of pesticide use that helped to make many Americans aware of environmental issues. "Just like her book changed America, I am hoping this encyclical will change America."

The encyclical does not just "put a Band-Aid" on the situation "by just saying 'decarbonize,'" he added. "It went to the underlying causes and said we need to attack all of this, but without losing sight of the climate change problem."

Ramanathan added that dealing with climate change requires science and technology, effective governance, and religious and faith leaders. He said he would like to see the pope and other religious figures invited to attend the Paris climate conference.

In a written statement, Achim Steiner, executive director of the United Nations Environment Programme, said the encyclical "is a clarion call that resonates not only with Catholics, but with all of the Earth's peoples. Science and religion are aligned on this matter."

However, not everyone lauded the pope's message. "I disagree with the pope's philosophy on global warming," U.S. Sen. James Inhofe (R-Okla.), chairman of the U.S. Senate Environment and Public Works Committee, said in a statement. "I am concerned that his encyclical will be used by global warming alarmists to advocate for policies that will equate to the largest, most regressive tax increase in our nation's history." He continued, "It's the poor that spend the largest portion of their expendable income to heat their homes, and they will be the ones to carry the heaviest burden of such onerous policies."

By **Randy Showstack,** Staff Writer

Addressing Challenges of Mitigating Flood Risk in Mountain Areas

Workshop on Modeling and Managing Flood Risk in Mountainous Areas
Folsom, California, 17–19 February 2015

Floods remain among the most widespread and impactful natural disasters, particularly in mountainous areas. Mountains represent areas of complex terrain, high relief, large precipitation variability, limited accessibility, and scarcity of hydrometeorological and pedological information. Hence, floods in mountainous areas present unique challenges in flood forecasting, response, and recovery.

Flood generation processes associated with localized, extreme events, such as cloudbursts, landslides, and glacial lake outbursts, are poorly understood. Furthermore, issues with remoteness, limited communication networks, and weak or inadequately supported governance structures make it difficult to establish effective forecasting and response systems in mountain areas. The result is greater flood vulnerability and increased potential for loss of life. Because mountain areas are particularly sensitive to climate change, their flood vulnerability will increase as changing precipitation, temperature, and snow and glacier extent affect the frequency and severity of many processes that trigger floods in mountains.

To identify the key challenges and find solutions for reducing flood losses in mountain areas, an international group of hydrologists, engineers, and managers convened in mid-February in Folsom, Calif. The goal of the workshop, which was funded by the Indo-U.S. Science and Technology Forum, was to bring together scientists and engineers from academia, industry, and government agencies in the United States and India for a discussion of ideas, techniques, and experiences.

Technical sessions focused on different facets of flood generation in mountain forecasting, hazard modeling, and management. Discussions and presentations centered on identifying the unique hydrometeorological, geological, socioeconomic, and governance conditions associated with flooding in mountainous areas and determining the key scientific and management needs for decreasing the potential of flood hazards turning into a flood disaster.

Outcomes included the identification of critical but unreported knowledge gaps in understanding atmospheric processes and their interactions with the mountain landscape. These gaps include the role of orography in driving extreme precipitation and the convergence of large-scale monsoon cells in the atmosphere. In addition, the group identified instrumentation needs specific to mountainous areas for advancing knowledge on flood generation, including specialized technologies for improved and wider monitoring of hillslopes, hydrometeorology, hydraulics, and glacial lakes.

Renoj Thayyen

Flash floods during 4 and 5 August 2010 in the Ladakh region of India affected 52 villages and 1402 hectares of crop area. The official number of deaths stands at 255, although it is believed that additional unaccounted losses occurred as many settlements of migrant laborers washed away during the flood. Total loss is estimated at 1380 million Indian rupees (approximately US$22 million). Photo taken 14 August 2010.

Participants also specified five management principles that address the unique challenges in reducing flood losses in mountains and summarized case studies in which those principles were successfully applied. For example, one principle argues for implementation of mitigation measures that are effective under limited or short forecasting times, including nonstructural flood infrastructure, land use planning and regulation, and early warning systems. A second principle calls for training local people and officials in disaster planning, response, and recovery. All principles are based on the premise that the forecasting, mitigation, and communication of flood hazards require additional efforts in mountain areas.

Data, details, and implications of the workshop are analyzed and reviewed in three manuscripts on the topics of mountain flood processes, forecasting, and management. These papers are currently in the final stages of preparation.

The workshop principle investigators are Desirée Tullos and Sharad Jain. More information can be found at the working group's website (http://bit.ly/OSUFlood).

By **Desirée Tullos,** Oregon State University, Corvallis; email: desiree.tullos@oregonstate.edu; and **Sharad Kumar Jain,** National Institute of Hydrology, Roorkee, India

Reality Check: Seismic Hazard Models You Can Trust

One is well advised, when traveling to a new territory, to take a good map and then to check the map with the actual territory during the journey.
Wasserburg *[2010]*

City planning boards, real estate investors, and average citizens naturally desire information that can help them decide where to live, build, and spend their money. Scientists are skilled in building models that use data from past events to predict the likelihood of similar events in the future. Thus, earthquake hazard maps based on models and observations are an appealing tool for risk evaluation, investment decisions, and emergency response preparation.

However, before earthquake hazard maps can be used for practical risk estimation, they must be based on sound Earth sciences. This includes rigorous testing against the available real seismic data to avoid the geophysical equivalent of medical malpractice. Overreliance on untested seismic hazard maps can cause a failure to predict risk levels accurately. Underpredicting earthquake risks can lead to fatalities and significant economic losses [*Wyss et al.,* 2012]. Overpredicting risks can drive investment in expensive and excessive safety measures.

We assert that current probabilistic methods to quantify earthquake hazards have serious problems. These methods rely on uncertain probabilistic assessments; overreliance on these methods can lead to significant confusion about what earthquake hazards actually may be. Instead, a deterministic approach may help us to achieve reliable hazard assessments by realistic and physically sound modeling of specific scenarios.

The Problem with Probabilistic Methods

Probabilistic methods of estimating earthquake hazard (the one by *Cornell* [1968] and its reappraisals) are not based on physically sound models and have some fundamental flaws [*Castaños and Lomnitz,* 2002; *Cyranoski,* 2011]. In particular, the dimensionless probability of exceedance (the probability that a given level of ground shaking will be exceeded in a given period of time) is erroneously equated to the dimensional rate of occurrence (the number of events per given period of time [*Wang,* 2011]), making problematic even the math of probabilistic seismic hazard analysis (PSHA).

Disastrous earthquakes are low-probability events locally; however, in any of the earthquake-prone areas worldwide they reoccur with 100% probability sooner or later. Very uncertain and long times between events and/or low probabilities—which provide the basis to downgrade the expected ground shaking—can and do lead to community officials systematically neglecting the most dangerous hazard. With this approach, disastrous earthquakes will keep occurring as catastrophic "surprises."

Seismic Hazard Map Reality Check

We used PSHA, namely, the Global Seismic Hazard Assessment Program (GSHAP) [*Giardini et al.,* 1999], as our guide on a journey to the actual territory of earthquake hazards [*Kossobokov and Nekrasova,* 2012]. Our study disclosed a gross inadequacy: the GSHAP estimates were exceeded in each of the 88 earthquakes with a magnitude (*M*) greater than or equal to 7.5 that struck around the world from 1990 to 2009. These estimates were also exceeded in the 12 deadliest earthquakes that shook between 2000 and 2011 (more than 700,000 total fatalities). Such a poor performance could have been foreseen with a simple check against earthquakes in the past before the GSHAP results were disseminated.

A check of the new map issued by the Seismic Hazard Harmonization in Europe (SHARE) project [*Giardini et al.,* 2014] discloses a further step away from seismic reality. A quick glance at the map "displaying the 10% exceedance probability in 50 years for peak ground acceleration" [*Giardini et al.,* 2014, p. 261] (Figure 1) captures the problem of seismic hazard assessment in Romania—an underestimation of the area where potential intensity is IX or higher ("violent" on the modified Mercali scale of earthquake effects, classified as an acceleration more than 40% that of gravity).

The well-established complex geometry of ground shaking from intermediate-depth earthquakes in the Vrancea zone of Romania suggests a donut-like pattern of seismic intensity on a large scale [*Radulian et al.,* 2000]. This is evident in the neodeterministic seismic hazard assessment (NDSHA) map (Figure 1a; see torus) but does not exist on the SHARE map (Figure 1b).

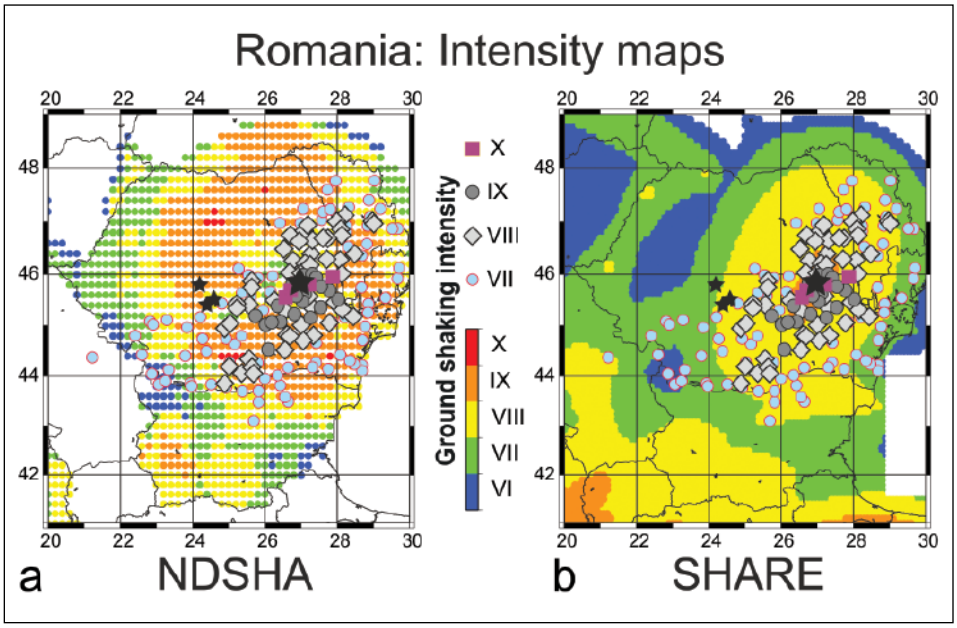

*Fig. 1. Seismic hazard assessment for Romania. (a) Neodeterministic seismic hazard assessment (NDSHA) method [*Radulian et al., *2000]; (b) Seismic Hazard Harmonization in Europe (SHARE) project [*Giardini et al., *2014]. Colored regions represent shaking intensities calculated using each method. Color-coded symbols indicate observed shaking intensities. The large star marks the shock epicenter of the 1940 M7.7 earthquake in Vrancea, and smaller stars are epicenters of violent shocks in the Fagaras zone in 1550, 1571, and 1590.*

National Geographic Romania

Rescue operations after the M7.7 Vrancea earthquake in Romania, which shook on 10 November 1940

The neodeterministic approach uses scenario-based assessments based on physical modeling of seismic wave propagation at various scales and, unlike PSHA, does not make mathematically questionable assumptions about local site responses. In the Romanian example, NDSHA recognizes the area of high seismic hazard in the Fagaras zone, to the west of Vrancea, which experienced a series of violent shaking events in the second half of the 16th century. These events were missed by the PSHA SHARE map.

