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## Magnetic Storms and Induction Hazards

Magnetic storms are potentially hazardous to the activities and technological infrastructure of modern civilization. This reality was dramatically demonstrated during the great magnetic storm of March 1989, when surface geoelectric fields, produced by the interaction of the time-varying geomagnetic field with the Earth's electrically conducting interior, coupled onto the overlying Hydro-Québec electric power grid in Canada. Protective relays were tripped, the grid collapsed, and about 9 million people were temporarily left without electricity [Bolduc, 2002].

A magnetic storm that was, by some measures, the most intense ever recorded followed a solar flare observed by astronomers Richard Carrington and Richard Hodgson in September 1859. Should a storm of similar intensity occur today, technological systems around the world could be adversely affected. According to some scenarios, the future occurrence of a rare "perfect magnetic storm" might cause widespread failure of bulk electric power networks (see Figure 1), with deleterious impact on the American economy and security [e.g., Baker et al., 2008].

Public and private agencies have responded to these findings. Notably, in May 2013, the Department of Energy's Federal Energy Regulatory Commission (FERC) directed, through Order 779, the North American Electric Reliability Corporation to develop reliability standards to address the potential impact of geomagnetic disturbances on the operation of the bulk power system. Concerns in the private sector have motivated reinsurance companies to commission related assessments of risk.

As part of an interagency project coordinated under the auspices of the U.S. National Space Weather Program (NSWP), the U.S. Geological Survey (USGS), the National Oceanic and Atmospheric Administration (NOAA), and NASA are working together to improve regional assessments and real-time operational estimation of natural induction hazards that can be realized at the Earth's surface during magnetic storms.

### The Natural Hazard

The geophysical quantity that directly interferes with the operation of electric power grids is the geoelectric field. It is generated in the Earth's interior through geomagnetic induction driven by magnetic activity originating overhead in the magnetosphere and ionosphere.

BY J. J. LOVE, E. J. RIGLER, A. PULKKINEN, AND C. C. BALCH

Electrical conductivity in the Earth's interior ranges from about  $10^{-4}$  siemens per meter (S/m) in some parts of the upper mantle to 3 S/m in the ocean. Generally speaking, electric power grids are susceptible to interference from naturally induced geoelectric fields that vary with periods from about 10 to 1000 seconds. Geomagnetic and geoelectric field variation over such periods plumbs the Earth's interior across diffusive depth and length scales of between about 2 and 3000 kilometers, but localized conductivity anomalies can reduce the upper length scale to about 50 kilometers.

As a subject of natural science, estimating the geoelectric field as a function of geographic location is distinct from the engineering subject of electric currents that flow in power grids in response to geoelectric fields [e.g., Kappenman, 2001; Pirjola, 2002]. Mapping the time-dependent geoelectric field is needed to evaluate the design, emplacement, and ever-evolving operation of electric power grids [e.g., Viljanen et al., 2012]. Here we focus on the present-day challenges and opportunities for studying and quantifying hazardous geoelectric induction.

### Geomagnetic Monitoring

Magnetometers around the world, such as those that are part of the International Real-time Magnetic Observatory Network (INTERMAGNET), record the temporal evolution of the geomagnetic field [Love and Chulliat, 2013]; an example time series is shown in Figure 2(a). As part of NSWP, the USGS magnetic observatory network produces high-quality magnetometer data for real-time nowcasting of magnetic storm conditions [Love and Finn, 2011]. Similarly integrated geomagnetic monitoring projects are supported in other countries, such as in Canada, the United Kingdom, and Japan.

Most national magnetic observatory networks are relatively sparse in geographic distribution. For example, the USGS operates only six stations in the lower continental United States, which is sufficient to resolve geomagnetic activity on a continental scale and to assess the general dynamic state of the magnetosphere-ionosphere system. More detailed analyses can exploit data from variometer magnetometer networks that are operated for specialized space weather projects [e.g., Viljanen et al., 2004; Yumoto et al., 2012].

### Geoelectric Measurements

Direct measurement of the geoelectric field is conceptually simple: The voltage between a pair of electrodes, planted straight into the ground, is measured as a



Fig. 1. Electric power lines at sunrise.

function of time. For magnetotelluric studies, geoelectric measurements are conventionally made in conjunction with magnetic variometer measurements, with sensors deployed over specific geographic regions on a temporary basis. The EarthScope program of the National Science Foundation has supported a transportable grid of magnetotelluric sensors across the United States. Deployed from 2006 to 2011 in the Pacific Northwest, the sensor grid is now being deployed across the north midwestern United States [Schultz, 2009].

In contrast, long-term measurements of the geoelectric field at observatories are much more sparsely distributed in geography. The Japanese Meteorological Agency has supported 1-second measurements of the geoelectric field at its three magnetic observatories since 1983; see Figure 2(b). Geoelectric measurements at observatories are supported by Germany's GeoForschungs-Zentrum, the British Geological Survey, and France's Institut de Physique du Globe de Paris. Analog geoelectric measurements were supported at the Tucson magnetic observatory from 1932 to 1942, but otherwise, very little long-term geoelectric monitoring has taken place in the United States. However, the USGS is considering a project for long-term 1-second resolution geoelectric monitoring at a few of its magnetic observatories.

### Modeling and Mapping

Although some geoelectric monitoring is important, it is challenging to directly use geoelectric measurements to estimate induction hazards across continental or even small-scale regional geography. Storm time geoelectric fields realized at one site are not always well correlated with those at another site, a difficulty that is partly due to the localized complexity of lithospheric electrical conductivity [e.g., McKay and Whaler, 2006] and the relatively high conductivity of ocean water compared to the lithosphere. Therefore, a priority for induction hazard science is the development of three-dimensional models of Earth conductivity that have a spatial resolution similar to the spatial scale of regional electric power grids. Some progress on this front is being made in the United States. The EarthScope project has, for example, enabled modeling lithospheric conductivity under the Pacific Northwest [Meqbel et al., 2014].

Another factor affecting the induced geoelectric field is the spatial complexity

of geomagnetic activity generated by magnetospheric-ionospheric electric currents. In principle, empirically parameterized maps of the temporal evolution of ground-level magnetic disturbance can be constructed by fitting basis function model parameters to ground magnetometer data [e.g., Pulkkinen et al., 2003], thus filling in the geography between magnetometer stations. Time-convolutional filtering of a magnetic activity map through a conductivity model can give a geoelectric field map [e.g., Thomson et al., 2009]. Geoelectric model accuracy can be established by comparison with geoelectric measurements, and indeed, a geoelectric modeling project can inform evaluations of the adequacy of the existing ground magnetometer network. In the end, estimates of the storm time geoelectric field need only be accurate enough to make operational hazard assessments and to enable mitigation of deleterious effects.

### Space Weather Prediction

The space weather that drives magnetic storms originates at the Sun. Abrupt ejections of concentrated plasma from the solar corona can be detected using telescopes on the NASA-European Space Agency Solar and Heliospheric Observatory (SOHO) spacecraft. Coronal mass ejections typically take about 2 days to traverse the Sun-Earth distance; energetic ejections can cross the distance in as little as 18 hours. If an ejection is directed toward the Earth, then NOAA's Space Weather Prediction Center (SWPC) will issue a prediction of the commencement time and intensity of a magnetic storm. From an upstream orbit between the Sun and Earth, NASA's Advanced Composition Explorer (ACE) spacecraft monitors solar wind conditions, with transmitted data arriving at Earth 15 to 45 minutes in advance of an oncoming coronal mass ejection. Within the magnetosphere and above the ionosphere, several satellites provide in situ magnetic field monitoring of the Earth's surrounding space environment.

Improved predictions of space weather require improved monitoring and physics-based modeling of the heliosphere and geospace environments. These developments will, in turn, facilitate predictions of ground-level magnetic disturbance, the accuracy of which can be measured against ground-based monitoring data [e.g., Pulkkinen et al., 2013]. Although forecasting

## Magnetic Storms

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induction hazards is still in its infancy and dedicated research efforts are required for further advancements, some new capabilities are being transitioned from testing at the Community Coordinated Modeling Center at NASA Goddard Space Flight Center into operations at NOAA SWPC [e.g., *Pulkkinen et al.*, 2010].

### Extreme Events

Over timescales longer than a few solar cycles, historical data from observatories reveal the statistical relationship between magnetic storm intensity and storm occurrence frequency [e.g., *Riley*, 2012]. This relationship can be used to forecast the future likelihood of magnetic storms across a range of intensities. Because extremely intense magnetic storms [e.g., see *Pulkkinen et al.*, 2012] are, by definition, rare, retrospective statistical inferences end up being made from historical records of a small number of intense storms [e.g., *Love*, 2012].

Another approach for analyzing intense space weather events exploits the modern availability of solar wind data. For example, in July 2012 an extremely large coronal mass ejection event was recorded in situ by one of NASA's Solar Terrestrial Relations Observatory (STEREO) satellites. This ejection was not Earth directed, but it provided researchers with an opportunity to study a space weather event that could have had deleterious consequences [Baker et al., 2013; Ngwira et al., 2013]. Together with historical data from ground observatories, this type of analysis informs scenario modeling of extreme events [e.g., *Pulkkinen et al.*, 2012], and it is guiding the development of geomagnetic disturbance standards, such as those mandated by FERC.

### Looking Forward

Induction hazard science is of increasing relevance for today's modern, electricity-dependent society. Continued collaboration between government, academic, and private

sectors will help maintain and expand real-time operational monitoring and modeling of the Earth and its surrounding space environment so that induction hazards can be better understood, evaluated, and predicted.

### Acknowledgments

We thank C. A. Finn, A. Kelbert, J. McCarthy, and E. W. Worthington for reading a draft manuscript. We thank J. L. Gannon and W. S. Leith for useful conversations.

