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Understanding North Pacific Sea Level Trends

Rising sea level poses significant challenges to infrastructure and populations, particularly for coastal [*Heberger et al.*, 2009] and island communities [*Webb and Kench*, 2010] in the North Pacific where population density at or near coastal waters is high. A significant portion of the United States' security, commerce, and ecosystem assets are located at or near the coast, making them vulnerable to sea level rise. Although global mean sea level (MSL) rise is a fundamental consideration, regional mean sea level (RSL) height variability within ocean basins and along their boundaries can be more critical, particularly in the North Pacific where the amplitude of interannual variability is high.

Causes of Global and Regional Sea Level Rise

The main causes for global MSL rise (Figure 1) are added water from the melting of ice sheets and glaciers and thermal expansion of the oceans [*Domingues et al.*, 2008], both driven by global warming [*Bindoff et al.*, 2007]. Regional sea level variations appear to fluctuate about the globally averaged trend, which has increased from the tide gauge estimate of about 1.7 ± 0.5 millimeters per year over the twentieth century [*Bindoff et al.*, 2007] to the satellite altimetry estimate of about 3.1 ± 0.7 millimeters per year since 1993 [e.g., *Bromirski et al.*, 2011; *Timmermann et al.*, 2010]. However, recent studies show that regional sea level trends are affected by local and remote wind forcing (Figure 1), which can cause sustained changes in ocean circulation and sea level height [*Bromirski et al.*, 2011; *Merrifield*, 2011; *Sturges and Douglas*, 2011; *Timmermann et al.*, 2010]. These studies cover different regions, indicating that RSL along most oceanic boundaries can be strongly affected by dynamic effects for sustained periods.

Along the U.S. Pacific coast, tide gauges suggest that regional sea level rise is approximately equal to global MSL rise over most of the twentieth century, but altimetry and tide gauges both indicate that RSL rise is significantly less than global MSL rise since about 1980 [*Bromirski et al.*, 2011; *Merrifield*, 2011; *Houston and Dean*, 2011]. In contrast, in the western tropical Pacific, RSL rise is much greater than global MSL rise since the early 1990s [*Merrifield*, 2011; *Bromirski et al.*, 2011]. Wind stress curl–related Ekman pumping and alongshore wind stress–related Ekman transport (Figure 1) mainly drive these regional departures from the global trend. These processes alter the thermocline depth, with a deeper thermocline associated with raised sea level height.

West Coast Sea Level Trends

Persistent regional wind stress patterns spanning a few decades [*Bromirski et al.*, 2011], as well as basin-wide wind-driven circulation changes and strong El Niño–related fluctuations on shorter time scales, strongly affect sea level trends along the Pacific coast of North America, exemplified by the San Francisco record (Figure 2). The recent U.S. West Coast "RSL less than MSL" rise rates are attributed to a dramatic change in eastern boundary and basin-wide wind stress patterns that occurred after the mid-1970s climate regime shift [*Miller et al.*, 1994]. This change in wind stress patterns has suppressed regional sea level rise along the West Coast, both in an absolute sense as well as relative to what is expected during a warm phase of the Pacific Decadal Oscillation (PDO) [*Mantua et al.*, 1997]. Similar near-zero RSL trends since 1980 are also observed at San Diego and Seattle [*Bromirski et al.*, 2011], which is consistent with altimetry observations. A similar protracted stationary West Coast RSL epoch occurred from about 1880 to 1930 (Figure 2), potentially also related to North Pacific wind stress patterns. Persistent wind stress regimes over the entire North Pacific basin have recently exhibited patterns and amplitudes not observed since before the mid-1970s regime shift, likely causing basin-scale thermocline adjustments. This change in broad-scale wind stress patterns may have foreshadowed a climate regime shift. The recent apparently-associated shift of PDO to its cold phase during the 2000s will further serve to suppress regional sea level rise along the West Coast if it persists.

In contrast to stationary eastern boundary sea levels, the strong regional sea level rise in the western tropical Pacific is related to a steady increase in the trade winds since the early 1990s [*Merrifield*, 2011]. Increasing trade winds are possibly associated with an intensification of the subtropical atmospheric Hadley circulation, which has been linked to an associated increase in mid-latitude westerlies and equatorward winds along the Pacific coast of North America. The eastern boundary wind patterns that have contributed to the RSL less than MSL pattern along the West Coast [*Bromirski et al.*, 2011] may be associated with these Hadley circulation changes, although natural decadal variability associated with PDO and other climate modes makes this relationship statistically uncertain [*Merrifield*, 2011].

The near-zero regional sea level trend along the West Coast since about 1980 occurred following an apparent abrupt increase in RSL along the West Coast that occurred after the mid-1970s regime shift [*Bromirski et al.*, 2011], which is consistent with the change from the cold phase to the warm phase of PDO. A similar relatively abrupt increase in RSL, associated with a change in trend, may have occurred near 1930 (Figure 2), suggested by the difference between the 1880–1930 and 1930–1980 trend levels at 1930. It is interesting that the Cascais, Portugal, tide gauge record also shows a similar abrupt RSL increase near 1930 [*Sturges and Douglas*, 2011], potentially associated with changes in regional winds. The difference between pre-1930 and post-1980 mean RSL levels (red dashed lines in Figure 2) at San Francisco is about 15.8 centimeters, giving an RSL rise of about 3.2 millimeters per year over the 1930–1980 epoch, similar to recent altimetry global MSL rise estimates. Note that these epochs are somewhat arbitrary and that selection of other epoch boundaries would give slightly different results.

El Niño–Related Extremes

Although regional sea level along the West Coast is important for near-coastal processes and provides the base level upon which other shorter-term fluctuations are superimposed, El Niño–related extremes (e.g., during the 1940–1941, 1958–1959, 1982–1983, and 1997–1998 strong El Niños; Figure 2) produce high-amplitude interannual fluctuations at San Francisco that are comparable to the total global MSL rise over the entire twentieth century. These fluctuations are associated with poleward propagating coastally trapped waves and tropical teleconnections to the atmosphere that affect storm patterns across the basin.

The impacts of these fluctuations on flooding, beach erosion, and shoreline retreat will be amplified under rising coastal RSL because, particularly during high tides, increased water levels allow more wave energy to reach farther shoreward. Because ocean wave extremes and storm-forced nontide fluctuations are not expected to change appreciably over the 21st-century [*Bromirski et al.*, 2012], upward trends in regional sea level will be the dominant factor affecting the intensification of coastal erosion processes along the West Coast.

Sea Level Changes in the Future

Future regional sea level changes across the North Pacific will depend on the magnitude of changes in PDO and the trade wind mode, as well as other regional and basin-wide anomalies in wind forcing [*Bromirski et al.*, 2011; *Merrifield*, 2011]. RSL changes are

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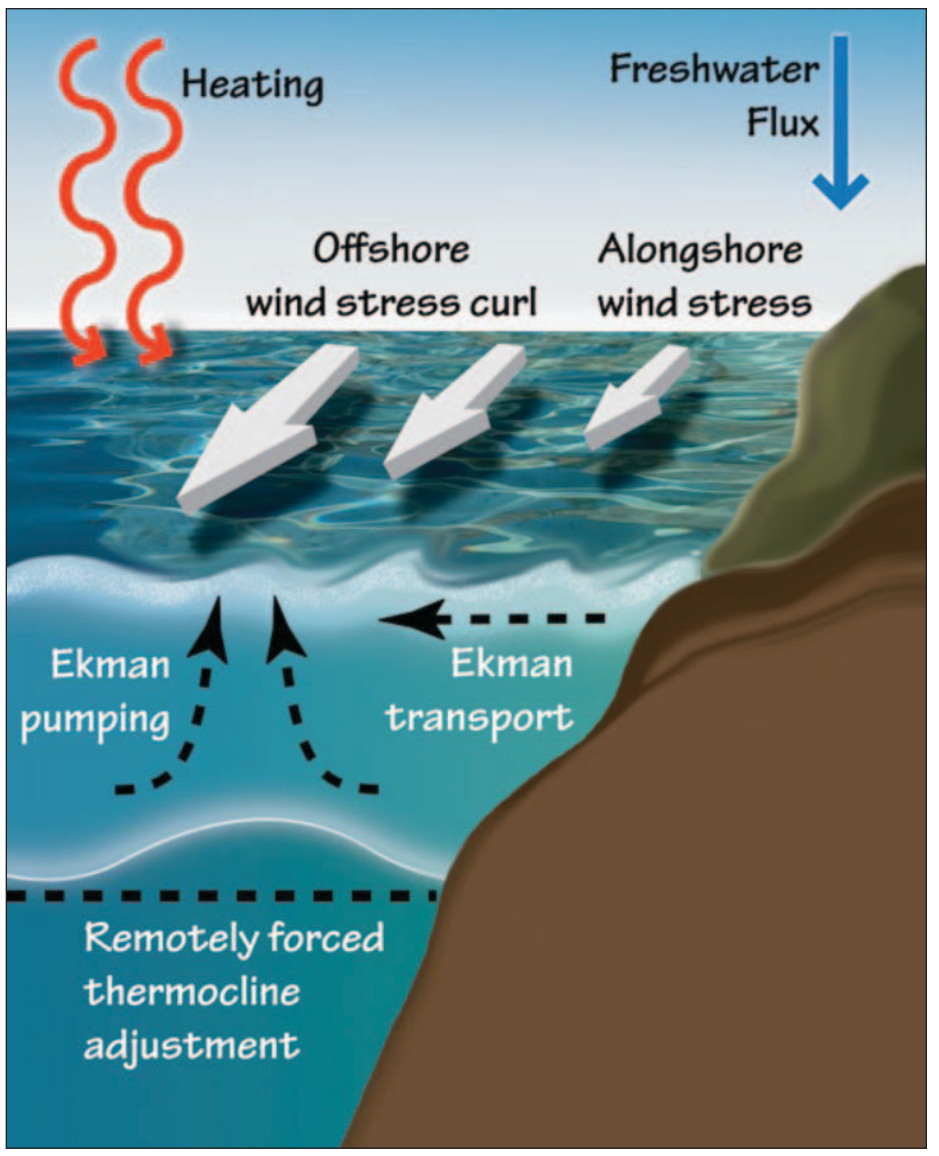

Fig. 1. Processes affecting sea levels along the eastern boundary of the North Pacific. Freshwater flux represents the net volume of added water from ice sheets, glaciers, runoff, precipitation, and evaporation, which contribute to global mean sea level. Heating represents the net effect of regional and global thermal forcing. Alongshore wind stress drives offshore Ekman transport that alters the thermocline depth, with associated changes in regional sea level. Ekman pumping offshore drives thermocline depth changes, both regionally and basin wide. Here upwelling is shown, raising the thermocline and thus lowering regional mean sea level (RSL). Downwelling produces the opposite effect on thermocline depth and RSL. Remotely forced thermocline adjustment results from basin-scale integrated effects of wind stress curl that are manifested in changes in broad-scale ocean circulation, also affecting RSL height.