For the largest instrumental event in the Vrancea zone of intermediate-depth earthquakes, the *M*7.7 earthquake of 10 November 1940 (large star in Figures 1a and 1b), the SHARE map inadequately describes the areal extent of the observed intensity VII–VIII ("very strong" to "severe") on the southwesternmost part of the violent ground shaking area at about 44°N, 23°E [*Kronrod et al.*, 2013]. (To facilitate checking, we converted the peak ground acceleration (PGA) values from both NDSHA for Romania [*Radulian et al.*, 2000] and the SHARE data source to the same macroseismic intensity scale.) Evidently, the simplistic geometries associated with the SHARE map are unable to capture the complex pattern of intensity distribution displayed by real observations [e.g., *Kronrod et al.*, 2013, and references therein], where maximum intensities are shifted with respect to the epicenter of an earthquake.

A Closer Look

A deeper analysis of SHARE maps [*Nekrasova et al.*, 2014] performed for Italy reveals that even relative to GSHAP, the new regional assessment shifts the distribution functions of ground shaking intensity away from reality, toward exceedingly high values (Figure 2). This discrepancy is seen by running models at 10% and 2% probability of exceedance over a period of 50 years.

Specifically, the empirical probability function based on the SHARE10% map deviates from distributions of the observed ground shaking by 80%, and the SHARE2% graph is an outlier in Figure 2 shifted by four units of intensity from the two distributions based on

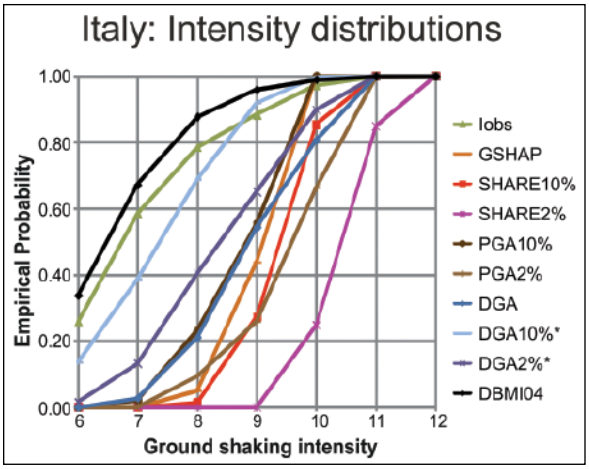

*Fig. 2. Empirical probability functions of the macroseismic intensity in Italy, comparing the probabilistic peak ground acceleration (PGA) and the neodeterministic design ground acceleration (DGA) methods with the observed ground shaking. The green line (Iobs) represents observed data taken from the SHARE European Earthquake Catalogue, and the black line (DBM104) represents direct seismic observations [*Stucchi et al., *2007]. Other lines represent probabilistic seismic hazard analysis (i.e., the Global Seismic Hazard Assessment Program (GSHAP) [*Giardini et al., *1999], SHARE10% and SHARE2 (models run at a 10% and 2% probability of exceedance over a period of 50 years) [*Giardini et al., *2014], and PGA10% and PGA2%) and NDSHA (i.e., DGA, DGA10%*, and DGA2%* [*Nekrasova et al., *2014]). Note that PGA10% and PGA2% are used to form the official seismic hazard map of Italy.*

observations. Available alternative maps, such as the neodeterministic DGA10%* [*Nekrasova et al.,* 2014], provide a better fit to the observed ground shaking in Italy than the PSHA products.

A Stable Foundation for Decision Making

Giardini et al. [2014, p. 261] wrote, "Thus, future safety assessments of and improvements to the built environment will be able to rely on these [SHARE] calculations." However, we show that such safety assessments and improvements can hardly rely on the SHARE calculations, at least in Romania and Italy. Given the above analysis, other state-of-the-art methods of modeling realistic earthquake scenarios allow for more realistic seismic hazard assessment [e.g., *Panza et al.,* 2012].

Therefore, we urge the necessary revision of widespread PSHA maps. Physically sound deterministic methods [*Italian Chamber of Deputies,* 2011] would enable the maximal magnitude of an expected earthquake for seismically hazardous areas to be estimated with a statistically justifiable reliability [*Kijko,* 2012]. Deterministic scenarios of catastrophic earthquakes may provide a comprehensive basis for decision making for land use planning, adjusting building codes, regulations, and operational emergency management.

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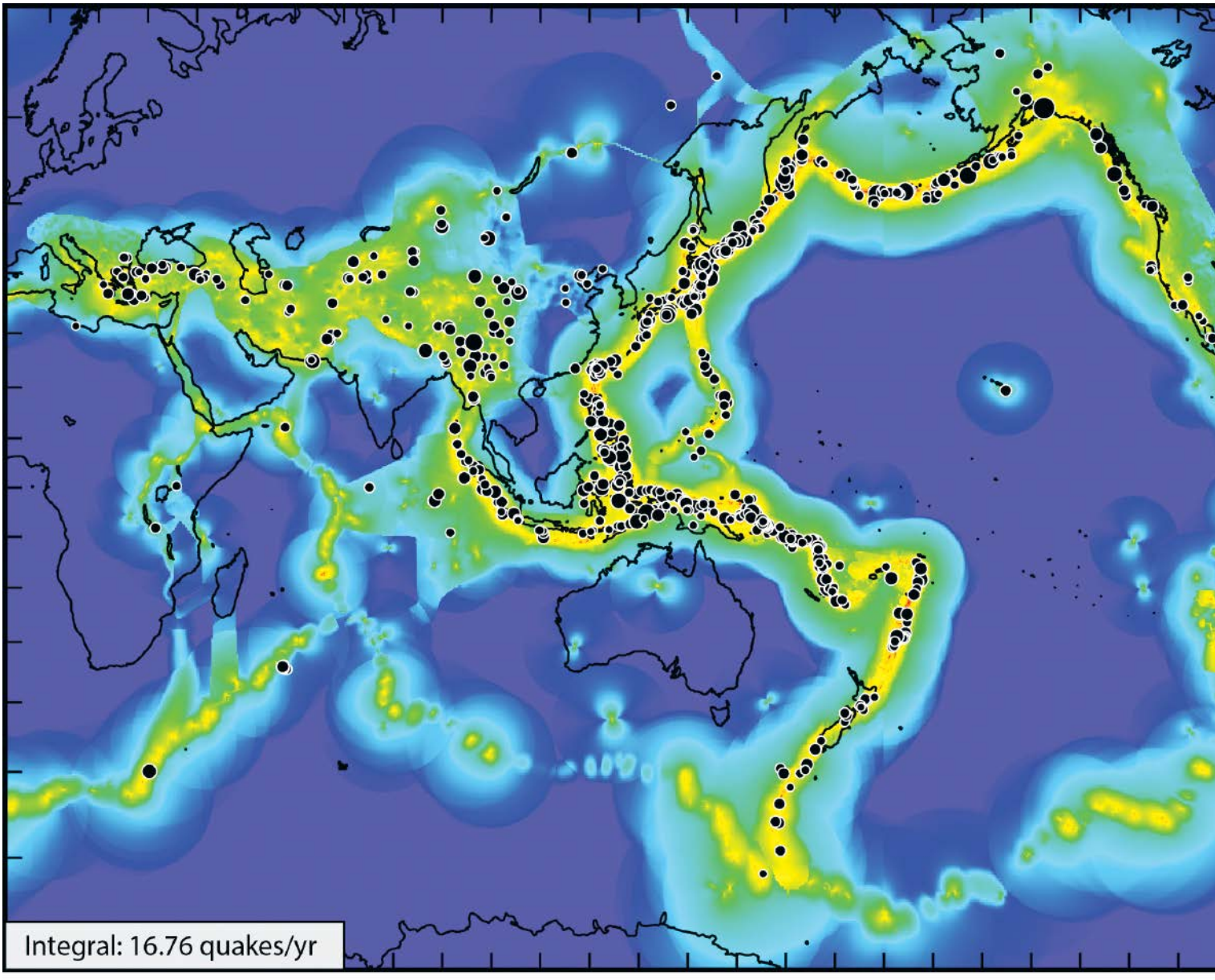
For more on efforts to resolve seismic hazard assessment debates, see p. 12.

SEISMIC HAZARD

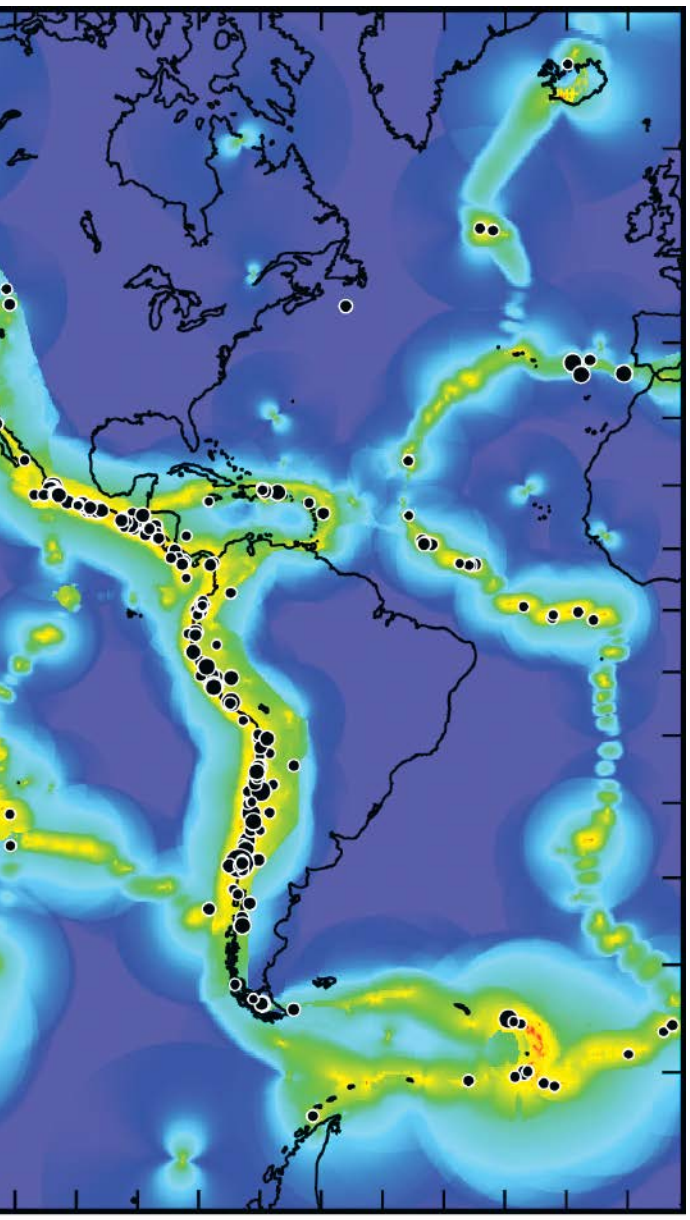
Honing the Debate, Testing the



ASSESSMENT

Models

By Ross S. Stein and Mark W. Stirling



Ross S. Stein

Devastating—and, in some sense, unforeseen—earthquakes in Nepal, Japan, New Zealand, Haiti, and elsewhere have triggered a heated debate about the legitimacy and limitations of probabilistic seismic hazard assessment (PSHA) [*Frankel*, 2013; *Stein and Stein*, 2014] (see p. 9 of this issue of *Eos*). PSHA attempts to capture the likelihood of exceeding a specific level of shaking over any time period of interest, explicitly incorporating data uncertainty and lack of knowledge.