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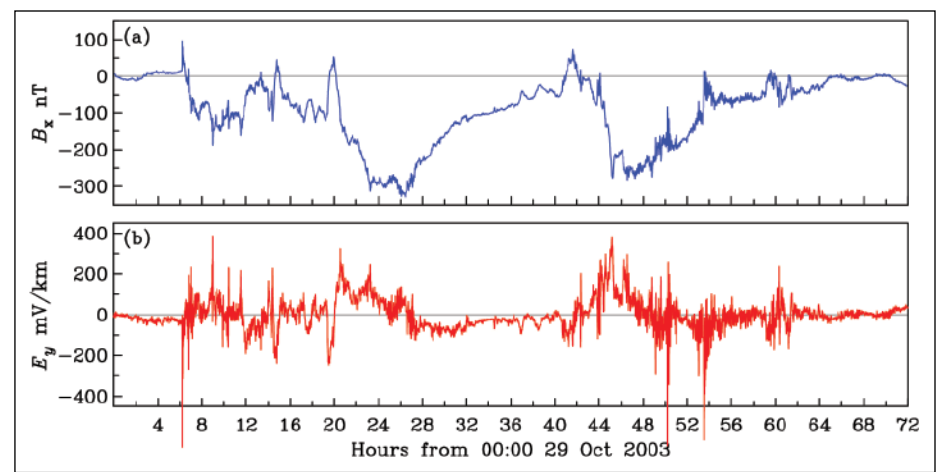


Fig. 2. Time series recording the Halloween storm of 29–31 October 2003, each with 1-second resolution, from the Kakioka Magnetic Observatory in Japan: (a) the north component of the geomagnetic field, with the quiet time baseline removed, and (b) the east component of the geoelectric field. Predicting the complex time-dependent relationship between the geomagnetic and geoelectric fields is an important goal of induction hazard science.

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*Eos*, Transactions, American Geophysical Union (ISSN 0096-3941) is published weekly except the last week of December by the American Geophysical Union, 2000 Florida Ave., NW, Washington, DC 20009, USA. Periodical Class postage paid at Washington, D. C., and at additional mailing offices. POSTMASTER: Send address changes to Member Service Center, 2000 Florida Ave., NW, Washington, DC 20009, USA. To submit a manuscript, visit <http://eos-submit.agu.org>.

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## NEWS

### Report Addresses Timeline For Cutting Greenhouse Gas Emissions

A new report states that “global carbon neutrality” needs to be achieved by 2055–2070 to limit global temperature rise to a 2°C increase relative to the preindustrial period. The report was released a few weeks prior to the United Nations (UN) Climate Change Conference, which will be held on 1–12 December in Lima, Peru.

*The Emissions Gap Report 2014*, issued by the United Nations Environment Program (UNEP) on 19 November, also states that total global greenhouse emissions need to shrink to net zero between 2080 and 2100 to keep within that 2°C limit.

Under a carbon neutral scenario with net zero emissions of carbon dioxide (CO<sub>2</sub>),

emissions could be compensated by CO<sub>2</sub> uptake through reforestation or techniques such as carbon capture and storage, according to the report.

### Limiting Global Temperature Rise

To limit global temperature rise to 2°C, the total maximum amount of CO<sub>2</sub> that could be emitted to the atmosphere from the 19th century onward needed to be kept to about 2900 gigatons (Gt), notes the report, which builds on the Fifth Assessment Report by the Intergovernmental Panel on Climate Change. However, much of that emissions “budget” already is used up, and to limit temperature rise to 2°C, the maximum amount of emissions since 2012 now must be kept at just 1000 Gt, according to the UNEP report.

The estimated gap for 2020 between emissions levels that are consistent with the 2°C limit and the levels expected if country climate change pledges and commitments are met is 52–54 Gt of CO<sub>2</sub>, whereas the emissions gap for 2030 is estimated at 14–17 Gt of CO<sub>2</sub>, the report states.

At a news briefing to release the report, Achim Steiner, UN under-secretary-general and UNEP executive director, said that continued emissions present an enormous risk in terms of global warming, particularly under a business-as-usual scenario. However, he also pointed to positive parts of the report, including its emphasis on the amount of emission reductions that could be gained through energy efficiency measures and a greater reliance on renewable energy.

In addition, he said that the 12 November U.S.-China announcement to limit greenhouse gas emissions—and other measures, including a recent commitment by the European Union to reduce greenhouse gas emissions by 40%—are indications that “the world is, in fact, moving to accelerating to action” to cut emissions.

### Some Evidence of Moving in the Right Direction

At the briefing, Andrew Steer, president and CEO of the World Resources Institute (WRI), said that “on the one hand, we are way off track” in cutting emissions and that with every year that passes, the world

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## News

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is falling further from the least cost solution to climate change. "On the other hand, there is increasing evidence that this can be done much more cheaply than had originally been estimated." WRI is part of a consortium of organizations involved in producing the UNEP report.

The report's emission gap figures do not yet incorporate potential emissions reductions that could result from the U.S.-China announcement because it is too recent, Steiner said. However, former U.S. Senator Tim Wirth, vice chair of the United Nations Foundation, suggested at the briefing that reductions could be significant, including possibly a 2–6 Gt reduction with just the U.S.-China agreement.

## Retaining the 2°C Limit

Some scientists recently suggested that the 2°C limit should be abandoned because

it might be unrealistic, but Steiner dismissed the notion. "We don't have that choice. It is an unethical choice, it is an irresponsible choice, and it is an unnecessary choice."

"You simply first of all cannot defend a set of decisions being deferred for another 20–30 years that lock in generations for 2000 years," he said. "Everything that we are discussing here is not a matter of saying you have the luxury to choose not to act. The question is how do we enable one another to act faster."

Steiner added, "With every year that passes, being able to meet that 2° threshold gets more difficult, more expensive, and riskier because you are relying on more dramatic actions, you are relying on more unproven technologies, and you are relying essentially on moments of catharsis where people suddenly have to jump" to act.

—RANDY SHOWSTACK, Staff Writer

## What's on the Web?

Read the latest offerings from the AGU Blogosphere:

**GeoEd Trek:** "Teaching professional skills...what exactly is a 'doctor of philosophy'?" (<http://ow.ly/Ex1Xs>)

**Dan's Wild Wild Science Journal:** "And this week's most scientifically illiterate post on Twitter goes to..." (<http://ow.ly/EB9tq>)

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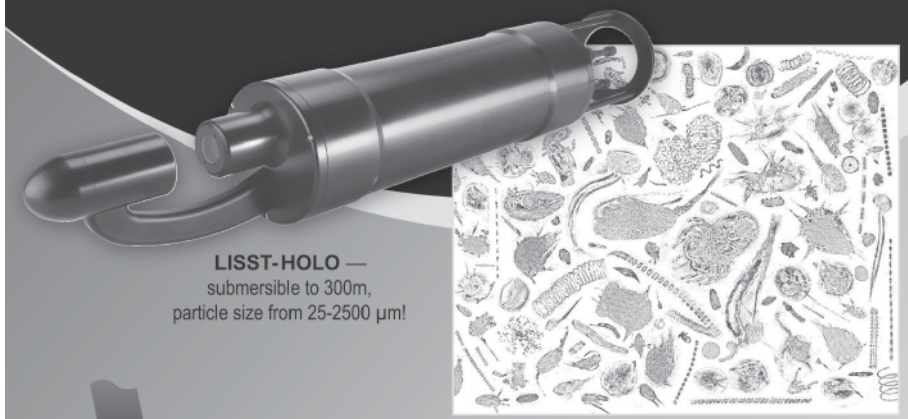


Nick Frearson

In the GeoSpace blog Kim Martineau reports on some results from a 2008–2009 expedition to Antarctica, in which researchers flew over subglacial mountains in a Twin Otter outfitted with ice-penetrating radar. They found evidence that cold temperatures and high pressures push the water uphill, in the same direction as overlying ice flows. This process causes ridges to refreeze, thus warding off erosion.

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## MEETING

## Multidisciplinary Monitoring Experiments at Kawah Ijen Volcano

Cities on Volcanoes "Wet Volcanoes" Workshop; Yogyakarta, Indonesia, 14–21 September 2014

"Wet volcanoes" with crater lakes and extensive hydrothermal systems pose challenges for monitoring and forecasting eruptions. That's because their lakes and hydrothermal systems serve as reservoirs for magmatic heat and fluid emissions, filtering and delaying the surface expressions of magmatic unrest.

One such volcano, Kawah Ijen, which hosts the world's largest natural acid crater lake (30 million cubic meters, pH <1), expelled large volumes of acidic lake water during its last major eruption in 1817, creating lahars that inundated areas that are now densely populated. Today, even small eruptions from Ijen pose a hazard and put the local population, including sulfur miners, and tourists, at risk.

During 2011 and 2012, swarms of locally felt volcano-tectonic earthquakes, low-frequency earthquakes, intense tremor, and a 12°C increase in lake temperature raised concerns within Indonesia's Center for Volcanology and Geologic Hazard Mitigation (CVGHM). The center determined that efforts are needed to better monitor and understand Kawah Ijen and other wet volcanoes. The center asked the U.S. Geological Survey's Volcano Disaster Assistance Program (VDAP) to convene a workshop to develop recommendations on how to improve monitoring and forecasting at wet volcanoes.

As a result, VDAP scientists teamed with colleagues from CVGHM, the Royal Observatory of Belgium, the Earth Observatory

of Singapore, GNS Science of New Zealand, and McGill University of Canada to organize an international workshop in mid-September 2014 at Kawah Ijen. The participants—25 scientists from 10 countries—conducted measurements using broadband seismic and infrasound arrays, thermal infrared imaging of surface temperatures, differential optical absorption spectroscopy for sulfur dioxide (SO<sub>2</sub>) emission rates, an ultraviolet SO<sub>2</sub> camera, multi-gas detectors for real-time measurement of multiple volcanic gas species, newly developed diode laser spectroscopy for atmospheric carbon dioxide (CO<sub>2</sub>) measurement, and samples of fumarole gases, acid waters, and gypsum deposits.

The workshop participants discussed analog volcanoes and monitoring methods, as well as interpretations of the magmatic and hydrothermal processes that are important when forecasting eruptions. One particularly useful outcome was the identification of the Ruapehu volcano in New Zealand as a "sister volcano" of Kawah Ijen, with remarkably similar and well-studied geologic structures and geochemical/geophysical processes. In the absence of modern monitored eruptions, information from analog volcanoes like Ruapehu aid in the interpretation and identification of precursory signals leading up to eruptive events at other wet volcanoes.