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also affected by vertical land movements both natural (e.g., glacial isostatic adjustments) and anthropogenic (e.g., subsidence associated with groundwater extraction), which can further complicate coastal RSL spatial patterns. While regional wind forcing is difficult to forecast on climate time scales, the recent apparent switch of PDO from its warm phase to its cold phase will likely cause substantial changes in North Pacific winds that will affect regional sea level trend patterns. Additionally, weakening and poleward expansion of Hadley cell circulation is anticipated under global warming [*Lu et al.*, 2007], with an associated poleward expansion of the subtropical dry zone. This could reduce trade wind strength and cause broad-scale ocean circulation changes that redistribute ocean water across the North Pacific basin and raise sea levels along the West Coast, although this regional effect is not statistically significant in previous ensemble mean model projections from the *Intergovernmental Panel on Climate Change* [2007, chapter 10.6.2].

The dynamics of the forcings that control Hadley cell intensity (and expansion and contraction) can couple with North Pacific decadal variability and with decadal oscillations of the tropical Pacific. If Hadley cell intensity is actually part of a decadal-scale oscillation associated with PDO, then West Coast sea level rise may also accelerate once the phase of the oscillation switches. The primary sea level signals from PDO-related climate variability are due to basin-scale "sloshing" of thermocline structure associated with wind stress (and its curl) forcing. Regional changes in sea level due to differences in surface heat flux forcing variability across the basin can also contribute to changes in regional sea level (Figure 1), but these effects appear to be much smaller than those due to wind stress changes [*Bromirski et al.*, 2011]. Understanding both regional-scale and gyre-scale responses of the North Pacific Ocean circulation to changes in the Hadley circulation is vital to anticipate the magnitude and timing of potential increases in RSL along the U.S. West Coast.

Acknowledgments

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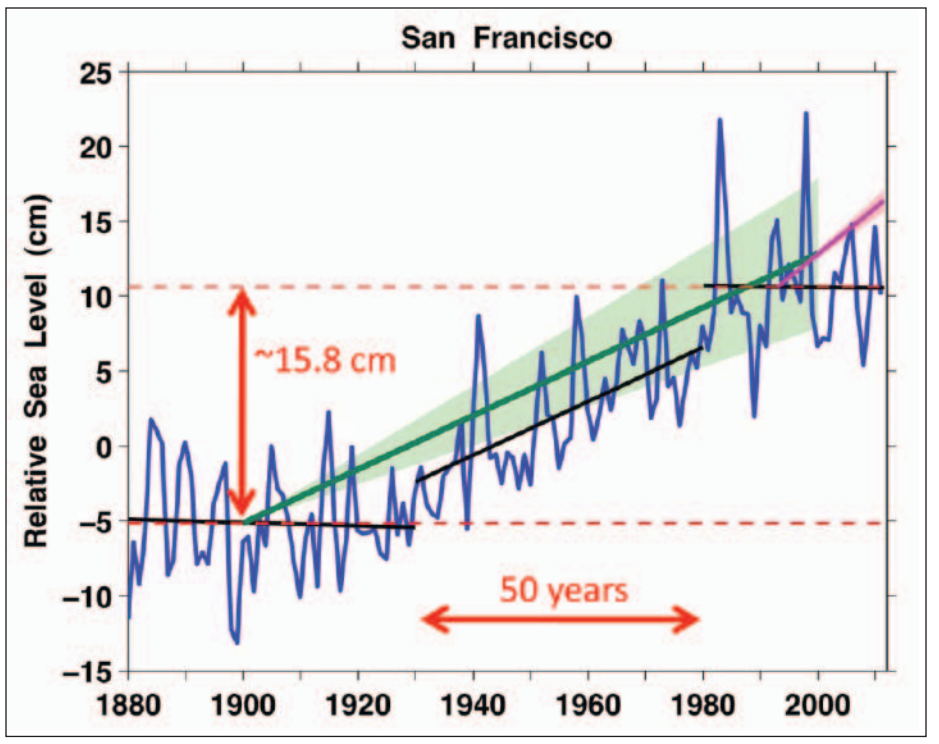

Fig. 2. The observed San Francisco tide gauge 3-year running mean sea levels (blue line). Trends in the tide gauge record (black lines) are near zero between 1880 and 1930 and since about 1980. The trend from 1930 to 1980 is close to the global mean sea level (MSL) rise rate (green line, green-shaded region denotes the 1.7 ± 0.5 millimeters per year bounds) [Bindoff et al., 2007]. Note that the global MSL satellite altimetry trend (magenta; 3.1 ± 0.7 millimeters per year) [Timmermann et al., 2010] is very different from the San Francisco regional sea level trend over the same period.

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NEWS

Space Station Astronauts Discuss Life in Space During AGU Interview

Just one day after China's Shenzhou-9 capsule, carrying three Chinese astronauts, docked with the Tiangong-1 space lab on 18 June, Donald Pettit, a NASA astronaut on the International Space Station (ISS), said it is "a step in the right direction" that more people are in space.

"Before they launched, there were six people in space," he said, referring to those on ISS, "and there are 7 billion people on Earth." The astronauts were "like one in a billion. Now there are nine people in space," Pettit said during a 19 June interview that he and two other astronauts onboard ISS had with AGU. Pettit continued, "So the gradient of human beings going into space is moving in the right direction. We need to change these numbers so that more and more human beings can call space their home so we can expand off of planet Earth and move out into our solar system."

Pettit, who, at the time of the interview was on his third mission to space—with a scheduled return to Earth on 1 July—said one change he has seen on the planet since his first mission is the number of city lights at night, particularly over South America. "In 2002 and 2003 it was pretty dark, and now it's amazing how lit up it is. Human beings are expanding and we are advancing with our technology, and electricity is part of that technology. It's a natural flow for human beings to expand and in the process turn on their lights."

While onboard ISS, Pettit said, "You learn lessons about yourself, you learn lessons about humanity in general, and you learn lessons in science about how things move and operate around you. And you take these lessons back with you."

One science lesson he has learned relates to the conservation of angular momentum. He recalled watching a vitamin tablet float and rotate end over end and noticing that when the tablet hit a wall it stopped tumbling and moved off from the wall much faster than its center of mass had been moving previously. It had exchanged angular momentum for linear momentum, Pettit explained. "You read about these things in textbooks, but you get to see them here. That imprints your mind, and when I go back to Earth and I start doing engineering that little tidbit is going to be stuck in my mind and who knows where it might surface for some new kind of invention."

André Kuipers, a medical doctor and Dutch astronaut with the European Space Agency who is on his second mission to ISS, had contemplated in a prelaunch interview that the space station is serving as preparation for future steps in space exploration. During the interview with AGU, which was broadcasted on NASA television, Kuipers elaborated, "We're only at the beginning of the discovery of our universe. It's like the whole ocean that is there to discover and you're only standing there with your toes in the water. So you still have to go with your feet and your legs and all the way to great depths. And we'll do the same thing with the universe. I'm very, very privileged that I can be part of this first little step into the water."

Kuipers, who is scheduled to come back to Earth on 1 July along with Pettit, reflected on the approaching end of his current mission. "Every time I look out of the window, it looks like the first time. Every time, it's so magnificent that I think this is awesome," he said, noting that he tries to keep those moments in his mind. "It's a fantastic planet but also very fragile. I wish everybody could see this and realize that it's one planet with limited resources, beautiful but fragile. And I think this is one of the most important things that I can bring back home."

NASA astronaut Joseph Acaba, who is on his second mission to ISS and is slated to stay aloft until September, also commented on the fragility of the planet. "When you come up to space and you look back at the Earth, it's just a beautiful site and you have a chance for the first time really to look at the big picture. A lot of what we do in geology is we look at small pieces and try to build

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(left to right) International Space Station astronauts Joe Acaba, André Kuipers, and Don Pettit answer questions during a live interview with AGU on 19 June. Photo courtesy of AGU/NASA.

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together a bigger map. From space, you get to see that: You see the atmosphere; you see how different parts of the Earth interact with each other. The importance of protecting the planet is very, very evident from space," said Acaba, whose background includes geology, hydrology, environmental education work with the U.S. Peace Corps, and teaching middle school science and math. "When I get back and I go talk to students in the classroom, it is really easy now to give them my perspective and to show them pictures to show how fragile the planet is and how much we need to do to protect it."

Acaba added that he also thinks about the planet and about the next generation during quiet moments on the space station when he is looking out a window. "It's pretty nice when you can sit up in the cupola and you can get the node nice and dark. The other crew mates are off doing something else and you have a chance to look back at the Earth," he said. "It makes you think about how beautiful our planet is, and how much more we have to learn, and all of the exciting times that are ahead of us. It's great to be here and I envy those kids that are out there now for the adventures they are going to have in the future."

To watch AGU's 19 June interview with the ISS astronauts, see http://www.youtube.com/watch?v=K_UAs12NnLo&list=PL3FA07373D085F220&index=1&feature=plpp_video.