To address this debate, four workshops held in 2013–2014 at the U.S. Geological Survey (USGS) John Wesley Powell Center for Analysis and Synthesis brought together university, government, and insurance industry scientists from countries that straddle plate boundaries and those in plate interiors. Participants were invited; the workshops' goals involved developing tests of PSHA and other earthquake hazard

*Global earthquake activity rate (GEAR) model, version 1.0 (colors), compared to the catalog from the independent International Seismological Centre Global Earthquake Model (ISC-GEM) earthquakes (dots [*Storchak et al., *2015]), which is complete for all magnitudes greater than or equal to 6.8 since 1918 [*Michael, *2014]. The GEAR model is perhaps the first globally uniform, intercomparable, and testable earthquake forecast; it could ultimately form the basis of a global uniform probabilistic seismic hazard assessment (PSHA) model that could also be further tested.*

Scientists rest midway through a group hike during one day of a seismic hazards assessment workshop in the Colorado Rockies. The workshop used hiking as a way to foster a sense of camaraderie and create long, unguarded discussions among the hikers, despite heated debate around the workshop table.

assessment strategies and seeking viable alternatives to overcome weaknesses to these strategies.

Workshop coordinators adopted a novel approach to ensure civil debate: roundtable discussions, sometimes over a group activity such as hiking. This approach could be adapted by any seeking to resolve scientific debates within disciplines. Three crucial aspects of the approach proved to be key to running the workshops.

First, we asked each invitee to take what we called the "Powell Blood Oath"; each was welcome to argue passionately for personal views but must also present and acknowledge the weaknesses in that position. The oath kept everyone humble; no one grandstanded or dismissed others because no one had all the answers. Those who could not abide by the oath turned our invitation down.

Second, we sat around the table, each participant with a laptop plugged into the projector, so that anyone could interject with figures or images from their computer by clicking a switch. No lectern, no uninterrupted talks, no fealty to the clock; everything was conversational, open, informed, and fluid. The minutes were written into an Etherpad that all could access and modify on the fly, so no single person shaped the record.

Third, we took a hike in the Rockies during the middle day of each workshop, during which the scientific conversations only deepened. Talking on a hike is less confrontational than around a table—delicate issues got discussed in depth. On the climb, when short of breath, you talk less and listen better. People who were quiet around the table found themselves in deep discussions; giving their views had greater impact. At the top, even hikers with divergent views have shared an accomplishment, which brings everyone together.

Critics of PSHA and critics of the cohosts—the USGS and the Global Earthquake Model (GEM) Foundation—were invited and listened to. Those who lead the PSHA modeling for their nations saw how others are tackling similar problems with different approaches. Together, we identified the tests that are most needed to assess the value of PSHA and what tools are most needed to improve it.

Two major efforts grew out of the Powell meetings: the global earthquake activity rate (GEAR) model and a retrospective test of the U.S. National Seismic Hazard Mapping Project models.

Global Earthquake Activity Rate Model

GEAR gives the rate of earthquakes of all sizes everywhere on Earth [*Bird et al.*, 2015]. It was constructed through a blend of the GEM strain rate model, which reflects the forces that drive fault slip, and the Global Central Moment Tensor Catalog of seismicity (the frequency of earthquakes in a given region), which records the results of fault slip.

This model was built by a uniform, open, and reproducible process. It has been submitted for independent test-

ing at the Collaboratory for the Study of Earthquake Predictability (CSEP). Because GEAR can be applied uniformly over the globe, it can serve as a reference model for regional efforts that use local fault and seismic data (see map on p. 12).

Testing Successive U.S. Seismic Hazard Models Against Observed Shaking

Because PSHAs are provided to the public, a second goal to emerge from the discussion was to demonstrate their utility. One outgrowth of this goal is a retrospective test of the 1996–2014 U.S. National Seismic Hazard Mapping Project (NSHMP) models.

After the workshops, all of the strong motion or "Did You Feel It?" observations from California were pooled to create a single hazard curve, giving the probability of exceedance (shaking above a given level) as a function of ground motion, which was compared to a pooled prediction curve from the models. The results are sensitive to how the data are binned and counted, but for high values of shaking (>10% that of the acceleration of gravity), each successive NSHMP model does a better job of matching the data.

Unresolved Problems of PSHA

According to the Powell workshop participants, assignments of the maximum earthquake magnitudes that will ever happen on faults are some of the least defensible elements of PSHA. We know only that the longer the observation period is, the higher the observed maximum magnitude is.

PSHA modeling typically seeks to strip out aftershocks, foreshocks, and swarms to isolate main shocks. This "declustering" is highly uncertain, leaving anywhere from 80% to 20% of the earthquakes as "main shocks." The gathered participants agreed that there should be standardized declustering algorithms and tests of whether the declustered catalog exhibits Poissonian behavior (in other words, whether earthquakes are independent of each other).

Regions far from the edges of tectonic plates present some of the most difficult conditions for PSHA. Since little is typically known of the faults or their slip or strain rates, the historical record of quakes is often used, in which the distribution of small shocks is smoothed and scaled to estimate the rate and distribution of large shocks. But do recent small shocks forecast large ones? Even if this strategy is justified, the appropriate amount of smoothing is unknown, attendees agreed.

The Powell process generated new models, tests, and problems. But perhaps more important, it brought people with opposing views together to work around a table and on a trail to find common ground.

Acknowledgments

We are grateful for support from the USGS Powell Center and the GEM Foundation and for the outstanding efforts of the Powell Center's codirector and host, Jill Baron.

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LEARNING GEOSCIENCE BY DOING GEOSCIENCE

Hemalantha Bhaskaran

Laura Murray

By Laura Murray

Science—as done by professional scientists—involves curiosity, hypothesis forming, experimentation, data analysis, and the thrill of discovery. However, you might never learn this in a traditional high school classroom, where teachers often present scientific subjects as sets of facts to be memorized rather than as perpetually evolving fields of active inquiry.

Teachers are hardly to blame for this disconnect: Too often, their own education involved "cookbook" laboratory exercises and dry, dated lectures. It's no wonder that many end up teaching as they have been taught.

To break this cycle and to expose teachers to genuine scientific practice, we developed a program in which scientists provide teachers with the tools and hands-on experience they

(left) Students participating in a pilot science education project investigate species diversity in Virginia's Chincoteague Bay. (right) Teachers investigate the ecology of the submersed plant Zostera marina *in a Virginia coastal lagoon.*

need to implement research projects with their students. Our results suggest that projects such as ours can increase student understanding of the scientific process.

Recognizing a Problem

Most secondary school educators do not have the opportunity to experience authentic research science during their academic tenure. They study science content in lectures and closed-ended lab exercises and take education methods courses that are frequently divorced from any scientific content.

Recognizing the gap between scientific practice and science taught in schools, the authors of the Next Generation Science Standards (NGSS; see http://www.nextgenscience.org) along with other science education experts [*Freeman et al.*, 2014] have called for reforms enabling students to be able to "mirror the practices of professional scientists" and to develop an "understanding of the nature of science and engineering." (p. 8 of the NGSS introduction).

We agree with the impulse behind these reform efforts, but we also recognize that they depend on teachers themselves being familiar with scientific practices and able to communicate to their students about the nature of science.

From the Lab to the Classroom

To enhance teachers' and students' understanding of how geoscientists create new knowledge, we developed the Research Experiences for Science, Technology, Engineering and Mathematics Students (RE STEM) pilot program. We engaged working scientists who would expose teachers and their students to research- and inquiry-based geoscience experiences.

The program blended expertise from a higher-education research facility, the University of Maryland Center for Environmental Science's Horn Point Laboratory (UMCES HPL), with administrative expertise from local public school districts. UMCES HPL scientists participated throughout the program as described below, whereas school administrators (especially science supervisors) approved the program concept, helped recruit and select teachers, and supported the integration of research projects for students into existing high school STEM courses.

Two-Part Plan

The RE STEM program consisted of two parts: a professional development workshop for teachers and the classroom implementation of research projects for students. The program staff first developed a protocol (Table 1) that was based on the scientific process and incorporated inquiry-based learning in a formalized format.

Table 1. Protocol for RE STEM Program.

1. Project leaders select significant content
2. Project leaders capture participant interest
3. Participants develop research questions
4. Participants submit a mini research proposal
5. Participants design and implement an experiment
6. Participants analyze data
7. Participants formulate conclusions
8. Participants communicate results

The protocol encouraged participants to develop research questions based on background knowledge, to conduct experiments to address the research questions, to formulate conclusions, and to communicate these results. This protocol guided both components of the program.

Teachers Practicing Science

We invited nine teachers from four local school districts to participate in a 5-day summer professional development institute held at UMCES HPL. At this institute, we introduced teachers to authentic geoscience research, incorporating research methods used by UMCES HPL scientists.

Following the RE STEM protocol, we chose two content areas (step 1)—aquatic food webs and land-water connections—to serve as topics for the participant research projects.

For each area of study, a faculty scientist and graduate student copresented background information and current

Hemalatha Bhaskaran

Students in the pilot RE STEM program assess nutrient (nitrogen and phosphorus) concentrations in Chincoteague Bay using colormetric analysis kits.

research (step 2). We then asked participants to form teams, choose a content area in which to conduct their research project, and formulate a research question (step 3).

Using a miniproposal template (step 4), participant teams wrote short background, hypothesis, and methods sections to address the question. UMCES HPL scientists reviewed the proposals and made suggestions, after which participants set up and conducted their research experiments (step 5), analyzed their data (step 6), formulated conclusions (step 7), and presented their results to the group via oral PowerPoint presentations (step 8).

Engaging Students

In the second phase of the project, teachers implemented in their classrooms the RE STEM protocol for scientific inquiry. Teachers chose topics for the student research projects that fit their course curriculum. They then prepared students by setting a stage for the research project that provided a compelling introduction to the topics and captured students' interest.

Once the students were introduced to the topics, they formed groups to complete the steps of the RE STEM protocol. Because teachers chose the topics and the course in which to pilot the research projects, the actual implementation of the experiments varied among the teachers.

Teachers led projects in STEM classes ranging from ninth-grade biology to senior-level Advanced Placement biology and environmental science (Table 2). Project topics ranged from the influence of land use on stream water quality to investigations of barrier island ecology. Several teachers chose to implement classroom-based projects, wherein students conducted investigations in class or on school grounds. Others took students on field trips to local

Table 2. Student research topics.

Course	Research Topics
Honors Biology	Mechanistic activity of enzymes
Lower Level Biology	Stream water quality and FieldScope
AP Biology	Effects of hydroponics vs. aquaponics on plant growth
	Effect of temperature on plant structure
	Responses of mice to unfamiliar environments
Environmental Science (9th)	Effect of temperature on algal growth
	What type of plants mitigate erosion
	How do sediment and nutrients affect aquatic plant growth
	Impact of environmental factors on algal cultures
AP Environmental Science	Relationship between sea grass and water quality
	Effects of erosion on aquatic plant species
	Comparison of plant species diversity on a barrier island
	Relationship between water depth and water quality in an estuary
	Effects of tourism on aquatic ecosystems
	Relationship between abiotic factors and fish abundance
	Assessment of tidal creek water quality

environmental centers and/or parks for their investigations.

One example of the implementation of a student research project involved four students working together to investigate plant species diversity on a coastal barrier island. Students chose three habitat areas (dune, maritime forest, and salt marsh) in which to make their comparison. They first formulated their research question and hypothesized that less resource-stressed environments will have a greater species diversity. They then systematically counted the number of species found in each habitat, compiled and analyzed their data, and presented the results in a paper and a verbal report to the class.

Positive Results

Of the nine teachers who participated in the pilot project, seven implemented student research projects. An external evaluation of teacher responses to the RE STEM program was very positive, and participants appreciated the efforts of project planners and staff.

Teachers identified two important ways that the pilot project prepared them for implementing the student research projects: (1) through modeling the inquiry-based learning process and (2) through engagement in the same procedures that students would experience. The teachers reported that they planned to incorporate more inquiry-based investigations into their lesson plans and to abandon the traditional process whereby teachers provide students with all the content information.