Recommendations include establishing a "best practice" suite of techniques and appropriate instrumentation for routine

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## AGU FALL MEETING

San Francisco | 15–19 December 2014

### Take a break or take in a talk at the Career and Student Lounges



Moscone South Poster Hall, Room 101

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### Mountain ranges and high plateaus:

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**Instructors:** David Battisti, Marin Clark, Inez Fung, Carmala Garzzone, Jung-Eun Lee, Peter Molnar, Nathan Niemi, and Gerard Roe.

Graduate students with background in earth and/or atmospheric sciences and with training in geochemistry, continuum mechanics, and relevant mathematics are encouraged to apply.

Deadline for applications is December 10, 2014.

Visit <http://www.earth.lsa.umich.edu/summerschool2015> for more information.



**Meeting**

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monitoring of wet volcanoes, taking into account the unique situation of each volcano (e.g., the extreme acid environment at Kawah Ijen). The international team recommended real-time (telemetered) monitoring of gases (especially CO<sub>2</sub>, which can provide early warnings of unrest owing to its non-reactivity in acid environments), coupled with traditional real-time seismic and geodetic monitoring, as well as frequent sampling of acid seepage springs that have direct links to active hydrothermal systems below the volcanic edifice.

A detailed account of the results of the experiments and recommendations for monitoring wet volcanoes is being prepared for an upcoming publication on volcanic crater lakes by the Geological Society of London.

—HENDRA GUNAWAN, Geological Agency, Center of Volcanology and Geologic Hazard Mitigation, Indonesia; JOHN PALLISTER, U.S. Geological Survey and U.S. Agency for International Development's Office of Foreign Disaster Assistance Volcano Disaster Assistance Program, email: jpallis@usgs.gov; and CORENTIN CAUDRON, Earth Observatory of Singapore, Nanyang Technological University

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# ABOUT AGU

## AGU Hosts Amazon Hack-A-Thon at Fall Meeting

As part of the Amazon Web Services Hack-A-Thon, this year's AGU Fall Meeting attendees will be challenged to create an idea for a Web product based on climate change data for individual cities.

The city climate projections will be provided by NASA's climate data set Earth Exchange Global Downscaled Daily Projections (NEX-GDDP). Data will be available for all cities with populations greater than 1 million. Coupled with Amazon's Web capabilities, this will allow participants to address the Hack-A-Thon's two challenges: What apps would you build if you had access to climate projections for the rest of this century at the scale of individual cities? How would you visualize these climate projections to effectively engage policy makers, managers, planners, educators, and the general public?

Participants will work to conceive a mobile or Web application that takes advantage of the idea that the future projected climate of a city is likely analogous to the current climate of a different city. Through such analogs, city planners and resource managers may be able to better quantify how climate change will affect water supplies, the spread of disease, agriculture, and other important factors, with the goal of addressing climate change on the local level.

"We do expect to see some innovative and promising concepts emerge," Amazon said in a statement. "The hope is that this Hack-A-Thon will be a catalyst for continued development in this topic and other similar areas of research."

To help build apps for the Hack-A-Thon, participants can compare projections in NEX-GDDP with a reference data set and "the

closest matches (i.e., the closest analogs in the reference data set)...can be analyzed for information about growing season lengths, species present, dominant crop types and farming practices, insurance costs associated with climate extremes, and other natural hazards," Amazon explains on its website. "Displaying the locations of the closest analogs itself provides a powerful visual impression of the potential magnitude of climate change."

The Hack-A-Thon approach provides an opportunity for scientists at the Fall Meeting to collaborate and foster unique ideas. By developing apps to showcase climate analogs, participants will work to help get critical information into the hands of decision makers, all at the touch of a button.

"Amazon can provide resources on a scale that most research institutions just can't match. I think they can also make it easier for us to share data and tools within our community," said Robert Pincus, research scientist at the University of Colorado Boulder and a judge at the Hack-A-Thon.

The 13–14 December event will be held at the Amazon Loft on Market Street in San Francisco. A panel of judges comprising climate scientists and technology developers will select the winners based on creativity and the potential to bring data to the public on a local level. Registration is open via the Fall Meeting events calendar, but space is limited. For more information, visit <http://fallmeeting.agu.org/2014/events/awshack-a-thon/>.

—TRICIA MCCARTER, Production Assistant, AGU; email: [tmccarter@agu.org](mailto:tmccarter@agu.org)

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## The International Continental Scientific Drilling Program (ICDP)

icdp

### Call for Proposals

The International Continental Scientific Drilling Program, ICDP coordinates and supports multinational endeavours in continental scientific drilling. The program focuses on challenging themes of global geoscientific and socio-economic relevance, including, but not limited to, active faulting, earthquake processes, heat and mass transport, global cycles, environmental change, and the hidden biosphere.

With this announcement, the ICDP invites Earth scientists to submit project proposals in which drilling is required to achieve critical research goals. This call is open to investigators from ICDP member countries (Austria, Belgium, Canada, China, Czech Republic, Finland, France, Germany, Iceland, India, Israel, Italy, Japan, New Zealand, Norway, Poland, South Africa, South Korea, Sweden, Switzerland, The Netherlands, United Kingdom, United States of America) as well as from countries considering membership in the ICDP. Please note that ICDP provides operational support and allocates co-funding for drilling-related costs only; research grants for the project should be sought from other funding agencies. This concept of commingled funding and international cost sharing, in addition to an exchange of technological capabilities and know-how, has proven very successful over the years.

#### PROPOSAL PREPARATION

The submission of proposals to the ICDP is normally handled in a 2-step procedure. The first step is the submission of a **pre-proposal** in which a request to hold an ICDP-funded workshop is submitted. The proposal should outline the main objectives, the scientific importance of the planned project, details of the proposed drill site, the expertise of the group of proponents and envisaged international collaboration. The workshop serves to bring together a competitive international research team which can develop a **full drilling proposal**. Principal Investigators should note that they are responsible for planning and running pre-site surveys needed to facilitate the choice of an appropriate drill site. Following a successful pre-proposal and workshop a full proposal can be submitted in a second step.

#### PROPOSAL EVALUATION

All proposals are evaluated by the Science Advisory Group (SAG) of the ICDP, which makes recommendations to the Executive Committee (EC) based on scientific quality and priority. The EC then reviews technical and financial issues in order to ensure that projects are feasible within the constraints of ICDP's annual and long-range plans. The EC informs the Principal Investigator(s) of the outcome of the evaluation, and states whether further development of the proposal is to be encouraged or not.

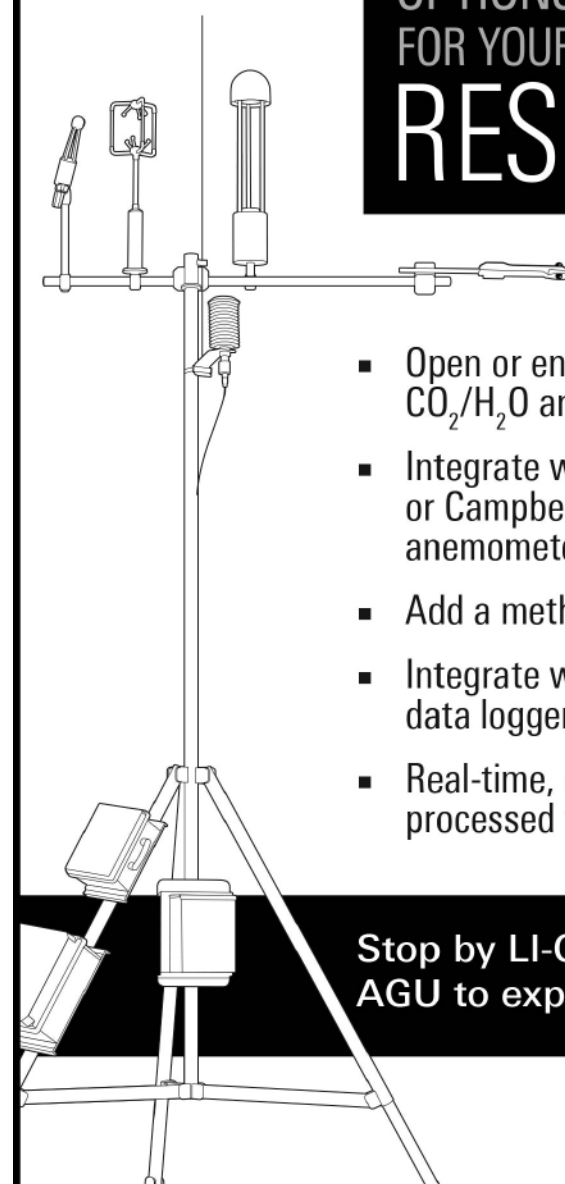
ICDP aims to foster joint projects with the International Ocean Discovery Program, IODP. We therefore cordially invite project proposals in which coordinated drilling on land and at sea is required or land-sea transect drilling series are planned ("amphibious projects"). Joint project proposal submission will be accepted by both programs and jointly evaluated.

The deadline for proposal submission to the ICDP, including those for amphibious projects, is **January 15, 2015**. Please submit a digital copy via email of the preliminary or full proposal to: Uli Harms, GFZ German Research Centre for Geosciences, Telegrafenberg, D-14473 Potsdam, Germany, phone +49-331-288-1085, fax: +49-331-288-1088, email: [u.harms@icdp-online.org](mailto:u.harms@icdp-online.org)

Detailed information on the scope of the ICDP, the submission of proposals, proposal format, and the process for development of a successful proposal is available on the ICDP home page at: <http://www.icdp-online.org/proposals>.