—Randy Showstack, Staff Writer

Induced Seismicity From Fracking and Carbon Storage is Focus of Study and Hearing

Hydraulic fracturing to recover shale gas does not pose a high risk for inducing felt seismic events, as the method is currently implemented, according to a 15 June report by the U.S. National Research Council (NRC). However, carbon capture and storage (CCS) has the potential to induce larger seismic events because of the large net volume of injected fluids involved in that process, according to the report. Scientists testifying at a 19 June hearing held by the U.S. Senate Committee on Energy and Natural Resources said they largely agreed with the report's findings. Neither the report nor the hearing focused on potential environmental impacts of hydraulic fracturing, which is commonly known as fracking.

"The factor that appears to have the most direct consequence in regard to induced seismicity is the net fluid balance (total balance of fluid introduced into or removed from the subsurface), although additional factors may influence the way fluids affect the subsurface," states the NRC report *Induced Seismicity Potential in Energy Technologies*. The report defines induced seismicity as earthquakes that are attributable to human activities. "Projects that inject or extract large net volumes of fluids over long periods of time such as CCS may have potential for larger induced seismic events, though insufficient information exists to understand this potential because no large-scale CCS projects are yet in operation. Continued research is needed on the potential for induced seismicity in large-scale CCS projects," the report notes.

The injection for disposal of wastewater, generated during oil and gas production (including during fracking), into the subsurface can pose a risk for induced seismicity, according to the report, though there are only a few documented events of this occurring over the past several decades. In addition, the report noted that different forms of geothermal resource development appear to have differing potential for producing seismic events that can be felt.

While the general mechanisms that create induced seismic events are well understood, scientists currently are not able to accurately predict their magnitude and occurrence because of the lack of comprehensive data about complex natural rock systems and the lack of validated predictive models, according to the report, which calls for additional research and the development of methodologies for quantitative, probabilistic hazard assessment of induced seismicity risk. "Such assessments should be undertaken before operations begin in areas with a known history of felt seismicity and updated in response to observed potentially induced seismicity. Practices that consider seismicity both before and during the actual operation of an energy project can be employed in the development of a 'best practices' protocol specific to each energy technology and site location."

One of the witnesses at the 19 June Senate hearing was Murray Hitzman, a professor of economic geology at the Colorado School of Mines, Golden, and chair of the NRC report committee. He said that while there are about 35,000 fracked shale gas wells in the United States, "only one case of felt seismicity in the United States has been described in which hydraulic fracturing for shale gas development is suspected but not confirmed." He said that globally there is only one confirmed case, which occurred in Blackpool, UK, of felt induced seismicity having been caused by fracking. "The very low number of felt events relative to the large number of hydraulically fractured wells for shale gas is likely due to the short duration of injection of fluids and the limited fluid volumes used in a small spatial area."

On the topic of CCS, Hitzman said, "Given that the potential magnitude of an induced seismic event correlates strongly with the fault rupture area, which in turn relates to the magnitude of pore pressure changes and the rock volume in which it exists, the committee determined that large-scale CCS may have the potential for causing significant induced seismicity."

At the hearing, Mark Zoback, professor of Earth sciences and professor of geophysics at Stanford University, California, said that while CCS may be a useful tool in specific situations, he doubts that it can be a successful major strategy for dealing with greenhouse gases.

Zoback said that about 3500 CCS facilities would be needed worldwide and that seismicity is the big concern. He said there is a "high probability" that earthquakes would be triggered by the injection of the enormous amounts of carbon dioxide (CO_2) associated with CCS for carbon storage to make a significant contribution in reducing greenhouse gases.

In addition, Zoback said that even small- or moderate-sized, naturally occurring earthquakes would prove a threat to the integrity of the seal on geological formations used to store CO_2 for long periods of time without any leakage. "The issue is not whether CO_2 can be safely stored at a given site; the issue is whether the capacity exists for sufficient volumes of CO_2 to be stored in geologic formations for it to have a beneficial effect on climate change," he said. "In this context, it must be recognized that large-scale CCS will be an extremely expensive and risky strategy for achieving significant reductions in greenhouse gas emissions."

William Leith, senior science advisor for earthquake and geological hazards for the U.S. Geological Survey, testified that the occurrence of induced seismicity associated with wastewater disposal from natural gas production in particular "has increased significantly since the development of technologies to facilitate production of gas from shale and tight sand formations." He said that while there appears to be little seismic hazard associated with fracking, "the disposal of waters produced with the gas does appear to be linked to increased seismicity."

Leith added that recent research shows that the number of earthquakes of magnitude 3 and larger has significantly increased in the U.S. midcontinent since 2000. "Most of the increase in seismicity has occurred in areas of enhanced hydrocarbon production and, hence, increased disposal of production-related fluids.

For more information, see http://www.nap.edu/catalog.php?record_id=13355 and http://www.energy.senate.gov/public/index.cfm/hearings-and-business-meetings?ID=2c908340-a9bb-40b4-bf7f-8308b272893d.

—Randy Showstack, Staff Writer

Subpoena of Scientists' E-mails Raises Concerns

A recent court order that required the Woods Hole Oceanographic Institution (WHOI) to hand over more than 3000 confidential e-mails to the energy company BP in May has led to concerns about the need to protect academic freedom, the deliberative scientific process, and intellectual property. Lawyers representing BP filed the subpoena in December 2011 to seek information from WHOI in relation to a lawsuit brought against BP by the U.S. government and others about damages from the 2010 Deepwater Horizon oil spill in the Gulf of Mexico. WHOI is not a party to the lawsuit.

BP and U.S. Coast Guard officials had asked for WHOI's assistance in assessing the spill. Several WHOI scientists and their colleagues had conducted work related to the spill, and they had determined that there had been an average flow rate of 57,000 barrels of oil per day from the spill site, amounting to about 4.9 million barrels released in total during the incident.

"BP claimed that it needed to better understand our findings because billions of dollars in fines are potentially at stake," WHOI researchers Christopher Reddy and Richard Camilli wrote in a 3 June opinion piece in *The Boston Globe*. The researchers noted that they provided BP with more than 50,000 pages of documents, raw data, and other material that they used in their research for the company to analyze and confirm the researchers' findings. However, BP "still demanded access to our private communications," the researchers wrote.

"Our experience highlights that virtually all of scientists' deliberative communications, including e-mails and attached documents, can be subject to legal proceedings without limitation," they wrote, adding that the situation "casts a chill over the scientific process. In future crises, scientists may censor or avoid deliberations, and more importantly, be reluctant to volunteer valuable expertise and technology that emergency responders don't possess." In addition, Reddy and Camilli noted that BP now has access to WHOI intellectual property that is attached to the e-mails.

A statement from BP noted that "BP is a company of scientists and engineers, and the subpoena served on Woods Hole is in no way an attack on science."

—Randy Showstack, Staff Writer

GEOPHYSICISTS

Honors

Tim Killeen has been appointed president of the Research Foundation for the State University of New York (SUNY) and SUNY vice chancellor for research, effective 9 July. Killeen has been assistant director for geosciences at the U.S. National Science Foundation since July 2008. As SUNY's research foundation president, Killeen will be responsible for the supervision and operation of the largest, most comprehensive university-connected U.S. research foundation, according to a foundation statement. Killeen served as AGU president from 2006 to 2008 and was director of the National Center for Atmospheric Research from 2000 to 2008.

Michael Brown of the California Institute of Technology, Pasadena, and **David Jewitt** of the University of California, Los Angeles, are recipients of the Kavli Prize in Astrophysics for their "fundamental contributions to our understanding of the outer solar system." Brown was cited for having designed and implemented the Caltech Wide-Area Sky Survey. He was also cited for discovering Quaoar and other large Kuiper Belt objects as well as the planetoid Sedna. Jewitt, along with Jane Luu of the Massachusetts Institute of Technology, was cited for discovering the first Kuiper Belt object, known as 1992 QB1, in 1992. "Their discovery of the Kuiper Belt and subsequent investigation of the composition of Kuiper Belt objects are bringing new insight into the early history and current state of the solar system," stated an announcement about the prize, which is a partnership among the Norwegian Academy of Science and Letters, the Kavli Foundation, and the Norwegian Ministry of Education and Research.

A number of AGU members will be honored by the Committee on Space Research (COSPAR) at its 39th scientific assembly on 16 July. **Neil Gehrels** is being honored with the Harrie Massey Award for outstanding contributions to the development of space research. Gehrels is chief of the Astroparticle Physics Laboratory, NASA Goddard Space Flight Center, Greenbelt, Md., and professor of astronomy at the University of Maryland. **Robert Lin** will receive the Jeoujang Jaw Award, presented jointly by COSPAR and the Chinese Academy of Sciences in recognition of scientists who have made distinguished pioneering contributions to promoting space research, establishing new space science research branches, and founding new exploration programs. Lin is director of the Space Sciences Laboratory, University of California, Berkeley.

Janet Luhmann will receive the COSPAR Space Science Award for outstanding contributions to space science. Luhmann is a senior fellow at the Space Sciences Laboratory, University of California, Berkeley. **Rafael Navarro-Gonzalez** will receive the Vikram Sarabhai Medal, jointly awarded by COSPAR and the Indian Space Research Organization for outstanding contributions to space research in developing countries. He is professor of astrobiology at the Laboratory of Plasma Chemistry and Planetary Studies, Institute of Nuclear Science, National Autonomous University of Mexico.

The Yakov B. Zeldovich Medal, jointly awarded by COSPAR and the Russian Academy of Sciences to young scientists for excellence and achievements, will be given to **Jadunandan Dash,** School of Geography, University of Southampton, UK, in recognition of original contributions to monitoring of vegetation dynamics from satellite observations; **Jonathan Eastwood,** the Blackett Laboratory, Imperial College London, UK, for outstanding research into the basic properties of collisionless plasmas in space that has led to a significant advancement of our understanding of magnetic reconnection and collisionless shocks; **Bethany Ehlmann,** California Institute of Technology and Jet Propulsion Laboratory, for fundamental discoveries of aqueous mineral phases on Mars that have transformed our understanding of aqueous processes on Mars and its potential for habitability; and **Tatsuhiro Yokoyama**, Research Institute for Sustainable Humanosphere, University of Kyoto, Japan, for his innovative modeling and experimental studies that helped resolve several outstanding problems concerning *E* and *F* region coupling processes.