Teachers reported that they planned to incorporate more inquiry-based investigations into their lesson plans and to abandon the traditional process whereby teachers provide students with all the content information.

In summative evaluations of the implementation of the student research projects process, teachers reported that they learned things about their own teaching methods as well as their students' abilities and inabilities as a result of participating in this RE STEM program. Some commented that it was hard to relinquish control and allow students to guide their own projects. Others were surprised that their advanced students knew so little about the scientific process.

Six of the RE STEM teachers said they plan to implement student research projects in following years, a result that demonstrates the lasting impact of the RE STEM program on its participants.

Results of preprogram and postprogram surveys of 342 participating students show significant increases in average scores for four survey items (out of 12; see Table 3), three of which relate to understanding how the scientific process works. These results indicate that the program had a measurable impact on student understanding of the scientific process. However, the survey results also revealed that students did not necessarily wish to take additional science courses or to choose careers in science as a result of going through the pilot program.

Table 3. Preprogram and postprogram student survey items that show a significant (*t*-test) increase in agreement or change in attitude. Pre Mean and Post Mean are the averages of responses to items on a 1–5 scale, where 1 = Strongly Disagree, 3 = Uncertain, and 5 = Strongly Agree; ± indicates the standard deviation from the mean; and Cohen's *d* determines the size of the effect indicated by the significance test, where <0.40 = small, 0.41–0.79 = medium, and >0.80 = large effects.

Item	Pre Mean	Post Mean	Cohen's *d*
I have a good understanding of how scientists do research	3.80 ±0.62	4.38 ±0.54	1.00
Advancements in science are largely responsible for the standard of living in the United States	3.89 ±0.85	4.36 ±0.71	0.60
I know how to conduct scientific research	3.68 +0.75	4.23 ±0.66	0.78
I am confident that I will be able to answer questions about the scientific process	3.72 +0.64	4.04 +0.73	0.47

Elements of Success

Support from local school district administrations was crucial to this program's success. Not only did school administrators help select teachers for the program, but they also provided in-school support for student research project implementation, for example, by allowing teachers the time and freedom to deviate from normal classroom protocols.

Also critical was the involvement of UMCES HPL scientists and graduate students, who provided current, real-world content for the RE STEM program and student research projects.

Finally, because teachers had the flexibility to implement projects associated with topics already taught in existing STEM courses, they indicated that they were likely to continue offering research experiences to their students in the years to come.

Acknowledgments

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AGU CHAPMAN CONFERENCE

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Working Toward Gender Parity in the Geosciences

Although women receive 40% of the undergraduate degrees in geosciences in the United States, these numbers plummet in postgraduate academic career paths. Why the drop-off? Could it be the lack of mentors for women in the geosciences or perhaps the implicit biases that affect hiring of women?

Mary Anne Holmes, a University of Nebraska professor of practice, geosciences/sedimentology, and women in geosciences, pulled together research in an attempt to address these issues in a new book titled *Women in the Geosciences: Practical, Positive Practices Toward Parity,* published 8 June by AGU (http://bit.ly/WomeninGeoscienes).

Eos sat down with Holmes to ask her a few questions about how women are represented in the geoscience fields and about the book.

Eos: *Why did you decide to put this book together?*

Holmes: The immediate motivation was that my coauthors and I became aware of how many women geoscientists were working in National Science Foundation (NSF) ADVANCE and ADVANCE-type programs across the nation, and it seemed like a good time to compile what we've learned. ADVANCE is an NSF crosscutting program—all the NSF directorates contribute to its funding because they support the goal—to increase the number of women on the faculty in science, technology, engineering, and mathematics—STEM—fields.

ADVANCE is the latest program that NSF launched to increase the number of women in the professoriate. It is a response to program officers recognizing that underrepresentation cannot be addressed by funding one woman at a time but that it was time to "fix the institution, not the woman."

The National Science Board, NSF's governing body, collects the data that show that women receive geoscience degrees, but those numbers have not been translating to numbers of women applying for grants at NSF. The first few programs to try to address this issue launched back in the 1980s and 1990s targeted individual women; ADVANCE targets the institution.

Really, the book addresses the broader issues of underrepresentation of women in STEM; we hoped that by writing specifically to geoscientists, we could have more of an impact on our own field.

Eos: *You mention that there is a large percentage of women who pursue geosciences as undergraduates but that this number drops off as they advance in academics. Where does "parity" begin?*

Holmes: Parity, I think, begins when the proportion of women in faculty and professional positions more or less matches the proportion that majored in geoscience. And we understand that there's a time lag.

In *Nature Geosciences* in 2008 [http://bit.ly/NGHolmes], we argued that parity will occur when every geoscience student can see someone on the faculty whose life they wish to emulate. For example, at one point my department had five women on the faculty, but none of us had children. I don't consider that "parity." I had women students in my office in tears because they loved geoscience but would not give up the opportunity to have a family; from the faculty they saw, they thought they had to choose between the two. This is a terrible choice no one should be forced to make.

> Parity begins when the proportion of women in faculty and professional positions more or less matches the proportion that majored in geoscience.

Now we have a baby boom in our department. I never have female students in my office in tears anymore.

Eos: *Why do women tend to turn away from geosciences between undergrad and more advanced degrees?*

Holmes: The closest we have to a systematic data set addressing this question is a set of focus group results from 2003 where we asked geoscientists whether they had ever considered leaving and, if so, why. We found that men and women considered leaving, but more women considered leaving than men.

Many of the reasons were common among respondents, including difficult classes or finding they were in the wrong subdiscipline. But only women had issues such as "unhelpful/discouraging advisors" and the utter lack of accommodation for family, particularly when they were students. Even tenured women considered leaving after tenure when the arrival of a new child or the dislocation of a spouse caused enormous stress in their lives.

So, from these results, the answer includes the continued denial of the need for faculty and students to attend to family needs and also a continued nonwelcoming or nonencouraging/nonsupportive climate in some departments.

In addition, from my personal experience, I see a lack of role models, a lack of encouragement from faculty, exclusion from networks, and crises of confidence also contributing.

Eos: *Why are mentors so important for women who want to pursue geosciences?*

Holmes: A good mentor elucidates informal policy and practice, whether the mentee is a woman or a man. He or she imparts the unspoken cultural rules and norms. In many cases, this process is so informal, even subtle, as to be nearly implicit. We may not even realize we are being mentored when it happens. But we learn the informal practices and policies from mentors, whether we are aware of it at the time or not.

In addition to mentors, it is helpful to have sponsors. These are people who go to bat for us, who make the argument on our behalf when we can't be in the room during performance evaluations.

Eos: *You mention in the book that the "pipeline" metaphor describing how students advance through academia has limitations. What are these limitations, and how does the "interstate highway" metaphor that you introduce better fit this issue?*

Holmes: For one thing, the metaphor suggests that the people in the pipeline are passively being moved along it—or not—with no agency of their own. For another, a pipe tends to go to one place, and in the geosciences, there are many career tracks possible.

The interstate highway metaphor is probably a better conceptual model because it allows for multiple entries, exits, rest stops, and destinations. The straight-line career path of undergraduate, graduate, postdoc, academic job works for some people but not for everyone. People have to pause along the way for many reasons. Currently, it is difficult to get back on track, but there are ADVANCE programs that address "on-ramping."

Mary Anne Holmes

A group of men and women geoscientists in Big Horn Basin, Wyoming, at an Iowa State/University of Nebraska–Lincoln field camp. Studies show that despite the number of women pursuing undergraduate degrees in geosciences, fewer women move on to earn advanced degrees.

An example of how on-ramping can benefit academia is the doctorate holder who works in industry, government, or a nongovernmental organization for a while. That person may not have the publication or grant-dollar record we normally look for in a candidate for an entry-level academic position, but he or she could bring a wealth of expertise and a new perspective that could greatly benefit the science.

Eos: *How do implicit biases affect hiring, promoting, evaluating, and accepting women students? What steps are being taken to mitigate this effect?*

Holmes: Implicit biases can cause small negatives against some group in any evaluative process. There are many studies—some discussed in the book—that demonstrate that if a resume for a STEM job is constructed out of thin air and a man's name is put on one copy and a woman's on the other, both men and women will prefer to hire or promote the man.

In academia, when there is a slight difference in who gets encouraged to apply for graduate school and a difference in who gets admitted and who gets the assistantship or fellowship, then those differences repeat for postdoctoral positions, this trend results in what Virginia Valian of Hunter College calls "the accumulation of disadvantage." As a result, there will be fewer women higher up the career ladder.

Further, research demonstrates that we all tend to write better, more superlative letters of recommendation for men when compared to those we write for women. Realizing that the letters for women and people from all underrepresented groups will be less stellar, we need to take that into consideration and not rely solely on the letters. It does make evaluation more time-consuming and troublesome at first, but with time, new procedures will become as routine as current ones are.

How to mitigate implicit bias? Surprisingly, there is not as much solid research on this, but what exists suggests that implicit biases are stronger when we are unaware that they exist, so learning about implicit bias is essential.

In addition, when we are in a rush, we rely on gut instinct. So allowing plenty of time to evaluate applications is essential.

Eos: *Why have you dedicated much of your life to studying the gender gap in the geosciences? As a geoscientist yourself, did you see discrimination or experience a "chilly climate" firsthand?*

Holmes: I absolutely have experienced and witnessed it, but that is all ancient history. What concerns me is how we move forward so that anyone attracted to our field is recruited and retained for whatever geoscience career they choose. I am concerned that in some places, there still is an unwelcoming or even chilly climate, as I have heard from some current graduate students; for example, a student recently told one of my coauthors that she was discouraged from doing strenuous field work.

Why have I dedicated much of my life to this issue? My friends joke it's in my genes: My mother worked with the League of Women Voters for decades for women's rights in Georgia. When she arrived in Georgia from Louisiana—so my father could attend Georgia Tech on the G.I. Bill—she was horrified to learn that Georgia did not allow women to enter contracts without having a male family member cosign. Women could not get a loan to buy a car, could not have their name alone on a home mortgage. Her mother, my grandmother, so cherished the right to vote—a right not honored until she was in her early 20s—that she saved her voting receipts and never missed a vote.

Eos: *Are there any data on other underrepresented groups, such as women of color or transwomen, in STEM fields or, specifically, geosciences? Is there any research being done on how these groups fare in STEM fields?*

Holmes: There is definitely research being done on other underrepresented groups, particularly in the ADVANCE program. Much of this work got a late start, unfortunately, and not enough was available for the geosciences as we began to put the book together.

The principal issue for ADVANCE is that numbers of women of color are so low that the Institutional Research Boards that govern how surveys are conducted rarely allow the disaggregation of the data. For example, there might be one woman of color in the biology department; to report this in data sets would allow her to be identified and would be a violation of her privacy, so at most institutions, we do not know the survey responses of people from underrepresented groups or, in many cases, even their numbers if there are fewer than five.

So with five we could have a bin labeled "racial/ethnic minority," but we have no idea even what races or ethnicities are in that bin. This really limits finding solutions.

As for transwomen, few surveys even ask about [gender identity], and if they did, we would have the same issues with low numbers and privacy protection.

I'm hopeful that someone will be able to bundle data sets from multiple academic institutions to reach the critical numbers we need to start to really dig deeper into the specific issues and barriers for our colleagues. The solutions will involve institutional transformation, just as ADVANCE recognized the need to fix the institution, not the woman.