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## POSITIONS AVAILABLE

### Atmospheric Sciences

#### FACULTY POSITIONS IN ATMOSPHERIC CHEMISTRY at the University of California, Irvine

The Department of Chemistry at the University of California, Irvine (Irvine, California) has two openings for outstanding scientists in atmospheric chemistry at the Full Professor level. These positions are part of an integrated, across-campus initiative in air quality and climate. We seek to build this initiative through cross-cutting and transformative research programs that complement existing activities at UCI, with an emphasis on interdisciplinary activities and those that combine fundamental laboratory research with field observations, theory and modeling. Areas of particular interest include particles and their roles in air quality and climate. Candidates must have a PhD in Chemistry or a related field and a demonstrated record of accomplishments in atmospheric chemistry. The position requires both the establishment of a vigorous research program and a strong commitment to excellence in teaching at both the undergraduate and graduate levels. Applications must be submitted electronically via the Internet at: <http://recruit.ap.uci.edu/apply/JPF02661>. Applicants should upload a cover letter, a curriculum vita (including a publication list), and a concise statement of proposed research. A separate statement that addresses past and/or potential contributions to diversity, equity and inclusion should also be included in the application materials. Names and contact information for three references must be provided; letters should not be requested at this time. Applications and supporting materials should be received by December 31, 2014 for full consideration. The University of California is an Equal Opportunity/Affirmative Action Employer advancing inclusive excellence. All qualified applicants will receive consideration for employment without regard to race, color, religion, sex, national origin, disability,

age, protected veteran status, or other protected categories covered by the UC nondiscrimination policy.

#### GEOPHYSICAL FLUID DYNAMICS/CLIMATE DYNAMICS

The Department of Earth and Planetary Sciences at Northwestern University invites applications for a tenure track, assistant professor position in geophysical fluid dynamics/climate dynamics, to begin as early as fall 2015.

Specifically, we seek a scientist who employs theoretical, observational, and/or numerical methods to study coupled geophysical fluid dynamical processes within the atmosphere, hydrosphere, cryosphere, and/or lithosphere. Candidates whose expertise complements that of existing faculty in solid earth geophysics, planetary science, and paleoclimate are particularly encouraged. The successful candidate is expected to teach both undergraduate and graduate courses and lead a vibrant externally funded research program. A Ph.D. is required at the time of appointment.

Deadline for applications is December 31, 2014. Applicants should visit [www.earth.northwestern.edu](http://www.earth.northwestern.edu) for submission instructions.

AA/EOE. Northwestern University is an Equal Opportunity, Affirmative Action Employer of all protected classes including veterans and individuals with disabilities. Women and minorities are encouraged to apply. Hiring is contingent upon eligibility to work in the United States.

#### Graduate Student Opportunities in Atmospheric Science, Rutgers, The State University Of New Jersey

The Rutgers Graduate Program in Atmospheric Science (GPAS) offers graduate programs leading to M.S. and Ph.D. degrees. GPAS comprises an interdisciplinary group of faculty from across the Rutgers New Brunswick/Piscataway campus who conduct research in a variety of topics, including climate dynamics from regional to global scales, synoptic meteorology and extreme events, tropical meteorology, paleoclimate, cloud and radiation

physics, ocean-atmosphere and land-atmosphere interactions, and atmospheric chemistry and aerosols. We are now accepting applications for Fall 2015. The deadline for application is March 1, 2015, although candidates wishing to receive full consideration for all financial aid opportunities are encouraged to submit applications by January 15, 2015. For further information and to apply, please visit <http://atmos.rutgers.edu>. If you have further questions, please email Dr. Ben Lintner, GPAS Director, at [lintner@envsci.rutgers.edu](mailto:lintner@envsci.rutgers.edu).

### Biogeosciences

#### Environmental Biogeochemistry/Geobiology-Dartmouth College.

The Department of Earth Sciences at Dartmouth College invites applications for a junior rank tenure-track position in the general areas of biogeochemistry and geobiology. We especially welcome applications from candidates with research interests that include microbially-mediated biogeochemical interactions in processes of mineralization, weathering, and sequestration of contaminants; hydrocarbon formation and degradation; biogeochemical cycling in fluvial and/or cold environments, including river-channel, floodplain, and lacustrine ecosystem response to environmental change. Particular attention will be given to candidates who combine a focus on understanding fundamental processes with state-of-the-art laboratory and/or field research programs that complement and contribute to ongoing research activities in the Department as well as in Dartmouth's Geisel School of Medicine and Thayer School of Engineering. The successful candidate will continue Dartmouth's strong traditions in graduate and undergraduate research and teaching. Teaching responsibilities consist of three courses spread over three of four ten-week terms.

The Department of Earth Sciences is home to 11 tenured and tenure-track faculty members in the School of Arts and Sciences, and enjoys strong Ph.D. and M.S. programs and outstanding undergraduate majors. To create an atmosphere supportive of research, Dartmouth College offers new faculty members grants for research-related expenses, a quarter of sabbatical leave for each three academic years in residence, and flexible scheduling of teaching responsibilities.

Dartmouth College, a member of the Ivy League, is located in Hanover, New Hampshire (on the Vermont border). Dartmouth has a beautiful, historic campus located in a scenic area on the Connecticut River. Recreational opportunities abound all year round. To learn more about Dartmouth College and the Department of Earth Sciences, visit <http://www.dartmouth.edu/~earthsci>.

To submit an application, send curriculum vitae, statements of teaching and research interests and objectives, reprints or preprints of up to three of your most significant publications, and the name, address (including street address), e-mail address and fax/phone numbers of at least three references to:

Environmental Biogeochemistry/Geobiology Search Committee

Department of Earth Sciences  
Dartmouth College 6105 Fairchild Hall  
Hanover, NH 03755

e-mail: [earth.sciences@dartmouth.edu](mailto:earth.sciences@dartmouth.edu)

Applications received by November 7, 2014 will receive first consideration. The appointment will be effective July 1, 2015.

Dartmouth is an equal opportunity/affirmative action employer with a strong commitment to diversity. In that spirit, we are particularly interested in receiving applications from a broad spectrum of people, including women, persons of color, persons with disabilities, veterans or any other legally protected group.

### Ocean Sciences

#### UConn Marine Sciences - Postdoctoral Fellow I

The Department of the Marine Sciences at UConn, Avery Point is seeking a postdoctoral scholar to study the ocean's role in glacial-interglacial CO<sub>2</sub> cycles. The candidate will work with Dr. David Lund to develop and synthesize stable isotope and trace element archives of ocean chemistry over the last 20,000 years. The project is part of a multi-institutional data and model inter-comparison effort to understand the ocean's biogeochemical response to perturbations in the deep circulation. For details on the position, qualifications, and application instructions, visit Husky Hire at [www.jobs.uconn.edu](http://www.jobs.uconn.edu). The University of Connecticut is an EEO/AA employer. (Search # 2015115)

### Solid Earth Geophysics

#### DIRECTOR AND ENDOWED CHAIR, ENVIRONMENTAL DYNAMICS AND GEOECOLOGY INSTITUTE UNIVERSITY OF CALIFORNIA, RIVERSIDE

The College of Natural and Agricultural Sciences (CNAS) invites applications for a tenured senior rank position for Director of the new Environmental Dynamics and GeoEcology (EDGE) Institute. The position will occupy a newly endowed chair and will include a tenured faculty position in one of the departments of CNAS. The successful candidate will lead a diverse group of faculty working in environmental change, global change biology, paleoecology, earth sciences, and conservation biology over both deep and contemporary time scales. The successful candidate will be expected to strengthen interdisciplinary collaborations, develop new funding initiatives, and become fully engaged in the research and teaching mission of the institute and the college.

The candidate is expected to develop an independent and innovative research program exploring the impacts and mechanisms of environmental change in arid or semi-arid regions. Appropriate areas of expertise include, but are not limited to:

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## TWO FACULTY POSITIONS AVAILABLE Department of Petroleum and Geosystems Engineering The University of Texas at Austin

The University of Texas at Austin's Department of Petroleum and Geosystems Engineering (UT PGE) seeks outstanding applicants to fill two faculty positions at the rank of Assistant Professor (tenure-track), or Full Professor (with tenure). Both positions require a Ph.D. in petroleum engineering or a related discipline. Applicants must have a strong interest in both undergraduate and graduate teaching and a record of research and professional accomplishments in one or more research areas related to petroleum engineering. In addition, the applicant for the tenured Professor position should be internationally recognized as an expert in their area of research.

Two or more years of experience in the exploration and production industry are preferred, especially for those without a degree in petroleum engineering. The successful candidate is expected to teach undergraduate and graduate courses, develop a strong funded research program, participate in interdisciplinary collaborations, and be involved in service to the university and the profession. Applications from women and minorities are encouraged.

UT PGE is home to the #1 petroleum engineering graduate program and the #2 petroleum engineering undergraduate program (by the latest *US News and World Report* rankings) and consistently has one of the largest Ph.D. programs in the country. We have an unmatched research program with more than \$22 million in funding annually. Our high-quality student programs currently include 87 Ph.D., 133 M.S., and more than 500 undergraduate students.

Interested persons should submit *in electronic form as a single PDF document* a detailed curriculum vitae including academic and professional experience, statements regarding their teaching philosophy and research plans, and a list of peer-reviewed publications and other technical papers. Applicants should also provide the names, addresses and telephone numbers of at least three references at the assistant professor level and five at the professor level.

Apply online at [www.pge.utexas.edu](http://www.pge.utexas.edu). Please apply by December 31, 2014, for primary consideration; however, the positions will remain open until filled. A security sensitive background check will be conducted on selected applicants. The University of Texas is an Equal Opportunity/Affirmative Action Employer.

# CIRES Visiting Fellowships



## Cooperative Institute for Research in Environmental Sciences (CIRES) University of Colorado Boulder

- Postdoctoral Visiting Fellowships (One year, with a possible extension for a second year)
- Visiting Scientist Fellowships, including sabbatical and faculty leave (3-12 months)

Join the research community in Boulder, Colorado, for unique opportunities to conduct challenging research in collaboration with recognized leaders in Earth system science. CIRES fellowships are intended to stimulate interdisciplinary research on campus and in partnership with scientists at the NOAA laboratories in Boulder. The CIRES Visiting Fellows Program has attracted more than 250 scientists from around the world over the past 45 years; many have gone on to lasting careers in CIRES and NOAA. Fellowships are available for postdoctoral candidates and those seeking hosts

for sabbatical or faculty leave opportunities. Visiting Fellows collaborate with CIRES Fellows in research areas such as atmosphere and ocean processes, cryospheric processes, ecosystem studies, regional and global environmental variability and change, global and regional water cycles, advanced observing systems, geophysics, geochemistry, geomorphology, environmental health, science and technology policy research, energy and environment, and space weather. Candidates are strongly encouraged to contact CIRES Fellows in advance of application.

**Deadline for application is January 5, 2015**

Go to <http://cires.colorado.edu> for more information about the Institute, and visit <http://cires.colorado.edu/collaboration/fellowships/apply/> for application instructions.