The Astronomical Society of the Pacific has announced that the Kepler science team is the recipient of the Maria and Eric Muhlmann Award for important research based on the development of groundbreaking instruments and techniques. **William Borucki**, a space scientist at NASA's Ames Research Center, Moffett Field, Calif., is the science principal investigator for the mission that is surveying our region of the Milky Way galaxy to discover exoplanets.

Alexey Pavlov is the new director of the Association of Polar Early Career Scientists. Pavlov was previously a junior scientist at the Arctic and Antarctic Research Institute, St. Petersburg, Russia.

Wendy Harrison has been selected to be the new director of the Division of Earth Sciences at the U.S. National Science Foundation. Her tenure will begin in late August. Harrison is currently a professor in the Department of Geology and Geological Engineering, Colorado School of Mines, Golden.

In Memoriam

Paul Kruger, 85, 17 September 2010, Hydrology, 1963

Paul Witherspoon, 93, 10 February 2012, Fellow, Hydrology, 1967

FORUM

Effective Strategies to Counter Campus Presentations on Climate Denial

Although 97%–98% of the climate researchers most actively publishing in the field accept the basic tenets of the Intergovernmental Panel on Climate Change's (IPCC) findings [*Anderegg et al.*, 2010], there is a consistent undercurrent of doubt among the general public (A. Leiserowitz et al., Global warming's six Americas in May 2011, online report, 57 pp., Yale Project on Climate Change Communication, Yale University, New Haven, Conn., 2011). To some extent, this doubt is fueled by high-profile climate change deniers who offer "the real view" of climate science [*Oreskes and Conway*, 2010]. Our campuses recently hosted two such speakers: Ivar Giaever at Rensselaer Polytechnic Institute (RPI) and Christopher Monckton (also known as Lord Monckton) at Union College. (Monckton's presentation can be seen at http://union.campusreform.org/group/blog/live-webinar-lord-monckton-at-union-college.)

While such speakers often intend to muddy the waters with respect to climate science [*McCright and Dunlap*, 2010], the effect at our campuses was to galvanize our students and colleagues to highlight the widely accepted facts of climate change and the nature of expert scientific consensus on this topic. This communication was achieved using social media and follow-up events that raised the profile of climate change discussions. These events proved to be so successful that we offer our experiences so that others can capitalize on similar visits by climate change deniers by converting them into "teachable moments."

It is our intention neither to address the content of the lectures nor to expand on the extensive rebuttals to their arguments [e.g., *Nordhaus*, 2012] (see also http://www.realclimate.org/wiki/index.php?title=Christopher_Monckton and http://courseweb.stthomas.edu/jpabraham/global_warming/Monckton/Monckton%20Presentation%20June%2022/index.htm). Instead, we describe the successful use of multiple strategies to present an accurate picture of climate science. The attention and publicity surrounding the presentations by the climate change deniers almost certainly engaged both of our institutions in a discussion of climate science to a far greater extent than would have occurred if controversial speakers were not brought to campus.

The announcement of each upcoming lecture was a cause for concern for us and our colleagues because—let us be clear—there is damage to be done by such (misre)presentations. Educating the public so that people understand the science of climate change, including its causes and potential consequences, is a difficult task. By distorting the scientific process or attacking the legitimacy of scientists, such as those involved in the presentation of the United Nations' IPCC reports, these speakers have a chance to undo much of the work we have done.

It was neither practical nor desirable to block either speaker from making his presentation at our campuses. Giaever, for example, is a member of the RPI faculty, and neither speaker received speaking fees from our institutions for his appearance. Furthermore, colleges and universities exist for the very purpose of exchanging ideas.

Rather, the most effective way to counter such distorting presentations is to provide a more accurate picture of climate science and to point out flaws in the speakers' analyses. We did this along with a diverse coalition of students and faculty from a variety of departments. Strategies included public displays with information and illustrations related to climate change science, the use of social media sites such as Twitter and Reddit to exchange information and ideas, and the organization of follow-up events that focused on the science of climate change.

The follow-up events, in particular, were essential to our efforts' success. The RPI event, called "The Science of Climate Change," took place approximately 2 weeks after the presentation by Giaever (http://approach.rpi.edu/2012/03/09/the-big-picture-of-climate-change-science/). The format was close to that of a lecture, with an opportunity for members of the approximately 150-person audience to ask questions. The Union College follow-up event was mostly organized around questions from the more than 60 students who attended. Significantly, Monckton came to the Union College follow-up and sat in the first row. This forum allowed students to ask questions of various members of the Union College faculty and carry on a high-level discussion of climate change, the threats it poses, and possible solutions. They were also able to engage Monckton in extensive exchanges about his arguments.

The principal lesson from our experiences is that our students are some of the most effective counters to such presentations by climate change deniers. Largely on their own, students at each of our institutions organized sophisticated campaigns to present a coherent message about the science of climate change. They engaged with each speaker during the question-and-answer periods that followed the lectures, used social media to communicate with one another and with their peers, and organized alternative forums in which the science of climate change was effectively presented. They displayed highly sophisticated critical thinking skills and the passion and energy to organize, to engage with the speakers, and to rebut arguments that misrepresented the state of climate science.

On the other hand, faculty involvement in the presentation of climate science can be critical as well. It is likely too much to ask that students shoulder the entire burden of rebutting prominent speakers who have well-practiced arguments. Even in the case of the student-organized question-and-answer forum at Union College, two members of the faculty, along with one student, moderated the discussion. Faculty members from several other departments were also in attendance to help answer questions.

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Forum

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The final challenge, and the one for which we were least prepared, was to deal with postevent publicity. While we had effectively used social media tools to organize and communicate within our own communities, the Union College event was subject to a well-organized campaign that used those same tools to discredit our efforts. (See comments at http://www.concordy.com/article/opinions/march-7-2012/a-lords-opinion-cant-compete-with-scientific-truth/4222/, http://wattsupwiththat.com/2012/03/10/moncktons-schenectady-showdown/, and http://opinion.financialpost.com/2012/04/20/aristotles-climate/.) Such campaigns have been mounted against a variety of other communicators of climate science as well [e.g., *Mann*, 2012]; yet we would have been far better prepared for the postevent publicity if we had anticipated that Twitter and other Internet tools can effectively nationalize discussions that take place even at small colleges.

The time and, more important, the expertise required to mount such an organized challenge can be daunting. The need for skills in social and media communications that typically fall outside scientists' graduate training is well described [e.g., *Bowman et al.*, 2010; *Moser*, 2010; *Pidgeon and Fischhoff*, 2011]. Yet, when we faculty engage climate science deniers, we make clear to our students and the entire community that we believe that much is at stake. If we yield the argument to speakers who attempt to discredit our research and contradict what we teach in our classes, then we risk giving the impression that scientific literacy and public awareness of climate science are of little importance to us.

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—Jeffrey D. Corbin, Department of Biological Sciences, Union College, Schenectady, N. Y.; E-mail: corbinj@union.edu; and Miriam E. Katz, Department of Earth and Environmental Sciences, Rensselaer Polytechnic Institute, Troy, N. Y.

What's on the Web?

Read the latest offerings from the AGU Blogosphere:

Magma Cum Laude: "Blown away by Bancroft: Part III" (http://bit.ly/MBtkpI)

Mountain Beltway: "*101 American Geo-Sites You've Gotta See*, by Albert B. Dickas" (http://bit.ly/MKo7si)

Dan's Wild Wild Science Journal: "Forecast track for Debby: You're on your own son!" (http://bit.ly/NCSQft)

Georneys: "Monday geology picture: Boulder at Sea Point, Cape Town, South Africa" (http://bit.ly/Mv4gSg)

GeoSpace: "AGU interviews astronauts in space" (http://bit.ly/PChzA8)

The Landslide Blog: "Did you see a landslide?" (http://bit.ly/MKD3dQ)

A close look at amphibole in Bancroft, Ontario, photographed by Magma Cum Laude blogger Jessica Ball.

ABOUT AGU

Improved Time to Publication in *Journal of Geophysical Research-Atmospheres*

Timely publication of manuscripts is important to authors and readers. AGU has significantly accelerated both the review and production processes for the *Journal of Geophysical Research-Atmospheres* (JGR-Atmospheres). Via a number of mechanisms (e.g., shortening the time allotted for reviewer selection, manuscript reviews, and revisions), the mean time to first decision has been decreased from 98 days in 2007 to 50 days in 2011, and the mean time to final decision has been decreased from 132 days in 2007 to 71 days in 2011. By implementing a new content management system, adjusting the workflow for improved efficiency, requesting authors to proofread their manuscripts quicker, and improving monitoring and follow-up to author and vendor queries, the mean production time from manuscript acceptance to publication has been decreased from 128 days in 2010 to only 56 days in 2012. Thus, in the past few years the mean time to publication of JGR-Atmospheres has been cut in half. These milestones have been achieved with no loss of quality of presentation or content. In addition, online posting of "papers in press" on JGR-Atmosphere's home page typically occurs within a few days after acceptance. JGR-Atmospheres editors thank manuscript reviewers, authors, and AGU staff who have greatly contributed to the more timely review and publication processes. This information will be updated periodically on the JGR-Atmospheres home page. A chart showing the average time from acceptance to publication for all of AGU's journals is available at http://www.agu.org/pubs/pdf/31May2012_Timeliness_Chart.pdf.

—Joost de Gouw, Steven Ghan, Sara Pryor, Yinon Rudich, and Renyi Zhang, Editors, JGR-Atmospheres

Enter AGU Student Contest to Win Free Fall Meeting Registration

AGU is excited to announce its first Student Video and Student T-shirt Design competitions. This is an opportunity for students to display their artistic sides and share their creativity and love of science with the world. Entries could highlight an aspect of Earth or space science in an educational and/or entertaining way or showcase a career path in geophysical sciences. Winners of these student-only competitions will be awarded free registration to the 2012 Fall Meeting in San Francisco, Calif.