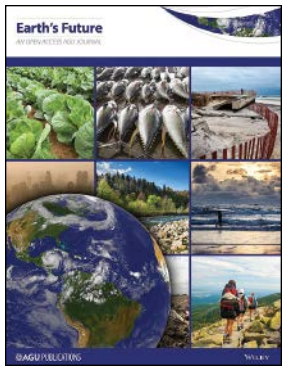
By **JoAnna Wendel,** Staff Writer

Women in the Geosciences: Practical, Positive Practices Toward Parity, 2015, 192 pp., ISBN: 978-1-119-06785-6, list price $79.95

Earth's Future: Now Indexed in Web of Science

AGU's open access journal *Earth's Future* has been accepted for future indexing in Thomson-Reuter's Web of Science. *Earth's Future* is a transdisciplinary journal that explores global change and sustainability (see http://bit.ly/AGUEarthsFuture)

More than 65 articles, including research articles, reviews, and commentaries, have been published in *Earth's Future* since its first issue in December 2013. *Earth's Future* articles have reached a broad global audience, with more than 112,000 views and more than 86,000 full article downloads. Individual articles are already included in Web of Science, Google Scholar, and other trackers.



Earth's Future, published by AGU since December 2013.

Although the official impact factor won't be available until 3 years after publication of the first article, *Earth's Future* articles have already received high citations and strong Altmetric scores. Altmetric analyzes the online activity around scholarly literature, including tracking news articles, blogs, Twitter, Facebook, and Google+. Several articles have received double-digit citations in fewer than 2 years, and the top article has gotten more than 50 citations.

Earth's Future articles have a mean Altmetric score of 28.2, greatly exceeding the global average score of 4.9. Some *Earth's Future* articles are in the 99th percentile, and many more are in the 95th percentile, of the nearly 3.8 million articles tracked by Altmetric (see box at right). The combination of impact factor and Altmetric score represents a more complete estimate of the professional and public impacts of scientific articles, with *Earth's Future* among the leaders.

Find out more about Earth's Future by

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By **Ben van der Pluijm,** Editor in Chief, Earth's Future; email: earthsfuture@agu.org

A Selection of Highly Viewed *Earth's Future* Articles

Remote sensing of fugitive methane emissions from oil and gas production in North American tight geologic formations
Oliver Schneising, John P. Burrows, Russell R. Dickerson, Michael Buchwitz, Maximilian Reuter, Heinrich Bovensmann
Altmetric Score: 125

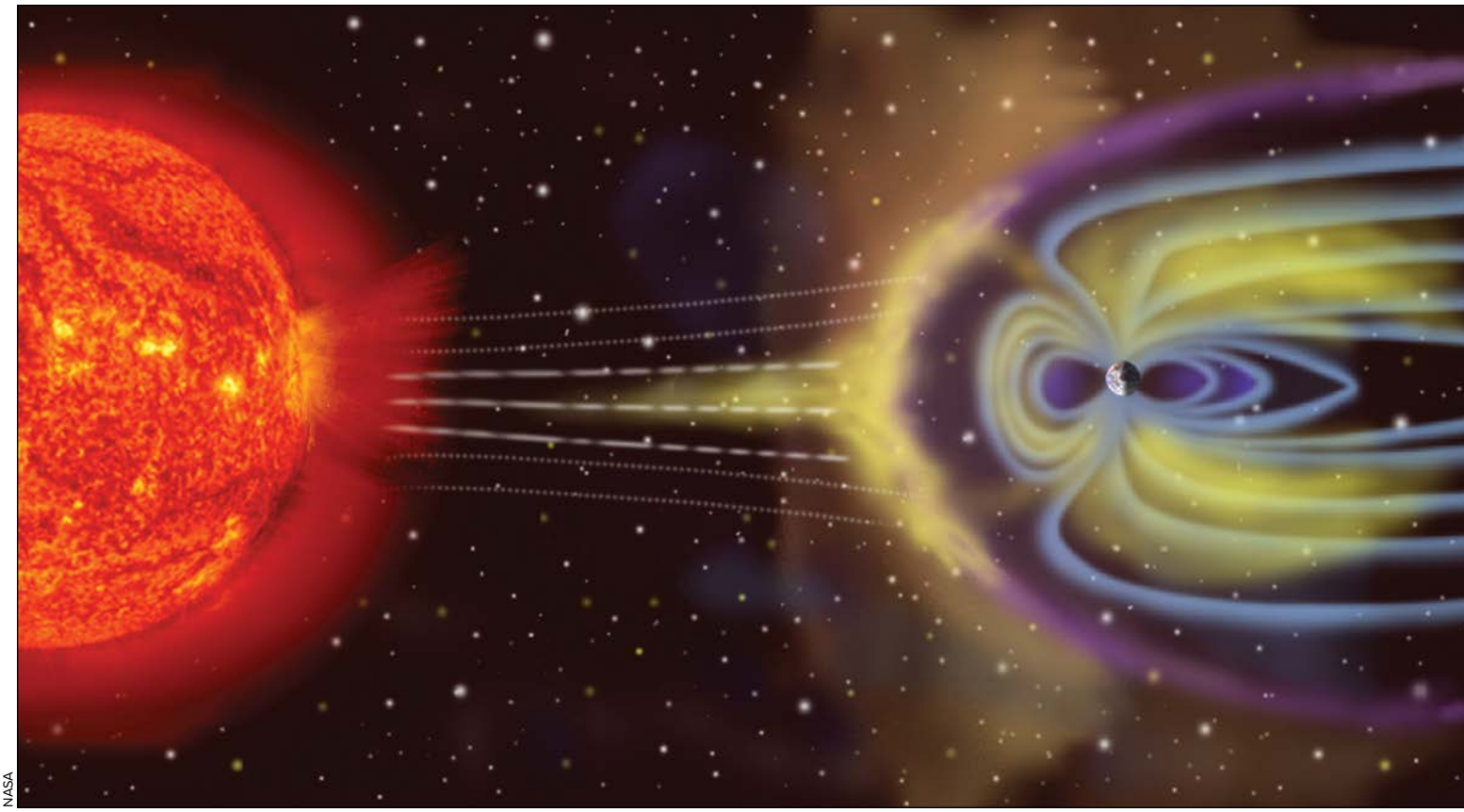
Multidecadal global cooling and unprecedented ozone loss following a regional nuclear conflict
Michael J. Mills, Owen B. Toon, Julia Lee-Taylor, Alan Robock
Altmetric Score: 131

An apparent hiatus in global warming?
Kevin E. Trenberth, John T. Fasullo
Altmetric Score: 312

Global warming releases microplastic legacy frozen in Arctic Sea ice
Rachel W. Obbard, Saeed Sadri, Ying Qi Wong, Alexandra A. Khitun, Ian Baker, Richard C. Thompson
Altmetric Score: 210

Climate scientists need to set the record straight: There is a scientific consensus that human-caused climate change is happening
Edward Maibach, Teresa Myers, Anthony Leiserowitz
Altmetric Score: 184

Probabilistic 21st and 22nd century sea-level projections at a global network of tide-gauge sites
Robert E. Kopp, Radley M. Horton, Christopher M. Little, Jerry X. Mitrovica, Michael Oppenheimer, D. J. Rasmussen, Benjamin H. Strauss, Claudia Tebaldi
Altmetric Score: 58



NASA

An artist's rendition of the Earth's magnetosphere interacting with solar wind.

X Marks the Spot of Magnetic Islands in Space

The boundary of Earth's magnetic field can be a turbulent, chaotic mess. However, a new analysis of decade-old satellite observations is putting Xs and "islands" on the map.

These strange magnetic field shapes are a result of the interaction between the magnetic fields of the Earth and the Sun. Drawn schematically, the Earth's magnetic field is coiled around the planet, with field lines sprouting from the poles, and is swept back into a long tail by the solar wind. Everything might stay simple and orderly, but the Sun has a magnetic field of its own, and the same solar winds send it careening toward Earth.

According to theory, when these field lines meet, they snap together in a process called magnetic reconnection that releases bursts of energy. When the solar wind is particularly stormy, reconnection injects showers of energetic particles from the Sun into Earth's magnetic field, which can wreak havoc on satellite communications and power grids.

When the field lines touch, they resemble an X, like rubber bands being pulled taut toward each other. Then, suddenly, the field lines from the Sun break apart and link up with field lines from the Earth, like two pairs of approaching square dancers switching partners. This process releases the built up tension, and the X lines quickly snap back, away from the original site of reconnection—at least according to theory. In practice, the snap back is difficult to observe and quantify in detail.

However, using the European Space Agency's Cluster satellites—a quartet of spacecraft that orbit Earth in formation—*Wilder et al.* have observed a retreating X line and measured its velocity for the first time. As the Cluster craft soared over the Southern Hemisphere in 2005, two of them roughly 5500 kilometers apart encountered a sharp reversal in the magnetic field direction and the flow of ions within 40 seconds of each other. The authors conclude that both craft flew right through an X line retreating down the Earth's magnetic tail.

The data also hint at a second reconnection event forming another X line behind it. This event would have isolated the patch of field lines caught between these two reconnection events, creating a "magnetic island" sliding down the tail of Earth's magnetic field.

The 40-second delay between the X line encounters also allowed the team to make the first direct measurement of an X line's velocity, clocking it at 136 kilometers per second, which is roughly the same speed as the flow of the ions just outside the Earth's magnetic field in the boundary region called the magnetosheath, where the solar wind slips past the Earth. The authors say this observation lends credence to one version of magnetic reconnection theory that predicts that the magnetosheath dominates the boundary region because of its much higher density of ions and that the ion flow carries the X line away with it. (*Journal of Geophysical Research: Space Physics*, doi:10.1002/2014JA020453, 2014) **—Mark Zastrow, Freelance Writer**

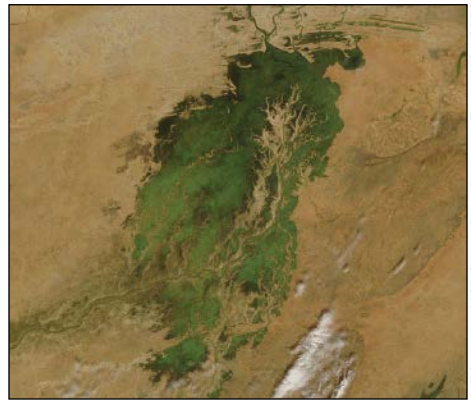
Satellite Measurements May Help Real-Time Water Management

With the demand for water stored in reservoirs rising in many areas, it is becoming increasingly important to optimize reservoir releases to meet human needs and to satisfy environmental constraints. To accomplish this in real time, managers must take into account reservoir storage and inflow records as well as data on downstream conditions, including inflows from tributaries and the operations of downriver facilities. In basins where in situ data are sparse or delayed in transmission, as is the case for many of Africa's large rivers, emergent satellite altimetry could provide a viable alternative.

In a proof-of-concept modeling study, *Munier et al.* investigated the potential for using water level data from the upcoming Surface Water and Ocean Topography (SWOT) mission—a collaboration between NASA and Centre National d'Etudes Spatiales—to more effectively manage water resources in Mali's Upper Niger River Basin. The primary SWOT instrument will be a wide-swath altimeter, which will have the ability to map water elevation and areal extent at an unprecedented spatial resolution (50–100 meters) and vertical accuracy of several centimeters when measurements are averaged over areas of 1 square kilometer.

In this study, the researchers incorporated virtual SWOT observations of reservoir and river levels into a modeling framework that simulates the hydrologic conditions on either side of Mali's Sélingué Dam. The results demonstrate that incorporating altimetry data into this framework improves estimates of water level and discharge, potentially helping resource managers ensure optimal reservoir releases. These lead to downstream discharges very close to the minimum flow requirement of 50 cubic meters per second at Kirango, a location just upstream of the ecologically crucial Niger Inner Delta.