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geological/geochemical approaches to address the patterns and drivers of climatic and paleoclimatic change, arid land dynamics, desertification or the global change processes related to arid land expansion, landscape ecology, biogeography or ecosystem ecology in the context of global change.

Applications must include a curriculum vita, statements of research and teaching interests, a perspective on leadership for a new institute, and full contact information for three to five referees. All application materials must be submitted through AP Recruit at:

<https://aprecruit.ucr.edu/apply/JPF00236>.

For more information about the position, please contact Prof. Mary Droser, Chair EDGE Institute Director Search, Department of Earth Sciences, University of California, Riverside, California. 92521. E-mail contact: [mary.droser@ucr.edu](mailto:mary.droser@ucr.edu). Review of applications will begin December 15, 2014 and will continue until the position is filled. Information about EDGE and the College of Natural and Agricultural Sciences at UCR is available at <http://edge.ucr.edu> and <http://cnas.ucr.edu>.

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

**Space Physics****Jovian Magnetic Field and Magnetosphere Postdoctoral Researcher**

Applications are now being accepted for a Postdoctoral Research Associate, funded through the University of Maryland College Park (UMCP) and the Center for Research and Exploration in Space Science and Technology (CREST), to work in the Planetary Magnetospheres Laboratory of the NASA Goddard Space Flight Center (GSFC) in the area of Jupiter's magnetic field and magnetosphere, using data from the Juno (New Frontier) mission. Additional details are available on the AGU Career Center posting or at <http://www.astro.umd.edu/employment/#Juno>.

The appointment will be initially for one year, with the possibility of renewal in subsequent years. Applicants may be new postdocs or may be more senior. Candidates should have a Ph.D. in a relevant scientific discipline with prior experience conducting scientific research. Experience with magnetometer instrumentation and data, disciplined programming skills (primarily Fortran and IDL), and scientific writing experience are desired.

Each applicant should send a Curriculum Vita, list of publications, statement of research interests, and contact information for three references to:

Junio Magnetometer  
CREST/UMCP  
Mail Code 660.8, NASA/GSFC  
Greenbelt, MD 20771, or  
Via e-mail to [virginia.c.peles@nasa.gov](mailto:virginia.c.peles@nasa.gov)  
Information regarding the Juno mission is found at <http://missionjuno.swri.edu/> and [http://www.nasa.gov/mission\\_pages/juno/main/](http://www.nasa.gov/mission_pages/juno/main/). For information on CREST and the UMCP's Department of Astronomy, please contact Tracy Huard ([thuard@astro.umd.edu](mailto:thuard@astro.umd.edu)).

The University of Maryland is an Affirmative Action, Equal Opportunity Employer. Women and minorities are encouraged to apply.

Applications will be accepted on an ongoing basis until the position is filled.

**Interdisciplinary/Other****Assistant Professor - Earth and Environmental Science**

College of Staten Island - City University of New York.

The Department of Engineering Science and Physics at the College of Staten Island is accepting applications for a tenure-track faculty member at the rank of Assistant Professor, in the field of Earth and Environmental Science beginning September 2015.

Visit our website at: <http://www.apsc.csi.cuny.edu/csiengdp/welcome/welcome.html>.

A PhD in Earth and Environmental Science or a related discipline is required, with areas of interest that include but are not limited to: Global Environmental Change, Hydrology, Oceanography, Atmospheric Science, Climatology, Biogeochemistry, Carbon Cycle, Glaciology. Postdoctoral experience is preferred. Candidates must demonstrate the ability to teach successfully; evidence of scholarly achievement; and the ability to cooperate with others for the good of the institution. The successful candidate should be able to present credentials appropriate for appointment to the doctoral faculty of the CUNY Graduate School. Postdoctoral experience is preferred.

To apply and view complete job responsibilities and requirements, long on to [www.cuny.edu](http://www.cuny.edu), find Job #11617. To be considered for this position, applicants must submit curriculum vitae, a statement of scholarship interests, and the names of at least three references. All items to be uploaded should be combined in a single PDF document. Job closes February 15, 2015. EO/AA

**Associate Sedimentologist or Sedimentologist (depending on qualifications) Illinois State Geological Survey Prairie Research Institute University of Illinois at Urbana-Champaign.**

The Illinois State Geological Survey (ISGS) is part of the Prairie Research Institute (PRI) at the

University of Illinois at Urbana-Champaign which is centrally located between Chicago, St. Louis, and Indianapolis. PRI houses five large scientific surveys covering a wide range of expertise including biology, water resources, climate, geology, sustainable technology and archaeology. The ISGS is a premier state geological survey, with over 200 scientists and technical support staff, serving the needs of the public, government, and industry with earth science information and research relevant to natural resources, environmental quality, economic vitality, and public safety. The University is a land-grant institution that provides access to world-class laboratory and academic facilities, Big Ten athletic events, and internationally acclaimed cultural opportunities.

We are seeking an individual to fill one position to plan, coordinate, and conduct basic and applied research related to bedrock geology and industrial minerals. Characterize sedimentary rocks with a focus on the lithostratigraphy and sequence stratigraphy utilizing sedimentology, biostratigraphy, chemostratigraphy, and bedrock geologic mapping. Serve as principal investigator, lead research and projects, and perform tasks in that capacity, including management and production of projects, grants, contract reports and other deliverables. Master's degree in sedimentology-stratigraphy or related discipline. Ph.D. is highly preferred. A minimum of 5 years related industry and/or research experience post master's degree. Research experience in sedimentology-stratigraphy (both carbonates and siliciclastics) including lithostratigraphy, sequence stratigraphy, chemostratigraphy, and other related field as applied to stratigraphic correlation and basin analysis. The successful individual's qualifications will determine the level to which he/she is appointed.

Applications must be received by January 9, 2015. To apply, please visit <https://jobs.illinois.edu/academic-job-board> to complete an online profile and to upload a 1) cover letter, 2) résumé/CV, 3) the names and contact information (including e-mail addresses) of three professional references. All requested information must be submitted for your application to be considered. Incomplete information will not be reviewed.

For further information please contact Lori Walston-Vonderharr, Human Resources, Illinois State Geological Survey, at [lwalston@illinois.edu](mailto:lwalston@illinois.edu) or 217-244-2401.

The University of Illinois is an EEO Employer/Vet/Disabled <http://inclusivellinois.illinois.edu/>.

**Civil and Environmental Engineering and Utah Water Research Laboratory of Utah State University has two water-related faculty openings.**

(a) Associate/Full professor level in agricultural water management and (b) Assistant professor level in remote sensing. For full details and application procedure, refer to [jobs.usu.edu](http://jobs.usu.edu). For any questions contact Melanie Ivans at [melanie.ivans@usu.edu](mailto:melanie.ivans@usu.edu).

**Joint Tenure-Track Faculty Position in Exoplanetary Science**

Earth and Planetary Sciences and Physics Department, McGill University

The Department of Earth and Planetary Sciences ([www.mcgill.ca/eps](http://www.mcgill.ca/eps)) and the Department of Physics ([www.physics.mcgill.ca](http://www.physics.mcgill.ca)) at McGill University invite applications for a joint tenure-track position at the rank of Assistant Professor, beginning as early as September 2015 in the area of Exoplanetary Sciences. We encourage qualified individuals with relevant research interests in experimental, instrumentation, observational or theoretical aspects of exoplanetary sciences to apply.

This is the first of two faculty positions being created in support of the new McGill Space Institute (<http://msi.mcgill.ca>), bringing together researchers in astrophysical, geological, atmospheric and astrobiological areas from multiple departments on campus. Existing complementary research strengths at McGill include early Universe cosmology, galaxy evolution and compact objects in the Department of Physics, as well as geology, astrophysics and atmospheric sciences in Earth and Planetary Science and other departments.

We seek candidates with a proven record of excellence in research and the capacity for excellence in teaching. The successful candidate will be supported by a generous start-up package. 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 of these materials should

be uploaded to <http://dualcore.physics.mcgill.ca/FACULTY/>

Review of applications will begin 15 January 2015, and continue until the position is filled.

McGill University is committed to equity in employment.

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

**Lecturer Department of Geology College of William & Mary.**

The Department of Geology at the College of William & Mary invites applications for a continuing non-tenure-eligible faculty lecturer position that will begin August 10, 2015. The department has six full-time faculty and a laboratory coordinator, and graduates ~25 undergraduate majors per year. We seek a colleague eager to interact with undergraduates in an environment in which both teaching and research are emphasized. Primary responsibilities include teaching introductory geology courses, geology labs, and one or more upper level courses. Other duties may include oversight of select department facilities (e.g., computer lab, analytical labs) and supervision of senior research projects. While the field of specialty is open, we seek an individual who can bring additional expertise to our program.

Candidate must apply online at <https://jobs.wm.edu>. Submit a curriculum vitae, a cover letter, and statements of teaching and research interests. You will be prompted to submit online the names and email addresses of three references who will be contacted by us with instructions on how to submit a letter of reference.

For full consideration, submit application materials by the review date, January 5, 2015. Applications received after the review date will be considered if needed.

Required: A Master's degree in an appropriate field is required.

Preferred: A Ph.D. or ABD is preferred at the time the candidate begins the appointment (August 10, 2015).

Information on the degree programs in the Department of Geology can be found at <http://www.wm.edu/as/geology/>.

The College of William & Mary values diversity and invites applications from underrepresented groups who will enrich the research, teaching and service missions of the university. The College is an Equal Opportunity/Affirmative Action employer and conducts background checks on applicants for employment.

**School of the Environment Washington State University Assistant, Associate or Full Professor**

Assistant, Associate or Full Professor, Structural Geology/Tectonics, Washington State University

Washington State University (WSU) is currently seeking to fill a tenure-track/tenured Assistant, Associate or Full Professor position in the area of Structural Geology/Tectonics. This position is a permanent, 9-month faculty position located on the Pullman Campus. This position is part of a multi-year series of new hires intended to contribute to the growth and development of the School of the Environment, an interdisciplinary academic unit at WSU that focuses on Earth, Water, and the Environment. Duties include developing and teaching undergraduate and graduate courses and mentoring MS and PhD graduate students. The successful candidate will develop an internationally recognized research program in structural geology/tectonics. Specific areas of emphasis within this broad field are open, but we are particularly interested in candidates who will develop an externally funded research program that includes a strong field-based component.