The Student Video Contest gives students the opportunity to share an original short video that will be showcased on AGU's Web site and shown at the Fall Meeting. In the videos, students can explain an aspect of Earth or space science for a nonscientific audience, showcase an interesting geophysical career path, or even perform a song or skit.

In the Student T-shirt Design Contest, students can show off their graphic design talents by creating a one-of-a-kind T-shirt with an Earth or space science theme. Designs can be humorous, educational, or both. The winning design will appear on T-shirts sold at the Fall Meeting, and proceeds will be donated to AGU's Student Travel Grants Program.

AGU is accepting submissions from 2 July to 13 August. AGU will choose five semifinalists from each competition, and then the winners will be chosen by AGU's Facebook and YouTube audiences. T-shirt designs will be posted on AGU's Facebook page, and videos will be posted on the YouTube page. Submissions receiving the most "likes" by 10 September will be the winners.

Students who are artistic, innovative, or simply need a diversion from classes and lab reports are encouraged to apply. This is your chance to take part in a fun and creative event and win free student registration to the 2012 AGU Fall Meeting.

For more information, see http://membership.agu.org/students/.

—Kara Smedley, Student Member Specialist, AGU; E-mail: ksmedley@agu.org

Outstanding Student Paper Awards

The following members received Outstanding Student Paper Awards at the 2011 AGU Fall Meeting in San Francisco, Calif. Awards for other sections and focus groups will be announced in future issues of Eos.

Atmospheric and Space Electricity (ASE)

Thomas Gjestland, University of Bergen, Bergen, Norway, *Are there more TGFs in the RHESSI data?*

Burcu Kosar, Florida Institute of Technology, Melbourne, *Sprite streamer formation in sub-breakdown conditions from an ionospheric disturbance*

Atmospheric Sciences (AS)

Alexis Attwood, University of New Hampshire, Durham, *The effects of mineral dust on the hygroscopic and optical properties of inorganic salt aerosols*

Adriana Raudzens Bailey, University of Colorado, Boulder, *Isotopic signatures of mixing processes and cloud detrainment in the subtropics*

Shannon Capps, Georgia Institute of Technology, Atlanta, *Quantifying relative contributions of global emissions to PM2.5 air quality attainment in the U.S.*

Matthew Christensen, Colorado State University, Fort Collins, *Aerosol-precipitation responses deduced from ship tracks as observed by CloudSat*

Evan Couzo, University of North Carolina at Chapel Hill, *A regulatory model's ability to simulate large spatial heterogeneity in observed ozone in Houston, Texas*

Stephen Griffith, Indiana University, Bloomington, *Hydroxyl and hydroperoxy chemistry at the CalNex-LA 2010 site: Measurements and modeling*

Will Johnson, Montana State University, Bozeman, *Development of an eye-safe micropulse differential absorption lidar (DIAL) for carbon dioxide profilings*

Chunsong Lu, Nanjing University of Information Science and Technology, Nanjing, China, and Brookhaven National Laboratory, Upton, Long Island, New York, *Observational study of different entrainment-mixing mechanisms in cumulus during RACORO: An implication for parameterization*

Corey Markfort, University of Minnesota, Twin Cities, *Effect of wakes on land-atmosphere fluxes*

Scot Miller, Harvard University, Cambridge, Massachusetts, *Large-scale environmental drivers of North American methane emissions*

Richard Moore, Georgia Institute of Technology, Atlanta, *Volatility and hygroscopicity of Atlanta CCN during new particle formation events in summer 2009*

Harshal Parikh, University of North Carolina at Chapel Hill, *A combined kinetic and volatility basis set approach to model secondary organic aerosol from toluene and diesel exhaust/meat cooking mixtures*

Brandon Strellis, Georgia Institute of Technology, Atlanta, *The influence of light absorbing aerosols on the radiation balance over central Greenland*

Michael Zucker, University of Colorado, Boulder, *Airborne passive microwave measurements from the AMISA 2008 science campaign for modeling of Arctic sea ice heating*

Biogeosciences (B)

Kristin Bergmann, California Institute of Technology, Pasadena, *The clumped isotopic record of Neoproterozoic carbonates, Sultanate of Oman*

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Janet Chen, University of Wyoming, Laramie, *Uptake and preference of soil nitrate, ammonium and amino acid pools by a native grassland plant are altered by experimental warming and elevated atmospheric CO_2*

Jonathan Duncan, University of North Carolina at Chapel Hill, *Hydrologic variability controls summer nitrate export: A multi-scale measurement and modeling approach*

Sarah Gustafson, Pennsylvania State University, University Park, *Influence of land management and hydrology on urea fate and transport within a coastal plain watershed dominated by intensive poultry agriculture*

Yadira Ibarra, University of Southern California, Los Angeles, *Do the Cotham Member stromatolites of the Late Triassic, SW UK, represent extinction "disaster forms"?*

Nicole Khan, University of Pennsylvania, Philadelphia, *Tracking the deposition of sediments from the great Mississippi flood of 2011*

D. Caleb King, University of Hawai'i at Manoa, Honolulu, *Organismal versus environmental control of the carbon isotope composition of Dicot Angiosperm pollen: Implications for paleoenvironmental reconstruction*

Emily Knowles, University of Colorado, Boulder, *A geochemical analysis of the formation and preservation of biosignatures in subseafloor basalt glasses*

Rebecca Lybrand, University of Arizona, Tucson, *Quantifying elemental compositions of primary minerals from granitic rocks and saprolite within the Santa Catalina Mountain Critical Zone Observatory*

Carla Rosenfeld, Pennsylvania State University, University Park, *Role of root exudates in dissolution of Cd containing iron oxides*

Eugenio F. Santillan, University of Texas at Austin, *Microbes under pressure: A comparison of CO_2 stress responses on three model organisms and their implications for geologic carbon sequestration*

Casey Schmidt, University of Florida, Gainesville, *Groundwater bioremediation for long term nitrogen reductions in agricultural effluent*

Yudai Sumiyoshi, University of Hawai'i at Manoa, Honolulu, *Belowground carbon cycle of Napier and Guinea grasses*

Ying Sun, University of Texas at Austin, *Forest recovery after a massive ice storm in China: Findings from the application of a unified quantitative framework for studying impacts of large-scale disturbances*

Thomas Weber, University of California, Los Angeles, *Regulation of the ocean nitrogen inventory by stoichiometrically diverse plankton*

Cryosphere (C)

Christine Dow, Swansea University, Swansea, UK, *Subglacial hydrological modelling of a rapid lake drainage event on the Russell Glacier catchment, SW Greenland*

Felipe Nievinski, University of Colorado, Boulder, *GPS interferometric reflectometry for ground-based remote sensing of snow depth and density*

Alek Petty, University College London, *The mixed layer over the Antarctic continental shelf*

Kathryn Semmens, Lehigh University, Bethlehem, Pennsylvania, *Snowmelt timing (onset and melt-refreeze) trends in the Yukon River basin determined from passive microwave brightness temperatures*

Jeffrey Thompson, California Institute of Technology, Pasadena, *Can ice streams transmit tidal stresses far upstream of the grounding line?*

Michael Winkler, University of Innsbruck, Innsbruck, Austria, *Kilimanjaro ice cliffs: Morphology, recession, micro-climate, and how they determine glacier area loss*

Earth and Planetary Surface Processes

Rebecca Caldwell, Boston College, Boston, Massachusetts, *The effect of grain-size distribution on river delta morphology*

Anna Crowell, University of North Dakota, Grand Forks, *Re-evaluating geothermal potential with GIS methods and new data: Williston Basin, North Dakota*

Kimberly Huppert, Massachusetts Institute of Technology, Cambridge, *Morphodynamics of disequilibrium wave ripples*

Alan Richardson, Massachusetts Institute of Technology, Cambridge, *Scalable, massively parallel approaches to upstream drainage area computation*

Kerry Riley, Boise State University, Boise, Idaho, *Wildfires, debris flows, and climate: Using modern and ancient deposits to reconstruct Holocene sediment yields in central Idaho*

Matthew Rossi, Arizona State University, Tempe, *Climatic controls on steady state erosion using the relationship between channel steepness and cosmogenic 10Be-derived catchment averaged erosion rates*

John Shaw, University of Texas at Austin, *Water and sand transport pathways through the delta front, Wax Lake delta, USA*

Virginia Smith, University of Texas at Austin, *The dynamic geometry of the lower Trinity River, Texas*

Andrew Wickert, University of Colorado, Boulder, *Dynamic drainage networks and discharge histories in North America over the last glacial cycle: Implications for geomorphic change and early human settlement patterns*

Education (ED)

Tiffany Rivera, Roskilde University, Roskilde, Denmark, *Overcoming challenges to making data re-usable: The example of geochemical databases*

Geodesy (G)

Yuning Fu, University of Alaska Fairbanks, *Vertical deformation in the Himalaya and Tibet constrained by GPS and GRACE measurements*

Garrett Thornton, University of Texas at El Paso, *Modeling vertical deformation along the San Andreas Fault system using geodetic, geologic, groundwater, and tide gauge data*

Matthew Travis, Pennsylvania State University, University Park, *Strain partitioning in a propagating ridge system: Inter and intra-ridge strain accumulation in south Iceland*

Richard Walters, University of Oxford, Oxford, UK, *Interseismic strain accumulation across the Ashkabad fault (NE Iran) from MERIS-corrected ASAR data*

Geomagnetism and Paleomagnetism (GP)

Mathew Domeier, University of Michigan, Ann Arbor, *Reconciling paleomagnetism and Pangea*

Earl Manning, University of Oklahoma, Norman, *An integrated paleomagnetic, rock magnetic, and geochemical study of the Marcellus Shale in the Valley and Ridge Province in Pennsylvania and West Virginia*

Global Environmental Change (GEC)

Benjamin Abbott, University of Alaska Fairbanks, *Timing and magnitude of CO_2 and CH_4 release from the permafrost region: An expert elicitation*

Juan Nogues, Princeton University, Princeton, New Jersey, *Investigation of dissolution and precipitation of carbonate rocks using reactive transport modeling in pore networks*

Anupama Rajan, University of Tromsø, Tromsø, Norway, *Imaging fluid migration-path networks for understanding the geo-constraints associated with fluid flow and venting mechanisms in gas-hydrated sediments of SW Barents Sea*

Yolanda Roberts, University of Colorado, Boulder, *Quantitative comparison of the variability of simulated and observed hyperspectral solar radiance*

CLASSIFIED

ADVERTISING INFORMATION

Eos is published every Tuesday, except the last week of December. For a classified or display advertisement to be published in a future issue of *Eos*, electronic copy must reach us by 23:59 eastern time, 9 days prior (Sunday) to publication, except around certain holidays, which have earlier deadlines. No cancellations accepted after deadline.