Although low-flow sustainability was the only management constraint considered in this study, the researchers contend that additional constraints can easily be incorporated into the modeling framework. Assuming the SWOT mission is successful, the team concludes that SWOT altimetry offers the potential for real-time water resource management on data-limited and ungauged rivers around the world. (*Water Resources Research*, doi:10.1002/2014WR016157, 2015) **—Terri Cook, Freelance Writer**



Jeff Schmaltz, MODIS Land Rapid Response Team, NASA GSFC

Niger River inner delta, from NASA Moderate Resolution Imaging Spectroradiometer (MODIS) imagery dated 11 November 2007, shortly after the end of the rainy season. The river can be seen entering the inner delta at lower left. The Kirango gauge, which is the control point at which the model attempts to maintain minimum dry season inflows, is slightly upstream of the lower left.

Deep Atlantic Conduit Boasts Longest Billow Train

Krister Valtonen, CC BY 3.0 (http://bit.ly/ccby3-0)

Kelvin-Helmholtz billow trains in the atmosphere, seen by their characteristic swirls. Similar-looking features can appear in the ocean.

Have you ever stared into the clouds and seen breaking waves? Those formations are called Kelvin-Helmholtz (KH) billow trains, and they exist both in the sky and within the sea. The enchanting swirls also appear in Saturn's bands and near Jupiter's red spot. KH billow trains come to the surface when two fluids of disparate densities slide in opposite directions at different velocities. The shear forces create the distinctive KH pattern of overturning.

Van Haren et al. report the longest train of Kelvin-Helmholtz billows ever recorded on this planet. The train occurred 4000 meters below the surface of the Atlantic Ocean at the entrance of the Romanche Trench. This conduit crosses the Mid-Atlantic Ridge, an underwater mountain range, linking deep ocean basins off the coast of Brazil and western Africa. The trench's extreme depth allows Antarctic Bottom Water, the densest water mass in the Atlantic, to pass between the basins.

The team found that when water spills from the southwestern sill of the Romanche, the velocity creates KH-like shear forces with the less dense overlying water. They made these observations by deploying two acoustic current meters at depths of 4414 and 4612 meters, respectively, between October 2013 and April 2014. The 198-meter steel cable between those devices was covered in 99 high-resolution temperature sensors that measured ocean mixing every second.

On 1 December, the turbulence at the Romanche sill created KH billows stretching in a chain with more than 250 consecutive swirls that ranged in size from 5 to 100 meters tall. To the authors' knowledge, this train is the longest "observed in either the ocean or the atmosphere." (*Geophysical Research Letters*, doi:10.1002/2014GL062421, 2014) **—Nsikan Akpan, Freelance Writer**

Rainfall Fluctuations Hinder Projections of Future Extremes

Scientists highly value multicentury records of weather because they can provide valuable insights into climatic changes and extremes. One station in Padua, Italy, has conducted daily observations of rainfall since 1725. Detailed data sets going back this far provide scientists a unique opportunity to better understand how climate fluctuates over time and how atmospheric and climatic cycles affect an area's weather patterns.

However, no one had ever analyzed the Padua data set at the daily level. *Marani and Zanetti* performed the first analysis of this station's data down to the individual day; despite some gaps in the record, the authors were able to study 268 full years of measurements.

Specifically, the authors document extremes in rainfall and assess how these extremes changed over time in response to atmospheric circulation patterns and climate change. The team found that annual rainfall slightly decreased over the period of study, and the number of rainy days, although fluctuating, showed no major trend. However, rainfall extremes seem to follow a very different behavior. Extremes slightly intensified and exhibited wide oscillations, partly in sync with a dominant climatic pattern known as the North Atlantic Oscillation (NAO).

The authors observed at least five distinct cyclical oscillations in the rainfall data, with cycle durations ranging from roughly 17–21 to 145–172 years. These long-term oscillations and weather patterns are likely to have affected precipitation in other regions as well. As a result, the authors conclude, past observations, especially from records lasting a century or less, cannot necessarily shed light on future climate extremes. (*Water Resources Research*, doi:10.1002/2014WR015885, 2015) **—Puneet Kollipara, Freelance Writer**

Ivanfurlanis, CC BY-SA 3.0 (http://bit.ly/ccbysa3-0)

The astronomical observatory in Padua (Italy), where meteorological observation started in 1725.

New Ionosphere Model Incorporates Solar Angles

Beginning roughly 60 kilometers above the surface of the Earth and extending hundreds of kilometers above that, the shell of plasma known as the ionosphere surrounds the planet. This ionized layer of Earth's atmosphere is a complex structure that conducts electricity, interacts with radio waves, and continuously changes throughout the day. As the Sun shines on it, the onslaught of photons begins to strip away the electrons from molecules in the atmosphere, ionizing them and producing even more plasma. Additional layers begin to form and layers within those layers.

The reason for the formation of these layers was first proposed by British geophysicist Sydney Chapman in 1931. In its simplest form, his theory states that a layer of ionization appears in a sweet spot between two competing factors. High in the atmosphere float many photons but not much air. Low to the ground, the atmosphere is thick with particles, but the amount of sunlight reaching it is reduced.

Somewhere in between exists an optimal zone where the availability of sunlight and particles is balanced and can produce the most plasma. The extra layers that arise during the day are due to the heating effect of the Sun, as well as the fact that there are several different kinds of particles in the atmosphere.

But this simple model begins to break down when scientists try to take into account the angle of the Sun shining on the ionosphere. As the Sun rises and sets over the course of the day, striking at different angles, the ability of the ionosphere to conduct electricity—known as its conductance—changes in a fashion that basic Chapman theory can't predict.

NASA/JSC

The Sun sets over the Indian Ocean, as seen from the International Space Station, revealing the layers of the Earth's atmospheres in its hues. The ionosphere corresponds roughly to the blue layers in the image.

Now *Ieda et al.* suggest additional factors to consider. One of these is the counterintuitive observation that at the high altitudes of the ionosphere, as the altitude increases, the atmosphere gets warmer, which causes it to expand slightly, decreasing its density.

Another is the fact that the incoming sunlight does not consist of a single color but the whole spectrum of wavelengths. This means that in the high regions of the ionosphere, sunlight can produce more plasma than Chapman theory predicts.

The final suggestion the team makes is to take into account the fact that the conductance can change depending on the direction that the electricity flows through the electric and magnetic fields of the ionosphere. Specifically, conductance in the direction parallel to the electric field stays stronger in the evening hours than conductance in other directions.

Taking these three factors into consideration, the team finds that their model greatly improves upon the original 1931 theory and all subsequent modifications, making it the most accurate prediction yet of how the angle of the Sun creates such an ionizing atmosphere. (*Journal of Geophysical Research: Space Physics*, doi:10.1002/2014JA020665, 2014) **—Mark Zastrow, Freelance Writer**

AGU's Career Center is the main resource for recruitment advertising. All Positions Available and additional job postings can be viewed at **https://eos.org/jobs-support.**

AGU offers printed recruitment advertising in *Eos* to reinforce your online job visibility and your brand.
Contact advertising@agu.org for more information about reserving an online job posting with a printed *Eos* recruitment advertisement.

- To view all employment display ad sizes, visit **http://sites.agu.org/media-kits/files/2014/12/ Eos- Employment-Advertising.pdf**
- *Eos* is published semi-monthly on the 1st and 15th of every month. Deadlines for ads in each issue are published at **http://sites.agu.org/media-kits/eos-advertising-deadlines/.**
- *Eos* accepts employment and open position advertise ments from governments, individuals, organizations, and academic institutions. We reserve the right to accept or reject ads at our discretion.
- *Eos* is not responsible for typographical errors.
- Print only recruitment ads will only be allowed for those whose requirements include that positions must be advertised in a printed/paper medium.

Atmospheric Sciences

California Institute of Technology Division of Geological and Planetary Science Assistant Professor in the fields of Atmosphere, Ocean, and Climate Dynamics

The Division of Geological and Planetary Sciences at the California Institute of Technology is seeking applicants for a tenure-track position at the assistant professor level. We seek applicants for a position in the broad area of the dynamics of the atmosphere, ocean, and climate. A strong commitment to both teaching and research is expected.

Initial appointments at the assistant professor level are for four years, and are contingent upon completion of the Ph.D. degree in a relevant field. Interested applicants should submit an electronic application at https://applications.caltech.edu/job/climate and include a brief cover letter, curriculum vitae, relevant publications, a description of proposed research, and a statement of teaching interests. Applications will be accepted until the position is filled.

Questions about the application process may be directed to marcia@gps.caltech.edu

EOE of Minorities/Females/Protected Vets/Disability

Program Director-National Suborbital Education and Research Center

The National Suborbital Education and Research Center (NSERC) seeks a Program Director to provide leadership in science mission operations support to meet the research, education, and technology needs of the NASA Airborne Science Program and the scientific community. The Program Director will be responsible for science operations support for various aircraft platforms, including the DC-8, P-3B, C-130, Global Hawks, and ER-2s, as well as for interfacing to the scientific community. Duties include mission planning, personnel scheduling, budgeting, logistical support, and supervision of NSERC staff. In addition, the Program Director will be expected to lead the implementation of improvements that will make the various airborne platforms more scientifically valuable. The Program Director will also be responsible for the organization and improvement of training and communications for the Airborne Science Program including the annual NASA Student Airborne Research Program (SARP).

Qualifications include a graduate degree in a natural or physical science, or in engineering. Extensive experience performing and directing research from multiple aircraft platforms is also required. Significant management experience is required including financial and personnel management.The Program Director will be expected to have strong interpersonal and leadership skills, as well as an ability to communicate effectively with a broad spectrum of clientele including NASA Headquarters management. He or she should also demonstrate an ability to collaborate with scientists and aircraft operations personnel. Experience working with students is a requirement and directing student research is highly desirable. A history of success earning external funding will be a plus.

Applicants are required to be eligible for employment under U.S. export control laws and must meet the requirement of being a "U.S. Person" (U.S. citizen, a lawful permanent resident, refugee, or granted asylum) or must be eligible to obtain appropriate U.S. Government authorization for access to export controlled equipment, technology, or software. UND will not sponsor an applicant for employment authorization for this position. All information collected in this regard will only be used to ensure compliance with U.S. export control laws, and will be used in compliance with all laws prohibiting discrimination on the basis of national origin and other factors.

NSERC is affiliated with the Earth System Science and Policy Department within the John D. Odegard School of Aerospace Sciences at the University of North Dakota (UND). More information is at http://www.nserc.und.edu/. NSERC is funded through a long-term cooperative agreement with NASA with NSERC staff currently based in Colorado, California, and at the University in Grand Forks, ND. The location base for the Director is negotiable. This opening is a twelve-month, non-tenure-track faculty position with the possibility of renewal.

Interested candidates should submit a CV, list of publications, statement of research and education interests, and contact information for three references by August 18, 2015 to: Karen Katrinak, NSERC, UND Earth System Science & Policy Dept., Clifford Hall Rm 300, 4149 University Avenue Stop 9011, Grand Forks, ND 58202-9011; phone (701) 777-2482; fax (701) 777-2940. Applications may be e-mailed to: k.katrinak@nserc.und.edu.

Applicants are invited to provide information regarding their gender, race and/or ethnicity, veteranís status and disability status on the form found at http://und.edu/affirmative-action/apcontrolcard.cfm. This information will remain confidential and separate from your application. Please reference Position Number 23851.

The University of North Dakota is an Affirmative Action/Equal Opportunity Employer. The University of North Dakota encourages applications from women, minorities, veterans, and individuals with disabilities.

The University of North Dakota determines employment eligibility through the E-Verify System.