Required: Assistant Professor: Earned doctorate in a discipline related to structural geology and tectonics, at time of employment; record of research accomplishments as demonstrated by peer-reviewed publications and/or extramural grantsmanship; demonstrated ability and/or potential to successfully teach and mentor students at the graduate and undergraduate levels. Associate Professor: in addition, 6 years of experience as an Assistant Professor or equivalent. Professor: in addition, 6 years of experience as an Associate Professor or equivalent, and national/international reputation in their field.

Preferred: Demonstrated ability to: develop collaborations; teach field camp and other field-based courses; lead field trips at the undergraduate and

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**POSTDOC and SCIENTIST OPPORTUNITIES**  
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**EARTH SCIENCES DIVISION**

The Earth Sciences Division of Lawrence Berkeley National Laboratory is a premier geoscience organization focused on creating new knowledge and capabilities to enable sustainable stewardship of critical environmental systems and judicious use of the Earth's subsurface energy resources. With deep expertise in climate science, geochemistry, geophysics, ecology and hydrogeology, Earth Scientists at Berkeley Lab are tackling critical 21st century environment and energy challenges.

Several postdoc and scientist positions are currently available. Interested candidates are encouraged to view the full job postings using the provided requisition number ('Req') at [jobs.lbl.gov](http://jobs.lbl.gov). Candidates are also encouraged to visit us at our booth during the American Geophysical Union Fall meeting in San Francisco; our booth number is 2309.

**Climate & Carbon Sciences:**

- **Research Scientist:** Quantify climate change impacts on tropical forests. (Req #79929)
- **Research Associate:** Assist with research projects related to measurements of atmospheric greenhouse gases (Req #80245)
- **Postdoc:** Quantify processes controlling soil organic matter dynamics (Req #80035)
- **Postdoc:** Investigate land-atmosphere interactions over crop and semi-arid ecosystems of the U.S. (Req #80151)
- **Postdoc:** Use multiple approaches to acquire and interpret CO<sub>2</sub> and CH<sub>4</sub> fluxes across a climate gradient in Alaska, as part of the NGEE-Arctic team (Req #79910)
- **Postdoc:** Acquire and interpret X-ray computed tomography and other tundra soil measurements as a function of polygon geomorphology and as a member of the NGEE-Arctic team (Req #80269)

**Environmental & Biological Systems Science:**

- **Research Scientist:** Integrate genomics approaches and datasets with terrestrial biogeochemical models (Req #76312)
- **Research Scientist:** Develop approaches to apply microbial genomics/metagenomics to quantify environmental system behavior, particularly soils (Req #78718)

**Energy Resources**

- **Research Scientist:** Quantify induced seismicity processes associated with carbon storage, oil and gas, and geothermal energy strategies (Req #78253)
- **Postdoc:** Perform active source seismic processing, analysis and modeling to quantify subsurface energy systems (Req# 79458)
- **Postdoc:** Contribute to the development of the Earthquake Soil Structure Interaction (ESSI) Simulator system (Req #79932)

**Fundamental Earth Sciences**

- **Postdocs** (Four positions) – Perform geochemical research as a member of the Nanoscale Controls on Geologic CO<sub>2</sub> Energy Frontier Research Center (Req #80175)

[ESD.LBL.GOV](http://ESD.LBL.GOV)



**INSTITUTE FOR GEOPHYSICS**  
JACKSON SCHOOL OF GEOSCIENCES  
**ENDOWED CHAIR IN GEOPHYSICS**

The Institute for Geophysics at The University of Texas at Austin, an Organized Research unit in the Jackson School of Geosciences, is seeking applicants for the Shell Chair in Geophysics. Appointment is expected to be at the Senior Research Scientist level within the Institute. Applicants with significant research experience are encouraged to apply.

The successful applicant will be expected to establish and conduct a vigorous externally funded research program that addresses fundamental problems in geophysics. Specific areas of research are open for discussion. Informal inquiries are encouraged.

A joint appointment with the Department of Geological Sciences, the teaching and degree granting unit of the Jackson School, may be possible depending on the applicant's professional experience and interests, and upon the teaching needs of the department.

An application should include a cover letter, statement of research interests, Curriculum Vitae, and names of at least three referees. The referees will only be consulted with the consent of the applicant.

Applications should be submitted via <http://utdirect.utexas.edu/pnjobs/index.WBX>. Applications should use posting number 13-01-08-01-0701. More information on hires can be found at <http://www.ig.utexas.edu/jobs/research.htm>.

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graduate level; and develop a strong field-based research component.

For questions about the position contact Jeff Vervoort at (509) 335-5597; [vervoort@wsu.edu](mailto:vervoort@wsu.edu)

To apply visit: <https://www.wsujobs.com>. Application materials must include a letter describing how your experience and training meet qualifications for the position, a research plan, a statement of teaching philosophy, current vitae, and names and contact information for three professional references. Screening begins January 6, 2015. EEO/AA/ADA

**Senior Program Manager Positions Various Locations**

Global Science & Technology, Inc (GST), a growing scientific and high technology company seeks experienced Senior Program Managers (PMs) for projects at federal agencies such as NOAA and NASA. Senior PM's serve as the primary point of contact with the government and provide overall leadership for all contractor and subcontractor personnel assigned to a program. Please consider helping us support these federal agencies in their efforts to improve our understanding of global land cover/land use, weather, and climate.

**Position Summary:**

Senior PM's are fully responsible for the scope, schedule, cost, and technical status; and provide technical coordination and oversight of multiple task orders to meet technical requirements.

**Job Description:**

Senior PMs are responsible for managing large multi-disciplinary workforces ranging in size from 15 to 300 personnel in the delivery of a range of science, engineering and IT services including requirements analysis, engineering, hardware and software development and operations. They manage 20-200 task orders annually, employing technical, business and enterprise practices, processes, tools and frameworks (i.e., CMMI, PMP, Six Sigma, etc.).

**Education:**

At least a Master's of Science degree in one of the Physical Sciences or in Systems Engineering or equivalent; a PhD is required for one of the Senior PM positions or equivalent. PMP certification is preferred.

**Required Skills:**

"10-15 years" experience in program/project management. PMP certification is preferred.

"Track record of successful program management in all aspects of technical performance, schedule and cost of large (\$10M - 100M, 15 - 100+ personnel) Government programs

"Strong background in science, engineering or IT

"Knowledge and experience in Federal Government IT Security requirements

"Experience working in a science related, high-technology environment

"Familiarity with civilian satellite projects, geophysical data products, processing and reprocessing.

"Excellent communication skills; both written and oral

"Ability to speak and write clearly and understandably in English

Selected applicants will be required to complete a federal government background investigation.

GST offers competitive benefits.

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All qualified applicants will receive consideration for employment without regard to race, color, religion, sex, national origin, disability or veterans' status. GST is an Equal Opportunity/Affirmative Action Employer.

**Tenure track position in Physical Hydrology Cooperative Institute for Research in Environmental Sciences**

University of Colorado Boulder

The Cooperative Institute for Research in Environmental Sciences (CIRES, [www.cires.colorado.edu](http://www.cires.colorado.edu)), an interdisciplinary research institute within the University of Colorado Boulder, seeks to appoint a tenure-track faculty member at the Assistant Professor level specializing in physical hydrology. We envision the successful candidate to have research interests in, and understanding of, one or more of the following areas: observational and modeling studies of hydrologic processes at watershed and regional scales, land-atmosphere interactions, and

hydrologic variability at interannual to multidecadal time scales with potential applicability to water resources management. The ability to productively collaborate within CIRES, especially with Western Water Assessment ([www.colorado.edu](http://www.colorado.edu)) and Earth Science and Observation Center ([cires.colorado.edu/esoc](http://cires.colorado.edu/esoc)) researchers, and across the wider Boulder climate and hydrology community will be desirable. This would include the ability to successfully interact/communicate with researchers involved in natural resource and ecological management and work as part of an interdisciplinary team. The successful candidate will have a tenure-track affiliation in a relevant academic department including, but not limited to, Civil, Environmental & Architectural Engineering, Geological Sciences and Geography. The distribution of effort for this position will be 40% research, 40% teaching, and 20% service.

Review of applications and requests for letters of recommendation will begin December 1, 2014, and will continue until a successful applicant is selected.

Questions can be sent to Professor Rajagopalan Balaji (Chair of the Search Committee) at [balajir@colorado.edu](mailto:balajir@colorado.edu).

Minimum academic requirements include a PhD in Hydrology, Civil Engineering, Geology, Geography or a related field with a demonstrated research record in physical hydrology.

**To Apply:**

<http://www.jobsatcu.com/postings/90955>

Applicants must complete the Faculty/University Staff and EEO Data (application) form, and upload the following required documents:

1-Upload curriculum vitae including funding history and publications.

2 - Cover letter (Professor to Professor Rajagopalan Balaji Chair of the Search Committee)

3 - List of 3 references, including all contact information.

4- Document 1-should be a description of the proposed research vision and program (up to 5 pages).

5- Document 2- proposed teaching program and vision and possible academic department(s) (up to 2 pages).

6 & 7 upload two of your most relevant papers as Publication 1 and Publication 2.

8- Proof of degree (unofficial transcripts or scan of diploma)

The University of Colorado is an Equal Opportunity Employer committed to building a diverse workforce. We encourage applications from women, racial and ethnic minorities, individuals with disabilities, and veterans. Alternative formats of this ad can be provided upon request for individuals with disabilities by contacting the ADA Coordinator at [hr-ada@colorado.edu](mailto:hr-ada@colorado.edu).

The University of Colorado Boulder conducts background checks for all final applicants being considered for employment.