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POSITIONS AVAILABLE

Atmospheric Sciences

Atmospheric Scientist U.S Army Research Office Research Triangle Park, N.C.

Applications are being solicited by the U.S. Army Research Office in Research Triangle Park, North Carolina for a scientist with the qualifications of Meteorologist, Physicist, Mathematician, Computer Scientist, Chemist, Environmental Engineer, or Aerospace Engineer. You must meet the qualifications of at least one discipline to apply.

There is one vacancy at either the DB-04 level (GS 14/15 equivalent), $99,638 - $152,364 per annum; or DB-03 level (GS 12/13 equivalent), $70,906 - $109,611 per annum. Starting salary includes a locality adjustment and will depend upon qualifications and salary history.

This is an interdisciplinary position. The work involves formulation, management, and leadership of an innovative, high-payoff extramural (primarily through grants to university faculty) basic research program in the atmospheric sciences. Expertise required includes capability to manage and direct successful fundamental basic research programs in areas of physical meteorology to include energy propagation through the environment and into the near subsurface, optical and acoustic monitoring, determination of aerosol properties, and boundary layer processes.

The incumbent will initiate new research projects to advance the frontiers of atmospheric science with goal of pursuing basic research to create unprecedented scientific opportunities relevant to Army needs. To accomplish this goal, the selectee will

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analyze and evaluate proposals, communicate with performers, review and analyze research reports. The incumbent must stimulate technology transfer to both Army and civilian users, maintain awareness of Army in-house programs, and communicate relevant program goals and objectives. The incumbent will focus the research community by initiating and participating in workshops, conferences, and symposia that address emerging research opportunities. In short, the selected individual will serve as the principal Army basic research leader in the pursuit of ground breaking basic research activities in atmospheric science. Some travel is required. A security clearance is required.

Interested individuals must apply at www.usajobs.gov. Announcement numbers are NEAC12832014671992D for the DB-04 and NEAC12832014672129D for the DB-03. This position is open to application from May 16, 2012 to July 31, 2012. If you have questions, contact Bruce Spruell, HR Specialist at 301-394-3396, e-mail: bruce.d.spruell.civ@mail.mil or Wanda Wilson, Administrative Officer, Army Research Office at (919) 549-4296, e-mail: wanda.e.wilson.civ@mail.mil.

Geochemistry

Two postdoctoral positions in Isotope Geochemistry, UC Berkeley.

The successful candidate(s) will perform research on fractionation of non-traditional isotopes in high temperature geochemical systems (igneous, metamorphic or hydrothermal).

Possible areas of research include: metal isotope fractionation in natural high temperature systems, experimental investigations of metal isotope fractionation during crystallization, and experimental studies of diffusion in silicate systems. Other projects closely related to the above themes are also possible. Experience with modern isotopic measurement techniques (TIMS, SIMS, and/or MC-ICPMS), clean laboratory chemistry and/or high pressure experimental apparatus (piston cylinder, cold seal vessels or Parr reactors) is highly desired.

This position is in the Center for Isotope Geochemistry (Donald DePaolo, Director), a joint-institution research center of both UC Berkeley and LBNL. The initial appointment will be one year, with renewal up to three years depending on funding and performance. Applicants should send an email describing research interests and qualification details, a CV, one journal or prepress article (pdf), and contacts for three references to cig@berkeley.edu. Enter "CIG postdoc" in the email's subject line to expedite. Consideration of applications will begin August 1, 2012, and review will be for 30 days or longer.

Preference may be given to candidates who can start on or before January 15, 2013. University of California is an Equal Opportunity/Affirmative Action Employer. All qualified applicants are encouraged to apply.

The total duration of an individual's postdoctoral service may not exceed five years, including postdoctoral service at other institutions.

Ocean Sciences

ASSISTANT RESEARCH SCIENTIST/STAFF SCIENTIST.

The Integrated Ocean Drilling Program (IODP) at Texas A&M University invites applications for the position of Assistant Research Scientist/Staff Scientist in our Science Operations section. A Ph.D. in geosciences or related field, and demonstrated research experience is required. Applicants with expertise in organic geochemistry, microbiology, and sedimentary inorganic geochemistry are encouraged to apply, but all fields of geosciences will be considered. Applicants must have a demonstrated fluency in written and spoken English. An experienced seagoing scientist, especially in scientific ocean drilling, is preferred.

The successful applicant will serve as the Expedition Project Manager to coordinate all aspects of cruise planning and implementation, and postcruise expedition activities. These duties include sailing as the IODP scientific representative on an IODP expedition approximately once per year. Individual research, as well as collaboration with colleagues at Texas A&M University through the university's interdepartmental Ocean Drilling and Sustainable Earth Science initiative (ODASES), is expected. The applicant will also provide scientific advice on laboratory developments in their area of specialization. Applicants must be able to cooperate and work harmoniously with others and have the ability to be an effective team leader. The successful applicant will be required to pass a new employee physical exam and annual seagoing physical exams.

Salary will be commensurate with qualifications and experience of the applicant. This is a regular full time position, contingent upon continuing availability of funds for IODP. We will begin reviewing applications on 31 August 2012, but will continue to accept applications until candidates are selected for interviews. Applicants may access the TAMU application at http://tamujobs.tamu.edu and apply online with reference to NOV#121261, attach a curriculum vita, including a list of published papers, statement of research interests, and names and addresses of three references.

Integrated Ocean Drilling Program
U.S. Implementing Organization
Texas A&M University
College Station, Texas 77845
Equal Opportunity/Affirmative Action Employer Committed to Diversity

The Atmospheric and Ocean Sciences Program at Princeton University seeks an outstanding Postdoctoral Research Associate or more senior Research Associate to engage in an ocean modeling project focused on Equatorial Pacific biogeochemistry.

The overall project goal is to identify the mechanisms governing the supply of Southern Ocean mode water nutrients to the equatorial Pacific thermocline. This will be addressed through the application of ocean modeling tools, including both Eulerian and Lagrangian diagnostics, to the interpretation of measured nutrient distributions in the ocean.

Candidates must possess a PhD in the earth sciences, applied math, or the physical sciences. An ability and interest to work across disciplinary boundaries is a must, as are strong modeling and quantitative skills. Postdoctoral appointments are initially for one year with the renewal for subsequent years based on satisfactory performance and continued funding. A competitive salary is offered commensurate with experience and qualifications.

Applicants are asked to submit vitae, a statement of research experience and interest, and names of at least 3 references to http://jobs.princeton.edu, Req. # 1200376. Review of applications will begin as soon as they are received, and continue until the position is filled. Princeton University is an equal opportunity employer and complies with applicable EEO and affirmative action regulations.

Solid Earth Geophysics

Terrestrial Scientist U.S Army Research Office Research Triangle Park, N.C.

Applications are being solicited by the U.S. Army Research Office in Research Triangle Park, North Carolina for a scientist with the qualifications of

Geologist, Geophysicist, Physicist, Mathematician, Computer Scientist or Environmental Engineer. You must meet the qualifications of at least one discipline to apply.

There is one vacancy at either the DB-04 level (GS 14/15 equivalent), $99,638 - $152,364 per annum; or DB-03 level (GS 12/13 equivalent), $70,906 - $109,611 per annum. Starting salary includes a locality adjustment and will depend upon qualifications and salary history.

This is an interdisciplinary position. The work involves formulation, management, and leadership of an innovative, high-payoff extramural (primarily through university faculty) basic research program in the terrestrial sciences. Expertise required includes capability to manage and direct successful fundamental basic research programs in areas to include, but not limited to, environmental sensing, problems of transport, and mathematical and statistical methods for analysis of complex soil, air, and hydrospheric systems.

The incumbent will initiate new research projects to advance the frontiers of terrestrial science with goal of pursuing basic research to create unprecedented scientific opportunities relevant to Army needs. To accomplish this goal, the selectee will analyze and evaluate proposals, communicate with performers, review and analyze research reports. The incumbent must stimulate technology transfer to both Army and civilian users, maintain awareness of Army in-house programs, and communicate relevant program goals and objectives. The incumbent will focus the research community by initiating and participating in workshops, conferences, and symposia that address emerging research opportunities. In short, the selected individual will serve as the principal Army basic research leader in the pursuit of ground breaking basic research activities in terrestrial science. Some travel is required. A security clearance is required.

Interested individuals must apply at www.usajobs.gov. Announcement numbers are NEAC12831983670873D for the DB-04 and NEAC12831983671216D for the DB-03. This position is open to application from May 16, 2012 to July 31, 2012. If you have questions, contact Bruce Spruell, HR Specialist at 301-394-3396, e-mail: bruce.d.spruell.civ@mail.mil or Wanda Wilson, Administrative Officer, Army Research Office at (919) 549-4296, e-mail: wanda.e.wilson.civ@mail.mil.

Space Physics

Postdoctoral Research Extraterrestrial Materials Analysis.