North Dakota veterans' preference does not apply to this position.

The University of North Dakota complies with the Jeanne Clery Disclosure of Campus Security Policy & Campus Crime Statistics Act. Information about UND campus security and crime statistics can be found at http://und.edu/discover/_files/docs/annual-security-report.pdf.

Hydrology

Geologist

Are you a recent college graduate looking to start a dynamic career in science? The U.S. Geological Survey's California Water Science Center invites applications for a permanent position to work with our team of hydrologic scientists in San Diego, California. The starting salary for this position is $52,655-$68,499, or $63,707-82,820 per year depending upon the extent and quality of your experience, education, and training relevant to the duties of the position, and offers a full range of federal benefits. The position is open to recent graduates who have completed, within the previous two years, a qualifying higher education degree or certificate.

As a Geologist with the U.S. Geological Survey, California Water Science Center, some of your duties will include:

- Serves as a Project Chief or senior project member for complete geologic, geomorphic, and hydrologic investigations. Plans, conducts, and reports on complex and diverse interpretative studies. These studies may require innovative modification of established techniques or procedures, and extensive collection, interpretation, analysis, and evaluation of geologic, geomorphic, and hydrologic - Develops complex three-dimensional computer models of the geologic conditions (including structure, stratigraphy, and lithology) of aquifers and confining units for hydrologic studies.

- Prepares reports on geologic, geomorphic, and hydrologic interpretative studies that summarize the results of investigations. Reports include sound application of complex geologic and hydrologic principles and concepts. Technically review parts of reports prepared by project team members. Excellent writing and oral presentation skills are required.

Interested applicants may apply to this position online at USAjobs.gov from Monday, June 29, 2015 through Friday, July 31, 2015. The job announcement number is PAC-2015-0564 where detailed position requirements and application procedures can be found. Join the U.S. Geological Survey for a career that makes a difference in both the lives of others and in the environment. U.S. Citizenship is required. The USGS is an Equal Oppor-

tunity Employer and actively recruits qualified applicants who share its commitment to cultural diversity in the workforce.

Ocean Sciences

Post-doctoral position in ocean ensemble prediction

A Post-doctoral research position in oceanography is available at NRL, Stennis Space Center. The objective of this project is to develop a state of the art global ensemble forecast system based on the Navy's operational HYbrid Coordinate Ocean Model (HYCOM) model. The system is expected to provide ocean forecasts and the associated uncertainty estimates that are critical to the US Navy's future missions. The technology to be used is based on the ensemble Kalman filter (EnKF) theory. The ensemble system is expected to be implemented for operation in the future. It will adequately represent the initial state uncertainties and accurately predict the ocean state and probabilistic information up to months. A stochastic forcing model is expected to be developed to account for the model-related uncertainties. This position is full time with a duration of one year initially and can be extended for further years. Applications will be reviewed immediately until the position is filled. Salary and benefits are highly competitive, relocation will be paid. Please email a resume and description of interest to Mozheng Wei (Mozheng.Wei@nrlssc.navy.mil; 228-688-4493).

Solid Earth Geophysics

Solid Earth Geophysics - Geochemistry Director/Institut de Physique du Globe de Paris

Applications are invited for the position of Director of the Institut de Physique du Globe de Paris.

Institut de Physique du Globe de Paris is a leading world-wide research institute in the Earth, Planetary and Environmental Sciences with a focus on experimental and field measurements. For information about the activities of IPGP, check the Web site : www.ipgp.fr

Applicants must be scientists, active in the field of Earth and Planetary sciences. They should send a letter of application and a detailed curriculum vitae, with statements of past and present work and a letter of interest.

The post will be open in the first quarter of 2016. Applications must be sent to: Lydia Zerbib, Institut de Physique du Globe de Paris, Secrétariat Général, 1, rue Jussieu, 75238 PARIS Cedex 05, before september 15, 2015.

Assistant Professor in Seismology The Faculty of Mathematics, Informatics and Natural Sciences of the University of Hamburg, Germany, invites applications for this position commencing on 1.4.2016, Ref. No. JP 244

Applicants are expected to have international research experience in the field of seismology as well as a first experience in acquiring external funding and carrying out externally-funded projects. The candidate's research activity is proven by projects and publications as well as broad interest in general scientific questions. The University places particular emphasis on the quality of teaching and therefore requests that applicants provide details of their teaching experience and objectives.

The University of Hamburg seeks to increase the proportion of women in teaching and research and we therefore especially encourage qualified female academics to apply. In accordance with § 14 (3) sentence 3 of the Hamburg Higher Education Act (HmbHG).

Area(s) of Responsibility:

The successful candidate is expected to carry out research in the area of Seismology. The candidate is expected to teach parts of the geophysics curriculum at undergraduate (BSc) as well as at graduate (MSc, PhD) levels.

Use of the marine seismological equipment of the institute is desirable as well as the development of a new research focus to transfer classical seismological techniques to near surface applications. An integration of seismological expertise into climate research problems (icequakes, location of storm centers) is desired as well.

Cooperation with other national as well as international institutions is expected and the establishment of externally funded research programs should be initiated. Scientific team leadership and cooperation in the academic self-administration are expected.

In accordance with § 12 (7) sentence 2 of the Hamburg Higher Education Act (HmbHG) applies.

Requirements:

Academic qualifications and additional requirements as specified in § 18 of the Hamburg Higher Education Act.

A tenure-track evaluation will be conducted during the second phase of the junior professorship (W1). If the evaluation is positive, the candidate is eligible for a tenured professorship (W2). The regulations prohibiting internal appointments (Hausberufungsverbot) also apply to junior professorships.

Qualified disabled candidates receive preference in the application process.

For further information please contact Prof. Dr. Dirk Gajewski at (+49) 040-42838 2975 (dirk.gajewski@uni-hamburg.de) or Prof. Dr. Matthias Hort at (+49) 040-42838 3969 (matthias.hort@uni-hamburg.de)

ETH zürich

Assistant Professor (Tenure Track) of Glaciology

→ The Department of Civil, Environmental and Geomatic Engineering (www.baug.ethz.ch) at ETH Zurich and the Swiss Federal Institute for Forest, Snow and Landscape Research, WSL (www.wsl.ch) invite applications for the above-mentioned assistant professorship.

→ The assistant professor will lead a research group to be shared between the Department of Civil, Environmental and Geomatic Engineering at ETH Zurich and the Swiss Federal Institute for Forest, Snow and Landscape Research, with a strong research focus on alpine glaciology. The new assistant professor will be expected to teach undergraduate and graduate level courses, to maintain an active research programme, and to contribute to the departmental service. The research group will be located at the Laboratory of Hydraulics, Hydrology and Glaciology at ETH campus Höng-gerberg in Zurich as well as at the Swiss Federal Institute for Forest, Snow and Landscape Research in Birmensdorf.

→ The successful candidate should hold a doctoral degree in civil or environmental engineering or a related discipline and should have expertise in physical glaciology. Relevant research areas include, but are not limited to, dynamic behavior of mountain glaciers, sub-glacial processes, fracture growth and mechanical failure in glacier ice, glacier hazards and climate-glacier interactions. We are particularly interested in individuals who combine acquisition and interpretation of data with theoretical work. The development and use of numerical models (e.g. ice flow, ice fracturing, glacier hydraulics) to combine research and engineering problems with observations is also a desired research direction. The selected candidate should establish an attractive teaching programme and must be committed to excellence in education, as well as promote, execute and apply modern teaching methods.

→ The new assistant professor will be expected to teach undergraduate level courses (German or English) and graduate level courses (English).

→ This assistant professorship has been established to promote the careers of younger scientists. The initial appointment is for four years with the possibility of renewal for an additional three-year period and promotion to a permanent position.

→ **Please apply online at www.facultyaffairs.ethz.ch**

→ Applications should include a curriculum vitae, a list of publications, and a statement of future research and teaching interests. The letter of application should be addressed **to the President of ETH Zurich, Prof. Dr. Lino Guzzella. The closing date for applications is 30 September 2015.** ETH Zurich is an equal opportunity and family friendly employer, and is further responsive to the needs of dual career couples. We specifically encourage women to apply.

The University of Hamburg is dedicated to sustainability, equal opportunity and family-friendly policies. We also prize cultural diversity, communication, and interaction among people from different backgrounds and with different lifestyles.

The application deadline is 23.07.2015. Please submit your application, including the standard documents and reference code JP 244 to:

An den
Präsidenten der Universität Hamburg
Stellenausschreibungen
Mittelweg 177,
20148 Hamburg
or via email to bewerbungen@verw.uni-hamburg.de.

UC SANTA BARBARA, DEPARTMENT OF EARTH SCIENCE GEOPHYSICS

The Department of Earth Science at the University of California, Santa Barbara, invites applications for a tenure-track Assistant Professor position in Geophysics, starting July 1, 2016. We seek an innovative geophysicist who investigates solid Earth processes with modern geophysical data and/or simulation methods. All areas of technical expertise will be considered, with preference for seismology, geodesy, and/or numerical modeling. We seek candidates who complement our current research program and integrate tectonics and geophysics.

The successful candidate is expected to develop a vigorous, externally funded research program and to advise graduate and undergraduate students. A Ph.D. or an equivalent degree is required at the time of appointment.

Applicants should submit a PDF containing a letter of application, their curriculum vitae, a description of teaching and research objectives and accomplishments, and the contact information of three referees who will provide letters. Applicants should request that the three referees send letters of evaluation by October 1st, 2015. The application file and letters of reference should be submitted to https://recruit.ap.ucsb.edu.

Review of applications will begin October 1st, 2015. The position will remain open until filled, but to ensure full consideration, application materials should be submitted by this date.

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

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

Interdisciplinary/Other

Assistant Professor in the Energy Cluster at the University of Pennsylvania

As part of a larger investment to create a new Center for Energy Research, the School of Arts and Sciences at the University of Pennsylvania seeks to add faculty to our newly formed Energy Cluster spanning the natural sciences. Following a first hire in Chemistry, we now invite applications for tenure-track assistant professor whose primary research and teaching affiliation will be in one of the following departments: Biology, Earth and Environmental Science, or Physics & Astronomy. Exceptional senior candidates will be given consideration. The successful candidate will mount an innovative program of fundamental scientific research with impact on our societal energy challenges, and in doing so will forge collaborative links with Penn scientists and engineers involved in energy research. Applicants must apply online at http://facultysearches.provost.upenn.edu/postings/590. Required application materials include: curriculum vitae with a list of publications, and a research and teaching statement that includes the candidate's perspective on how she or he fits into one of the three departments and identifies potential collaborative links with other natural science departments. Applicants should also submit the names and contact information for three individuals who will provide letters of recommendation. Review of applications will begin no later than September 1st, 2015 and will continue as long as the position remains open. The School of Arts and Sciences is strongly committed to Penn's Action Plan for Faculty Diversity and Excellence and to establishing a more diverse faculty (for more information see: http://www.upennledu/almanac/volumes/v58/n02/diversityplan.html). The University of Pennsylvania is an EOE. Minorities/Women/Individuals with disabilities/Protected Veterans are encouraged to apply.

Executive Director, PAGES
The PAGES (Past Global Changes) project supports and facilitates international and interdisciplinary past global change research. We are seeking a new Executive Director to coordinate the project's activities from our office in Bern, Switzerland. Applications close 26 July 2015.

Learn more about the role, PAGES, and how to apply at: www.pages-igbp.org/my-pages/paleo-jobs/118-other/1191-ed

Faculty Position in Geology or Geophysics at the University of Michigan

The Department of Earth and Environmental Sciences at the University of Michigan anticipates an opening for a tenure-track assistant professor in the areas of geology or geophysics for a

university-year appointment starting September 1, 2016. The Department intends to pursue additional hires in this direction in future years, and we are particularly interested in candidates whose strengths will complement existing research programs within the Department.