**Faculty position: Space Technology**

The Department of Mechanical Engineering (ME) at Boston University invites applicants for a tenure track faculty position at the Assistant Professor level in Space Technology, and its commercial, scientific, and societal applications. Possible areas of focus include small satellites, spaceflight control, sensors and instrumentation, robotics, and space communications. The university seeks to build upon its traditional strengths in Space Science through the development of a synergistic technology program in the College of Engineering. The selected candidate will have the opportunity to work with a diverse group of faculty through BU's interdisciplinary Center for Space Physics (CSP). A joint appointment with the department of Electrical and Computer Engineering is possible depending on background and interests. Interested candidates should have a Ph.D. degree in a relevant field of engineering or applied science, and should have the ability to develop and sustain a funded research program. The applicant should be able to teach courses in the graduate and undergraduate programs in Mechanical Engineering or related courses in the College of Engineering. Salary is competitive and commensurate with experience. Boston University is an equal opportunity employer, and all qualified applicants will receive consideration without regard to race, color, religion, sex, national origin, disability status, protected

veteran status, or any other characteristic protected by law. Additional information and application instructions can be found at <http://www.bu.edu/me>. Inquiries may be addressed to Joshua Semeter at [jls@bu.edu](mailto:jls@bu.edu).

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**Turner Postdoctoral Fellowship University of Michigan**

This highly competitive fellowship is open to candidates who have obtained a PhD in any field within Earth and environmental sciences.

The Department seeks qualified applicants who are interested in collaborating with one or more faculty members. Applicants are encouraged to contact prospective faculty host(s) prior to the application deadline to discuss areas of common interest and to develop innovative research proposals.

Turner Postdoctoral Fellows receive an annual salary of \$55,000, discretionary research funds of \$5,000 per year, and a generous benefits package. The fellowship is awarded for a one-year period, with an anticipated extension for a second year.

Application: Applicants must have a PhD. To apply please go to: <http://www.earth.lsa.umich.edu/turner2015/newapplicant>. Complete the online application, including the names and addresses of at least three references, and upload (as a single PDF) the required application documents, which should include a curriculum vitae and a research proposal (5 pages maximum excluding references).

Deadline: Applications and reference letters for the 2015 competition are due January 15, 2015.

Inquiries should be sent to Michigan-Earth-Search@umich.edu. Women and minorities are encouraged to apply. The University of Michigan is an equal opportunity/affirmative action employer.

**Two Open Positions in Evolutionary Ecology and Ecosystem Modeling**

The Appalachian Laboratory (AL) of the University of Maryland Center for Environmental Science (UMCES) invites applications for two tenure-track/tenured faculty positions at the Assistant or Associate Professor level. We are searching for highly collaborative individuals who will complement our institutional expertise in landscape and watershed ecology.

We seek an evolutionary ecologist who applies modern genomic and traditional genetic techniques to the study of terrestrial or aquatic ecosystems at broad spatiotemporal scales, consistent with UMCES' perspective of "genes-to-ecosystems" and "mountain-to-the-sea" research domains. Preference will be given to candidates who demonstrate experience and vision for research that integrates across levels, from the molecule to the landscape, with the objective of improving understanding of how genetic diversity within ecosystems affects and is affected by current and emerging global change processes. Potential study organisms include soil and sediment microbes, higher plants, or terrestrial and aquatic vertebrates.

We seek an ecosystem modeler who employs state-of-the-art data-model fusion techniques to address ecological questions and to integrate ecosystem processes across time and space. Preference will be given to those candidates who demonstrate experience in using multiple datasets to constrain landscape, ecosystem, or earth system models, with the objective of utilizing systems modeling to improve our understanding of ecosystem responses to global change processes. Scientists at AL and other UMCES laboratories are at the cutting edge of producing increasingly large and diverse datasets in hydrology, air and water quality, land use/land cover change, wildlife habitat, species distributions and genomic variation, biogeochemistry, and terrestrial and aquatic ecology, thus providing

numerous opportunities for improved scientific understanding of ecosystems through interdisciplinary collaborations and systems modeling.

The UMCES mission includes advancing world-class basic research, promoting graduate-level education, conducting community outreach and science application, and providing scientific expertise for regional environmental policies on topics such as air, land, and water management in the Chesapeake Bay watershed. We seek to build faculty at AL and across our three sibling UMCES laboratories with complementary areas of expertise in the environmental sciences. These faculty positions provide 75% of salary support, with the expectation of raising 25% salary from grants. The successful candidates will be expected to mentor graduate students and carry a modest graduate-level teaching load. The AL is located in the headwaters of the Chesapeake Bay watershed, with a diverse range of forested and agricultural ecosystems found nearby. While research relevant to the Chesapeake Bay watershed should become part of the successful candidates' project portfolios, other regional, national, and global research domains are strongly encouraged.

These two positions are the first of several coordinated new hires expected over the next few years. Faculty positions at AL provide a unique opportunity to focus broadly on research, while also mentoring graduate students and participating in collaborative regional and global application and outreach of environmental science. The AL offers strong administrative support and excellent research, computing, and teaching facilities, including isotopic, molecular, plant, soil, and water analysis laboratories, growth chambers, and a greenhouse. The AL is located in Frostburg, MD, a small college town (Frostburg State University) in the heart of the central Appalachian Mountains, with excellent recreational and cultural activities nearby.

Applicants should send the following electronically: (1) a curriculum vitae; (2) statement of research interests and a brief discussion of how their research aligns with one of the two job descriptions and would complement ongoing research at AL and UMCES; (3) statement on experience with and approach to graduate-level teaching and mentoring of graduate students; (4) up to five selected reprints and preprints; and (5) names of four references (including title, mailing address, telephone, FAX, and e-mail address) to [Plsearch@al.umces.edu](mailto:Plsearch@al.umces.edu). Review of applications will begin on January 20, 2015, and will continue until the positions are filled. Information about the AL and UMCES and this search can be found at: <http://www.umces.edu/al> UMCES is an Affirmative Action/Equal Opportunity Employer, and women and minorities are strongly encouraged to apply. Inquiries may be addressed to the AL Director, Dr. Eric A. Davidson: [edavidson@al.umces.edu](mailto:edavidson@al.umces.edu).

**Student Opportunities****Graduate Fellowships and Assistantships: University of Illinois at Urbana-Champaign**

Earn your graduate Geoscience degree at one of the nation's top public research universities, the flagship campus of the University of Illinois. Several fellowships and assistantships are available for students wishing to pursue Ph.D. or M.S. degrees beginning Fall, 2015. World class analytical facilities and computing resources as well as strong interdisciplinary ties provide a rich research environment. Students with interests in geophysics, geomicrobiology, geomorphology, igneous geochemistry, hydrogeology, and sedimentology are particularly encouraged to apply. Applications are due Jan. 15; for more information, visit <http://www.geology.illinois.edu> <http://www.geology.illinois.edu/>

**Graduate Student Funding Opportunities in Geology, Geography, and Marine Science and Policy**

The College of Earth, Ocean, and Environment (CEOE) at the University of Delaware is pleased to announce the availability of graduate student

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**INSTITUTE FOR GEOPHYSICS**  
JACKSON SCHOOL OF GEOSCIENCES

**UTIG POSTDOCTORAL FELLOWS PROGRAM**

The University of Texas Institute for Geophysics (UTIG) invites applications for its postdoctoral fellows program for 2015-2016. UTIG, which is part of the Jackson School of Geosciences at UT Austin, is known for international field programs in geophysics (solid earth, marine, polar) as well as quantitative geophysics, planetary science, and climate science.

This is a highly competitive institutional award open to recent doctorates (degree within the past 3 years) in earth, marine, and planetary science or allied fields. The appointment is for 24-months. Recipients may pursue their own research interests in any scientific subfield where UTIG has ongoing programs, and are encouraged to identify a UTIG mentor. Successful applicants may take up residence at UTIG as early as September 1, 2015, but no later than December 31, 2015. Salary is \$60,000 per year and appointees are eligible for group health and dental insurance. Limited support may be available for travel, equipment, and other research expenses.

Applications must contain: 1) a current Curriculum Vitae (CV) that includes education, employment history, publications, and record of any extramural funding; 2) a concise statement of research interests, and a discussion of how these interests merge with those of UTIG (see [http://www.ig.utexas.edu/people/research\\_areas.html](http://www.ig.utexas.edu/people/research_areas.html)); and 3) names and contact information for three individuals willing to write letters of reference. Applicants can send applications electronically as email attachment to [PostDocUTIG@ig.utexas.edu](mailto:PostDocUTIG@ig.utexas.edu). For full consideration, applications must be received by January 25, 2015.

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funding. Eligible students could be funded through various opportunities including fellowships, research assistantships, teaching assistantships and tuition scholarships. Students who apply and are being considered for admission will be invited for a paid visit to campus. For more information visit [www.ceoe.udel.edu](http://www.ceoe.udel.edu).

**IGERT: ADAPTATION TO ABRUPT CLIMATE CHANGE (A2C2) University of Maine Ph.D. assistantships available**

The University of Maine is seeking outstanding applicants for a doctoral graduate training program in adaptation to abrupt climate change (ACC) funded by the NSF IGERT program. This is a joint program between the Climate Change Institute and the School of Policy & International Affairs at UMaine ([a2c2igert.umaine.edu](mailto:a2c2igert.umaine.edu)). The A2C2 IGERT is designed to train doctoral students in earth sciences, ecology,

anthropology, archaeology, international affairs, and economics to meet critical societal needs in human adaptation to ACC. Please see the program website for descriptions of program goals and research themes.

Students in this program will receive an annual stipend of \$30,000 per year in each of the first 2 years, plus tuition, fees, and health insurance coverage. Students must be U.S. citizens or permanent residents to receive IGERT support.

Application instructions are provided on the program website. For full consideration, submit all documents no later than February 1, 2015. Please send any questions or inquiries about this program to the A2C2 IGERT Program Coordinator, Mr. Misa Saros, at [a2c2igert@umit.maine.edu](mailto:a2c2igert@umit.maine.edu).

**PhD Opportunity in River-Groundwater Science and Engineering at Virginia Tech.** Dr. Erich Hester and Dr. Mark Widdowson in the Dept.

of Civil and Environmental Engineering at Virginia Tech seek a PhD student starting Spring or Fall 2015 for a new multi-year NSF-funded laboratory and numerical modeling project in the area of hydraulics and pollutant migration in river systems. Contact [ehester@vt.edu](mailto:ehester@vt.edu). More information on the opportunity, the Hester Lab, Virginia Tech, and Blacksburg VA can be found at [www.flow.cce.vt.edu/index.html](http://www.flow.cce.vt.edu/index.html).