The Research Foundation of the State University of New York at Plattsburgh seeks applicants to fill an anticipated Postdoctoral research position to study the elemental, mineralogical and organic compositions and structure of comet Wild 2 particles collected by the Stardust spacecraft and interplanetary dust particles (IDPs) available starting Fall of 2012 or January 2013. The position will involve analyzing these particles using synchrotron-based X-ray Microprobes, X-Ray Diffraction, X-Ray Absorption Near-Edge Structure Spectroscopy, and Infrared Spectroscopy, providing the Postdoctoral Associate with expertise in the operation and data analysis of several state-of-the-art research instruments working with Dr. George Flynn.

The initial term for this full-time appointment will be for a one-year period, which may be renewed in one-year increments.

Minimum Qualifications: PhD in physics, geology, or a related field.

Salary: Competitive + Excellent Fringe Benefit Package

Search will remain open until successful candidate has been selected. Applicants should send a curriculum vitae including a list of publications, a statement of research interests, names, e-mail addresses and telephone numbers of three references to the following:

Research Foundation of SUNY
RF-371
101 Broad Street
815 Kehoe Building
Plattsburgh, NY 12901
Fax: (518) 564-2157
RFHRApply@Plattsburgh.edu

The Research Foundation For The State University of New York

Is An Equal Opportunity / Affirmative Action Employer

Interdisciplinary/Other

Brown University: Assistant Professor Environmental Remote Sensing Environmental Change Initiative.

Environmental Remote Sensing:

The Environmental Change Initiative (ECI) (http://www.eci.brown.edu/), Brown University, invites applications for a Brown University tenure-track faculty position in Environmental Remote Sensing. We seek a scholar who uses remotely sensed data to analyze the multiscalar and complex relationships between human societies and the natural environment. Requirements include a Ph.D. in an environmentally-relevant social or natural science, a record of achievement in the use of remotely sensed data in environmental science-focused research demonstrated by peer reviewed publications and/or externally funded research, and a commitment to excellence in graduate and undergraduate teaching. We seek candidates whose research interests and expertise complement and strengthen existing ECI research foci in land change science, biogeochemical processes, and conservation science. The successful candidate should integrate research efforts with environmentally relevant natural and social sciences spanning sociology, ecology, evolutionary biology and geological and climate science and have experience working in an interdisciplinary team. In addition to remotely sensed data, we are interested in candidates who broadly incorporate geospatial technologies in their research. S/he will maintain an active, externally-funded research program and be involved in teaching at both undergraduate and graduate levels. ECI fosters interdisciplinary research and education in the environmental sciences at Brown. The University is making investments in the ECI including new resources for interdisciplinary research, post-doctoral research appointments, graduate education and a cooperative graduate program with the Marine Biological Laboratory (MBL) at Woods Hole. The candidate will be a core faculty member of the ECI with an appointment in a tenure-granting department such as Sociology, Geological Sciences, or Ecology and Evolutionary Biology. Appointment is expected at the Assistant Professor level, although exceptional circumstances would warrant appointment at a higher level. The department appointment will require that the candidate's qualifications are

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ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Schweizerischer Erdbebendienst
Swiss Seismological Service

Professor of Seismology and Director of the Swiss Seismological Service (SED)

The Department of Earth Sciences (www.erdw.ethz.ch) and the Swiss Seismological Service (www.seismo.ethz.ch) at ETH Zurich invite applications for the above-mentioned position.

The successful candidate will lead a diverse team of currently 80 scientists, staff members, and students. The SED is a national service and competence centre for earthquake related risk analysis and research, service, and education. It operates the national seismic network, consisting of more than 120 real-time stations, a 24/7 alert service, is responsible for seismic hazard assessment at a national scale and acts as the Swiss National Data Centre for the CTBT. Presently, the SED conducts research and development covering a wide range of topics, including seismic hazard assessment, engineering seismology, induced seismicity, computational and statistical seismology, real-time seismology and seismotectonics.

The new Professor and Director should have expertise in any domain of seismology and will direct the national seismological service and shape the research activities at the SED responding to the increasingly cross-disciplinary challenges of the future. He or she has an outstanding research record, proven ability to raise competitive funding and demonstrated managerial as well as communication skills. A contribution to teaching within the Department of Earth Sciences at both undergraduate level (German or English) and graduate level courses (English) is expected. Furthermore, a willingness to learn German is required.

Your application should include your curriculum vitae, publication list, statement of research interests, and the names of three potential referees. The letter of application should be addressed **to the President of ETH Zurich, Prof. Dr. Ralph Eichler. The closing date for applications is 16 September 2012.** ETH Zurich is an equal opportunity and affirmative action employer. In order to increase the number of women in leading academic positions, we specifically encourage women to apply. ETH Zurich is further responsive to the needs of dual career couples and qualifies as a family friendly employer.
Please apply online at www.facultyaffairs.ethz.ch.

THE CHINESE UNIVERSITY OF HONG KONG

Applications are invited for:-

Earth System Science Programme, Faculty of Science
Professors / Associate Professors / Assistant Professors
(Ref. 1112/230(061)/2)

The Chinese University of Hong Kong, founded in 1963, aspires to be acknowledged regionally and internationally as a first class comprehensive research university (*http://www.cuhk.edu.hk*). The Faculty of Science comprises four Departments and two Schools, and also offers a number of interdisciplinary programmes. The Faculty has 300 full-time teaching and research staff, 1,650 undergraduate students and 560 postgraduate research students. Further information about the Faculty is available at *http://www.cuhk.edu.hk/sci/*.

A new programme in **Earth System Science (ESSC)** will be launched in 2012-13 under the Faculty of Science. The ESSC programme is seeking qualified applicants for several faculty posts at Professor / Associate Professor / Assistant Professor levels in the following disciplines related to ESSC: atmospheric science, geodesy, geodynamics, global environmental change, and seismology. Applicants of exceptional quality who specialize in other areas will also be considered.

Applicants should have (i) a PhD degree; and (ii) a good scholarly record demonstrating potential for teaching and research excellence. The appointees will (a) teach undergraduate and postgraduate courses; (b) develop a significant independent research programme with external funding; and (c) supervise postgraduate students. Appointments will normally be made on contract basis for up to two years initially commencing as soon as possible, which, subject to mutual agreement, may lead to longer-term appointment or substantiation later. Applications will be accepted until the posts are filled.

Salary and Fringe Benefits
Salary will be highly competitive, commensurate with qualifications and experience. The University offers a comprehensive fringe benefit package, including medical care, a contract-end gratuity for appointments of two years, and housing benefits for eligible appointees. Further information about the University and the general terms of service for appointments is available at *http://www.per.cuhk.edu.hk*. The terms mentioned herein are for reference only and are subject to revision by the University.

Application Procedure
Applications (a cover letter with indication of the rank applying for, a full curriculum vitae, a detailed list of publications, and contact information of three professional referees) should be sent to the Personnel Office by post or by fax (no.(852) 3943 1462). The Personal Information Collection Statement will be provided upon request. Please quote the reference number and mark 'Application – Confidential' on cover.

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commensurate with the tenuring department's standards for a tenured or tenure-track appointment.

Requirements include a Ph.D. in an environmentally-related discipline, a record of achievement in the use of remotely sensed data in environmental science-focused research, and a commitment to graduate and undergraduate teaching.

To apply, please submit a letter of interest addressed to Jack Mustard, Search Committee Chair, Environmental Change Initiative, along with a current CV, teaching and research statements, and 3 letters of reference for the Assistant Professor position. Applications should be submitted through Interfolio at http://www.interfolio.com/apply/12528 and must be received by September 6, 2012 in order to receive full consideration.

For administrative questions regarding this position please contact Bonnie Horta at Bernadette_Horta@brown.edu or (401) 863-3032.

Brown University is an EEO/AA employer. Minorities and women are encouraged to apply.

CLIMATE CHANGE ASSISTANT PROFESSOR.

Tufts University invites applications for a full-time, tenure-track position as an Assistant Professor of Earth and Ocean Sciences in the area of Climate Change, beginning September 1, 2013. This position resides in the Department of Earth and Ocean Sciences but is part of a multidisciplinary cluster-hiring initiative designed to deepen and broaden the Environmental Studies program as well as to enhance traditional academic departments.

The successful candidate will be expected to teach an undergraduate introductory course in climate science, and one or more upper level courses in a field related to the person's expertise. At least 2 courses will count toward both the EOS and the Environmental Studies majors, and the successful candidate will work with others in the cluster hire to create a capstone experience for students in the program. We are particularly interested in those with research interests in the geological record of climate change, methods for interpreting climate change, or implications of climate change that may span a range of temporal scales.

Qualifications include: a Ph.D. by time of appointment in an Earth and Ocean Science discipline; demonstrated potential for research supported by external funding; and preferably teaching experience at the college level. The applicant should be able to fit into a small, well-equipped department where teaching diverse student populations is highly valued, and will be able to work with the Environmental Studies faculty to offer courses that also complement that interdisciplinary program.

A letter of application, statement of teaching and research interests, transcripts, CV, and the names and addresses of three references should be sent to Professor Jack Ridge, Chair, Department of Earth and Ocean Sciences, Tufts University, Medford, MA 02155 (jack.ridge@tufts.edu). Review of applications will begin September 15, 2012 and will continue until the position is filled. Tufts University is an Affirmative Action/Equal Opportunity employer. We are committed to increasing the diversity of our faculty. Members of underrepresented groups are strongly encouraged to apply.

GIS Technician.

The Michigan Geological Survey in the Department of Geosciences, College of Arts and Sciences, at Western Michigan University invites applications for a GIS Technician for a one year, full-time appointment with the possibility of renewal. This position will play a major role in assisting the survey in transitioning to 3-D mapping and modeling applications. The candidate will be responsible for: (1) production of geologic maps and related products; (2) management and maintenance of the survey's web-based data bases and website; and (3) assisting in writing technical sections of proposals and reports. Minimum qualifications include a bachelor's or higher degree in geology, geography, computer science or related field and three years of experience with programming, ArcGIS Server, database management, system administration, and strong computer skills from training and/or experience in geologically oriented ArcGIS applications. GIS experience in the public or private sector and familiarity with 3-D visualization software are preferred.