Geology: We encourage applications from candidates whose research interests encompass the origin, evolution, or dynamics of the continents. The successful candidate will develop a strong field-based research program, complemented by expertise in modern analytical techniques or in numerical or analogue modeling. Candidates with an interest in understanding continental evolution in deep geologic time are particularly encouraged to apply.

Geophysics: We encourage applications from candidates who will develop an observationally based research program using geophysical methods (e.g. seismology, geodesy, or potential fields) to study the Earth at the crustal or continental scale. We are particularly interested in those applicants whose work is relevant to societal concerns including natural hazards, such as earthquakes, volcanism, and associated hazards, or environmental change to the hydrosphere or cryosphere.

The successful candidate is expected to establish an independent research program and contribute to both undergraduate and graduate teaching. Applicants must have a Ph.D. at the time of appointment, and should submit a CV, statement of current and future research plans, statement of teaching philosophy and experience, evidence of teaching excellence (if any), and names and contact information of at least four persons who can provide letters of recommendation.

Information about the Department and instructions for submitting an application can be found at www.lsa.umich.edu/earth.

To apply please go to http://www.earth.lsa.umich.edu/facultysearch/newapplicant, complete the online form and upload the required application documents as a single PDF file. If you have any questions or comments, please send an email message to Michigan-Earth-Search@umich.edu.

The application deadline is September 15, 2015 for full consideration, but applications will continue to be reviewed until the position is filled. Women and minorities are encouraged to apply. The University of Michigan is supportive of the needs of dual career couples and is an equal opportunity/affirmative action employer.

Tenure-Track Faculty Position in Global Biogeochemical Changes Department of Earth and Planetary Sciences, McGill University

The Department of Earth and Planetary Sciences (www.mcgill.ca/eps) at McGill University invites applications for a tenure-track position at the rank of Assistant Professor, beginning as early as January 2016 in the area of Global Biogeochemical Changes. The successful candidate will be supported by a generous start-up package.

We seek a candidate who applies quantitative techniques to interpret records of environmental change on a range of time scales and their impact on global/planetary biogeochemical cycles. Applicants should have a proven record of excellence in research and the capacity for excellence in teaching. Applicants should submit a detailed curriculum vitae, a statement of teaching interests, and a research plan. They should also arrange for three letters of reference. All these materials should be sent in electronic form to the Chair of the Department: alfonso.mucci@mcgill.ca

Review of applications will begin September 1 2015, and continue until the position is filled.

McGill University is committed to diversity and equity in employment. It welcomes applications from: women, Aboriginal persons, persons with disabilities, ethnic minorities, persons of minority sexual orientation or gender identity, visible minorities, and others who may contribute to diversification.

All qualified applicants are encouraged to apply; however, in accordance with Canadian immigration requirements, Canadians and permanent residents will be given priority.

Poste de professeur adjoint en Changements Biogéochimiques Globaux

Département des sciences de la Terre et des planètes, Université McGill

Le département des sciences de la Terre et des planètes (www.mcgill.ca/eps) de l'Université McGill invitent des candidatures pour un poste de professeur au rang d'adjoint menant à la permanence, dans le domaine des changements biogéochimiques globaux. La date d'entrée en fonction pourrait être dès janvier 2016. Une substantielle subvention de démarrage sera offerte au candidat retenu.

Nous recherchons des candidats qui appliquent des méthodes quantitatives à l'étude des changements environnementaux à diverses échelles temporelles, tels que détectés dans les registres sédimentaires, et qui en évaluent les impacts sur les cycles biogéochimiques globaux ou planétaires. Le candidat doit posséder un excellent dossier de recherche et avoir démontré un potentiel d'excellence en enseignement. Le dossier du candidat doit inclure un curriculum vitae détaillé, un énoncé de sa philosophie d'enseignement, un plan de recherche et trois lettres de recommandation. Ces documents doivent être transmis électroniquement au directeur du département: alfonso.mucci@mcgill.ca

Le comité de sélection évaluera les candidatures reçues à partir du 1 septembre 2015 et jusqu'à ce que le poste soit comblé.

L'Université McGill souscrit à la diversité et à l'équité en matière d'emploi. Elle accueille favorablement les demandes d'emploi: des femmes, des peuples Autochtones, des minorités ethniques, des personnes handicapées, des personnes de toutes orientations et identités sexuelles, des minorités visibles, et d'autres personnes qui pourraient contribuer à une plus grande diversité.

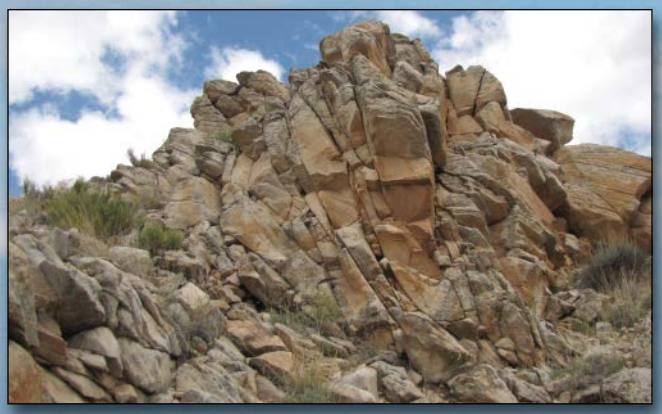
On encourage tous les candidats qualifiés à postuler; veuillez noter que, conformément aux exigences de l'immigration canadienne, la priorité sera toutefois accordée aux Canadiens ainsi qu'aux résidents permanents.

Student Opportunities

Ph.D. Research Assistantships in Mineral-Water Interface Geochemistry

Funding is available in the Environmental Sciences Ph.D. Program and the Chemistry Department at Wright State University in the area of mineral-fluid interface geochemistry. Students will conduct independent research on mineral dissolution and growth using SPM, XPS and modern analytical instruments. Projects are interdisciplinary with collaborative opportunities at DOE labs. More info: contact Dr. Steve Higgins (steven.higgins@wright.edu) or visit http://www.chm.wright.edu/higgins/contact/

Postcards from the Field



Hello –

We completed a new survey of the structural deformation generated by the Meteor Crater impact event in northern Arizona. The 1.2-kilometer-diameter crater (also called Barringer Meteorite Crater) is the best preserved impact site in the world and is still providing new clues about cratering processes. Within a few seconds, 175 million metric tons of rock were excavated to produce the bowl-like cavity in the Colorado Plateau. As shown in the inset, the impact event shattered a block of Coconino in the crater wall, in addition to other units of the upper Grand Canyon sequence of strata. In a field project funded by NASA's Solar System Exploration Research Virtual Institute (SSERVI), Rice University undergraduate geology student Adeene Denton is studying the faults that tore through the Coconino, Toroweap, Kaibab, and Moenkopi strata when the crater was formed.

David A. Kring
Lunar and Planetary Institute
and SSERVI principal investigator

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

AGU FALL MEETING

San Francisco | 14 – 18 December 2015

Geophysical Information for Teachers Workshop

AGU is currently seeking scientist/education and outreach professional teams to present at the GIFT workshop at Fall Meeting. *Presenting teams will receive one* ***FREE*** *full-week registration.*

Application Deadline: 5 August

Exploration Station

Interested in presenting at Exploration Station at the 2015 Fall Meeting?

Registration Deadline: 21 August

Learn More at

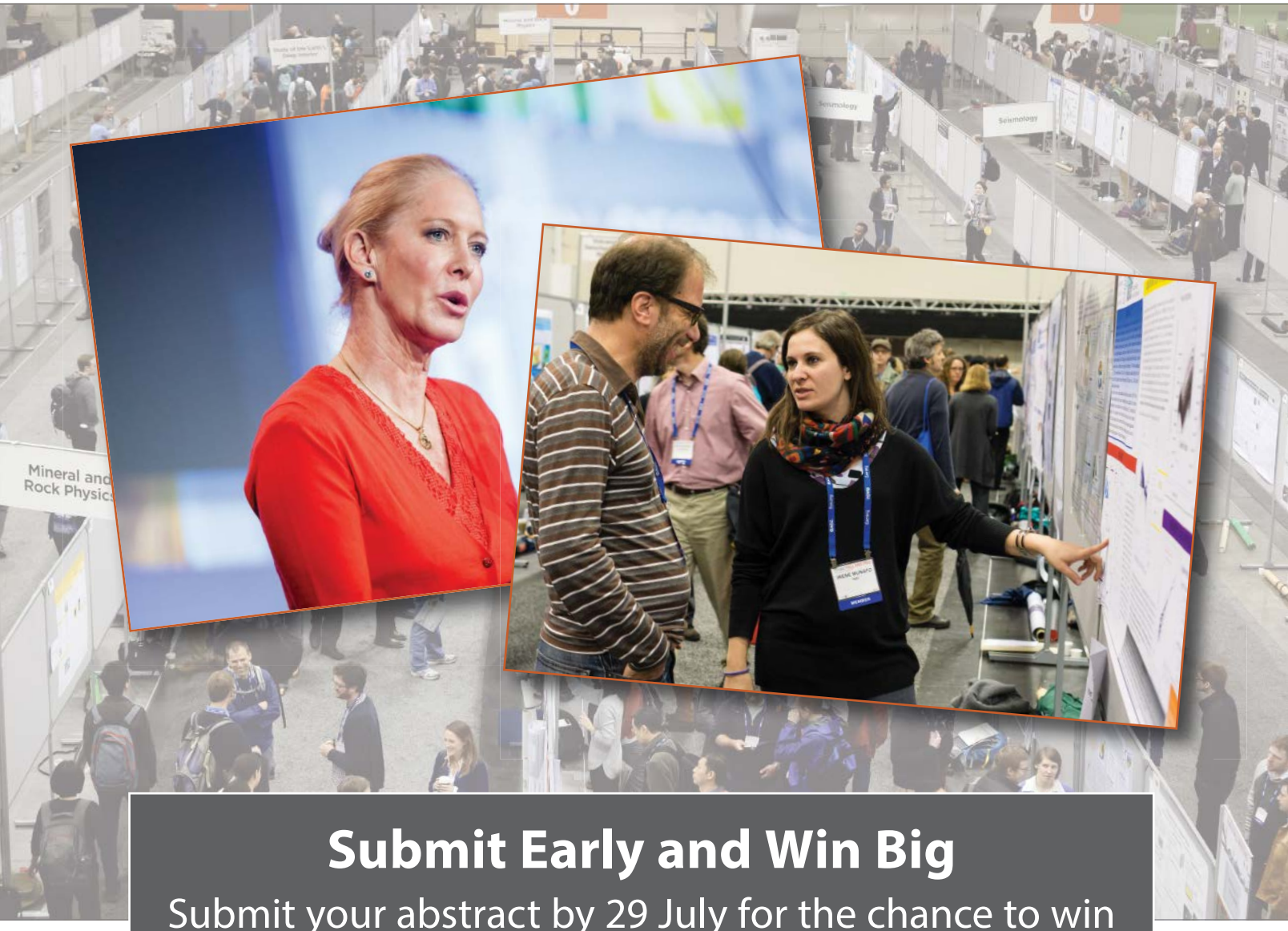
education.agu.org

AGU FALL MEETING

San Francisco | 14 – 18 December 2015

Give Your Research the Visibility it Deserves

Abstract Submission Deadline: 5 August



Submit Early and Win Big

Submit your abstract by 29 July for the chance to win **FREE** registration to the 2015 Fall Meeting

fallmeeting.agu.org