**PhD positions in Atmospheric Physics and Climate Change at UCLA.** Projects will involve understanding physical processes that play important roles in climate change, with a particular focus on the global cycle of mineral dust aerosols and its effects on climate. Methods employed will include data analysis, numerical modeling, use of first-principles physics, and simple climate modeling. Desired qualifications include strong quantitative skills and a B.S. or M.S. in physics, atmospheric sciences, engineering, mathematics or related fields. Contact Prof. Jasper Kok at [jkok@ucla.edu](mailto:jkok@ucla.edu) for more information, or see <http://jasperkok.com>. More information on the Department of Atmospheric and Oceanic Sciences at UCLA is available at <http://www.atmos.ucla.edu/students/graduate/>

phd-program; the graduate program application deadline for Fall 2015 admission is December 10th. Interest from women and underrepresented minorities is particularly encouraged, and U.S. citizenship or residency is not required.

**The Geological Sciences Department at Central Washington University seeks motivated students for two NSF-funded projects; prior research experience is beneficial.** Student research positions (MS) are available starting Fall 2015.

1. Geodynamic modelling will focus on characterizing the extensional evolution of the West Antarctic Rift System. The student must be willing and able to participate in Antarctic fieldwork; computer programming skills are beneficial. Contact: Dr. Audrey Huerta ([huerta@geology.cwu.edu](mailto:huerta@geology.cwu.edu)).

2. Geochronology and thermobarometry will focus on documenting the spatial and time evolution of PT conditions in the North Qaidam ultrahigh-pressure terrane, western China. A strong petrology background is required. Contact: Dr. Chris Mattinson ([mattinson@geology.cwu.edu](mailto:mattinson@geology.cwu.edu)).

# RESEARCH SPOTLIGHT

Highlighting exciting new research from AGU journals

**A dearth of hurricanes cannot explain Maya collapse**

A thousand years ago the great Maya culture of Central America collapsed. Climate change was one factor that stressed the civilization until it fractured: A prolonged period of intense and persistent drought left the Maya's descendants to carry on without a robust elite urban class.

Living on the Yucatán Peninsula, the Maya depended on seasonal rainfall. In previous research, scientists suggested that a prolonged drop in hurricane activity pushed the region into drought from 800 to 950 C.E., coincident with the Maya collapse, or Terminal Classic period. Using new observations, however, *Frappier et al.* showed that hurricane frequencies during the 9th and 10th centuries were not appreciably different from those in the surrounding centuries.

The authors' observations—a 1642-year record of hurricane activity spanning 365 to 2007 C.E.—are derived from a relatively novel technique.

The northern Yucatán Peninsula's Ring of Cenotes region is peppered with caves linked to the water table, and growing in one cave 4.5 meters above the water level is a stalagmite nearly 17 centimeters tall. The region has strong annual wet and dry seasons, and each year the stalagmite grows a new layer couplet of bright and dark calcite.



The stalagmite that yielded Frappier et al.'s paleohurricane activity record, shown with a marker pen on the left for scale.

When heavy hurricane rains raise the water table, the cave floods, immersing the stalagmite in water for a few days. As the water recedes, the stalagmite is coated in a thin film of mud before it resumes growing, and the distinctive mud layer becomes locked between carbonate layers. By counting the annual couplets within the stalagmite and noting which years contained mud layers, the authors derived a rough measure of hurricane activity from year to year.

During periods of prolonged drought, the regional water table is lower, so the cave should not be flooded by hurricanes as often. Contrary to their expectations, the authors found that the cave flooded regularly throughout the Terminal Classic droughts.

The authors present two explanations for this curiosity: Either Yucatán hurricanes during the drought period were disproportionately strong and frequent, or the megadrought was punctuated by breaks and had normal hurricanes. (*Geophysical Research Letters*, doi:10.1002/2014GL059882, 2014) —CS

**Cloud variations in current climate a guide to climate changes**

Clouds come in many flavors—like wispy cirrus, cotton-puff altocumulus, and ominous stratus—and each presents a unique set of challenges for scientists trying to understand their effects on climate. Because of this, clouds have long accounted for much of the disagreement between climate models, and for most of the uncertainty in estimates of how much the Earth is expected to warm with a doubling of atmospheric carbon dioxide (CO<sub>2</sub>).

This uncertainty stems from the fact that models suggest the extent, altitude, and optical thickness (a measure of how much short-wave radiation penetrates through a cloud) will change in different ways for different kinds of clouds in a warming world. To better understand these changes, *Gordon and Klein* analyzed low clouds in an ensemble of climate models. Then they assessed how model predictions of the change in low-cloud optical thickness with temperature compared to

short-term variations in low clouds observed by satellites in the current climate.

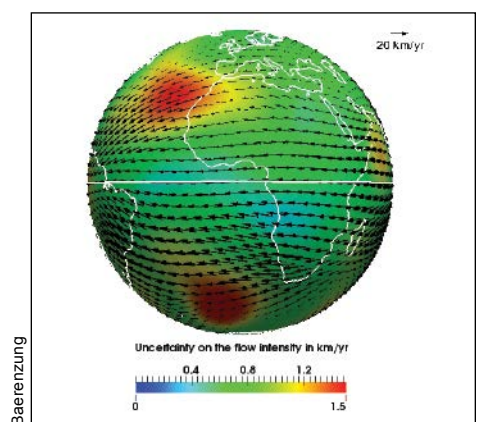
The researchers found that both models and real-world observations show that optical thickness increased with warming for the cold, low clouds common at mid-latitudes to high latitudes, contributing to an overall negative climate feedback. The researchers attributed this trend to an increase in the water content of clouds at higher temperatures. For warm, low clouds, on the other hand, the study found that optical depth decreases with temperature in model simulations and satellite measurements, probably because these clouds tend to get thinner as they warm.

The researchers showed that variations in the optical depth and temperature of low clouds in the current climate provide a reasonable guide for how low clouds might behave under future climate changes, and could be used as a target for calibrating climate models. Currently, however, models overestimate the temperature dependence of optical thickness, suggesting cloud feedbacks are more positive than previously thought. (*Journal of Geophysical Research: Atmospheres*, doi:10.1002/2013JD021052, 2014) —JR

**From magnetic field data, the flow of Earth's core**

The outer core of the Earth is made of liquid metal, and its flow both affects and is affected by our planet's core magnetic field. It is impossible to directly measure the outer core of the Earth, the outer boundary of which is about 2900 kilometers below our feet. However, the turbulence of the core's liquid is so complex—including large-scale features and small-scale features—that it cannot be modeled as a simulation.

In a recent study, *Baerenzung et al.* developed a method to determine the flow of the core at the core-mantle boundary, using satellite-collected information on the outer magnetic field. The authors focused on the large-scale behavior of the core, devising an equation to filter magnetic field data to leave out features smaller than 500 kilometers. Then



The velocity field and its associated intensity uncertainties at the level of the Earth's core mantle boundary below Africa for the beginning of 2005.

they created an algorithm to figure out what behavior in the core would most likely result in a hypothetical set of magnetic field data.

After testing the process on made-up data, they created a snapshot of the speed and direction of flow of the outer core at the beginning of 2005, as well as the associated uncertainty. The map included several expected features, like the way that the liquid metal spirals on a planetary scale. (*Journal of Geophysical Research: Solid Earth*, doi:10.1002/2013JB010358, 2014) —SP

**Sea levels changing in response to natural variations**

Scientists have widely accepted that sea levels have been rising since the end of the 19th century due to human activities that warm the planet and melt land-locked ice. Models of future sea level rise suggest that sea levels will continue to increase at an accelerating rate if emissions of greenhouse gases continue at the current rate. This has motivated a number of scientists to search for already existing accelerations in global and regional sea level during the past 2 decades. However, *Dangendorf et al.* note that current attempts to detect a significant acceleration in sea level rise might have overestimated the role of anthropogenic forcing.

The authors instead suggest that natural variation could be playing a larger role in regional and global sea level rise than previously thought. To test their theory, the authors analyzed 138 years of tidal gauge and ocean reanalysis data and found that natural variations may have caused random, persistent multidecadal changes of sea level that can be erroneously interpreted as a systematic acceleration of the rate of sea level rise. Such persistent patterns of sea level rise are found in climate-related components governing sea level change, such as thermal expansion and mass changes.

The authors note that future sea level rise could be higher or lower than previously estimated because rises due to anthropogenic warming are offset by deviations due to natural variability. The authors further propose to include the effect of long-term correlations in the most recent projections to fully understand anthropogenic effects on global sea level dynamics. (*Geophysical Research Letters*, doi:10.1002/2014GL060538, 2014) —JW

—JOANNA WENDEL, Staff Writer; and ERIC O. BETZ, SHANNON PALUS, JULIA ROSEN, and COLIN SCHULTZ, Writers

**Ocean acidification worse in coral reefs**

The rate of ocean acidification in coral reefs outpaces the rise in carbon dioxide (CO<sub>2</sub>) in Earth's atmosphere, indicating that anthropogenic carbon emissions alone are not to blame for the threat to coral reefs, a new study shows.

*Cyronak et al.* demonstrated that CO<sub>2</sub> levels have risen 3.5 times faster in coral reefs than in the open ocean. Unlike in the open ocean, where long-term tracking of CO<sub>2</sub> levels is done at many individual stations, in individual coral reefs there is a lack of uninterrupted measurements. To compensate for this lack, the authors compared CO<sub>2</sub> levels reported in the literature from coral reefs throughout the globe.

The authors also developed a model of reef metabolism based on data from Heron Island (in the Great Barrier Reef) to investigate the potential causes of this accelerated increase in ocean acidification. They found that the increase is likely due to human activities bringing elevated levels of nutrients and organic matter from surface runoff and submarine groundwater discharge.



Coral reef and fish off of Heron Island in the Great Barrier Reef.

According to the authors, the results show that reductions in CO<sub>2</sub> emissions alone will not be enough to end threats to coral reefs, and local officials will need to confront the management challenge of dealing with

pollutants. The team cited a need for increased long-term monitoring not only of coral reefs but also of estuaries, which could be exhibiting similar problems. (*Geophysical Research Letters*, doi:10.1002/2014GL060849, 2014) —EOB