The appointment will begin in August 2012.

To apply, applicants must submit on-line a cover letter and resume. For additional position information and to complete the online application process, please go to http://www.wmich.edu/hr/careers-at-wmu.html.

Review of applications will begin July 21, 2012, and will continue until the position is filled. Western Michigan University is an affirmative action/equal opportunity employer.

Volcano-Lithosphere Interactions on the Terrestrial Planets Postdoctoral Fellowship: Lunar and Planetary Institute.

The Universities Space Research Association's Lunar and Planetary Institute (LPI), in Houston Texas invites applications for a postdoctoral fellowship in the field of geophysical studies of the growth and evolution of large volcanic edifices and provinces on the terrestrial planets.

The successful candidate will work with Dr. Patrick McGovern exploring mechanical interactions between intrusive and extrusive volcanic edifice growth, lithospheric flexural response, and magma ascent, using numerical modeling techniques, including Finite Element (FEM) and Distinct Element (DEM) Methods. The postdoctoral research will also entail analysis of imagery, topography, gravity, and spectral datasets for large planetary volcanoes in order to constrain the modeling efforts. Potential bodies of interest include Venus, Io, the Moon, Earth, and Mars.

The position requires a recent Ph.D. in geophysics or geology, and experience in quantitative modeling of geophysical, geological, or magmatic processes. Previous experience with advanced codes such as COMSOL Multiphysics (FEM) and PFC (DEM) along with programming languages such as MATLAB or FORTRAN 95 is desirable. The position will be offered for an initial period of two years with a possible extension to a maximum of three years.

Applicants should send a letter of interest, a curriculum vita with a list of relevant publications, a brief (maximum three pages) statement of research interests, and a list of three references to resume@lpi.usra.edu. Review of candidates will begin August 1, 2012; applications arriving before this date will receive full consideration. Further information on current research and facilities at the LPI may be found on our website www.lpi.usra.edu.

The Universities Space Research Association is an Equal Opportunity Employer.

Queen's University

TENURE-TRACK FACULTY POSITION AVAILABLE in Applied Geophysics Department of Geological Sciences and Geological Engineering

The Department of Geological Sciences and Geological Engineering at Queen's University, which has a long history of excellence in undergraduate and graduate education and world class research, is seeking individuals with outstanding research and teaching capabilities for a tenure-track position at either the Assistant or Associate Professor in Applied Geophysics to begin on January 1, 2013, or July 1, 2013. The successful candidate will be a Professional Engineer, or will be eligible to apply for Professional Engineering status immediately, by virtue of having graduated from an accredited engineering program. The candidate will build on the existing applied geophysics specialization stream in the Geological Engineering program, and may also teach students from Geological Sciences and other departments at Queen's. Demonstrated excellence in teaching and field investigation in a variety of geophysical techniques, data analysis, and interpretation will be an asset. The candidate is expected to carry on an active, externally funded research program of international calibre and to supervise graduate students at the M.Sc. and Ph.D. levels. A willingness to engage in collaborative research with Departmental colleagues will also be considered in the selection process. For more information about faculty research interests, the full range of undergraduate and graduate teaching programs, and our laboratory facilities, visit www.geol.queensu.ca.

The University invites applications from all qualified individuals. Queen's University is committed to employment equity and diversity in the workplace and welcomes applications from women, visible minorities, aboriginal people, persons with disabilities, and persons of any sexual orientation or gender identity. All qualified candidates are encouraged to apply; however, Canadians and permanent residents will be given priority.

Academic professionals at Queen's University are governed by the *Collective Agreement* between the Queen's University Faculty Association (QUFA) and the University, which is posted at http://www.queensu.ca/provost/faculty/facultyrelations/qufa/collectiveagreement.html. Remuneration will be in accordance with the *Collective Agreement*, which considers qualifications and experience.

Applications should include a complete and current curriculum vitae, letters of reference from three (3) referees of high standing, a statement of teaching experience, a statement of research interests and future plans, and samples of research writing. **Please arrange to have applications and supporting letters sent directly to:**

Dr. D.J. Hutchinson, Head
Department of Geological Sciences and Geological Engineering
Queen's University, Room 240 Bruce Wing
Kingston Ontario Canada K7L 3N6
adminassistant@geol.queensu.ca

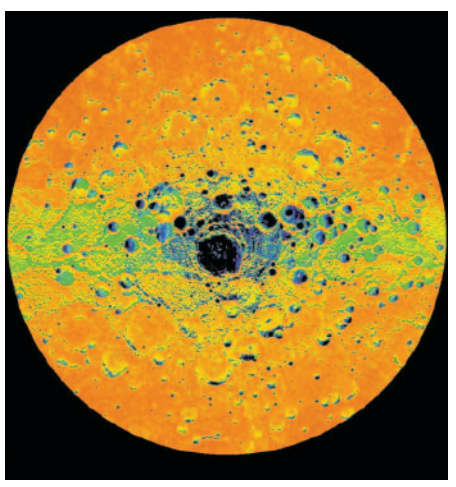
Applications will be accepted until August 31, 2012, or until a suitable candidate is identified. Review of applications will commence shortly thereafter, and the final appointment is subject to budgetary approval.

RESEARCH SPOTLIGHT

Highlighting exciting new research from AGU journals

New images support proposal for water ice on Mercury

Two decades ago, radio telescope observations showed radar-bright features in Mercury's polar regions. The radar characteristics are similar to those of the icy satellites of Jupiter and at the south polar ice cap on Mars. The radar-bright spots on Mercury were therefore believed to be water ice, and images from MESSENGER provide new support for this idea. MESSENGER, the first spacecraft to orbit Mercury, has provided a view of Mercury's south polar terrain over a full Mercury day that makes it possible to identify areas in permanent shadow. *Chabot et al.* compared the MESSENGER images of craters in the south pole region with the distribution of radar-bright features from previous radio telescope studies. They found that the radar-bright areas do correspond to areas in permanent shadow in the new images. The authors also applied thermal models to confirm that water ice could be stable in these craters if the ice is insulated by a thin covering layer of regolith. The study supports the hypothesis that Mercury's south polar region contains deposits of water ice in permanently shadowed craters. (*Geophysical Research Letters*, doi:10.1029/2012GL051526, 2012) —EB



Map of fractional illumination of Mercury's south polar region during one Mercury solar day. Blue and purple areas receive little sunlight.

An efficient approach to imaging underground hydraulic networks

To better locate natural resources, treat pollution, and monitor underground networks associated with geothermal plants, nuclear waste repositories, and carbon dioxide sequestration sites, scientists need to be able to accurately characterize and image fluid seepage pathways below ground. With these images, scientists can gain knowledge of soil moisture content, the porosity of geologic formations, concentrations and locations of dissolved pollutants, and the locations of oil fields or buried liquid contaminants.

Creating images of the unknown hydraulic environments underfoot is a difficult task that has typically relied on broad extrapolations from characteristics and tests of rock units penetrated by sparsely positioned boreholes. Such methods, however, cannot identify small-scale features and are very expensive to reproduce over a broad area. Further, the techniques through which information is extrapolated rely on clunky and mathematically complex statistical approaches requiring large amounts of computational power.

Saibaba and Kitanidis have developed a way to significantly simplify this extrapolation through a mathematical technique that breaks down dense matrices of data into easily digestible blocks. They describe their approach from theory to implementation and demonstrate how results from using their techniques increase computational efficiency while maintaining the accuracy of previous methods for large-scale extrapolations. (*Water Resources Research,* doi:10.1029/2011WR011778, 2012) —MK

Ross Ice Shelf airstream driven by polar vortex cyclone

The powerful air and ocean currents that flow in and above the Southern Ocean, circling in the Southern Hemisphere's high latitudes, form a barrier to mixing between Antarctica and the rest of the planet. Particularly during the austral winter, strong westerly winds isolate the Antarctic continent from heat, energy, and mass exchange, bolstering the scale of the annual polar ozone depletion and driving the continent's record-breaking low temperatures. Pushing through this wall of high winds, the Ross Ice Shelf airstream (RAS) is responsible for a sizable amount of mass and energy exchange from the Antarctic inland areas to lower latitudes.

Sitting due south of New Zealand, the roughly 470,000-square-kilometer Ross Ice Shelf is the continent's largest ice shelf and a hub of activity for Antarctic research. A highly variable lower atmospheric air current, RAS draws air from the inland Antarctic Plateau over the Ross Ice Shelf and past the Ross Sea. Drawing on modeled wind patterns for 2001–2005, *Seefeldt and Cassano* identify the primary drivers of RAS.

In their analysis of the 150-meter altitude wind field, the authors identified the northward flow of RAS. They found that RAS was more prevalent in winter than summer and that it was most common when there was an atmospheric cyclone over the Ross Sea. The authors suggest that the primary driver for RAS is the pressure gradient established by such atmospheric cyclones. (*Journal of Geophysical Research-Atmospheres*, doi:10.1029/2011JD016857, 2012) —CS

Vegetation affects hillslope hydrodynamics

Hillslopes are an important part of the hydrological cycle because water from rainfall or snowmelt runs downhill to networks of streams. Understanding hillslope hydrological dynamics is important for flood and debris flow prediction.

However, because hillslopes are highly varied, developing general frameworks for analyzing them is difficult. *Bachmair et al.* compared three hillslopes to try to synthesize understanding of subsurface flow processes at the hillslope scale, focusing on the effect of vegetation. Over a period of 9 months, the researchers compared the dynamics of three hillsopes in the Black Forest in southwestern Germany. The three hillslopes had similar slope, curvature, soil type, and climate but different vegetation cover (grass, coniferous forest, and mixed forest).

The researchers observed clear differences in hydrologic response between the grassland and forested hillslopes. They also observed that water table dynamics varied between the wet fall and winter and the dry summer seasons. (*Water Resources Research,* doi:10.1029/2011WR011196, 2012) —EB

—Ernie Balcerak and Mohi Kumar, Staff Writers, and Colin Schultz, Writer