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Pirate Attacks Affect Indian Ocean Climate Research

Pirate attacks in the Gulf of Aden and the Indian Ocean off the coast of Somalia nearly doubled from 111 in 2008 to 217 in 2009 [*International Maritime Bureau*, 2009, 2010]. Consequently, merchant vessel traffic in the area around Somalia significantly decreased. Many of these merchant vessels carry instruments that record wind and other weather conditions near the ocean surface, and alterations in ship tracks have resulted in a hole sized at about 2.5 million square kilometers in the marine weather–observing network off the coast of Somalia.

The data void exists in the formation region of the Somali low-level jet, a wind pattern that is one of the main drivers of the Indian summer monsoon. Further, a stable, multidecadal record has been interrupted, and consequently, long-term analyses of the jet derived from surface wind data are now showing artificial anomalies that will affect efforts by scientists to identify interannual to decadal variations in the climate of the northwestern Indian Ocean.

The Somali low-level jet, also called the East African jet, is a barrier-forced wind current that forms when the development of a high-pressure region southeast of South Africa results in counterclockwise flow around the high and subsequent onshore winds along the east coast of Africa. The onshore winds north of Madagascar are blocked from moving inland by Somalia's elevated terrain, which forces the winds to flow northward. The curvature of the coastline and the Coriolis force cause the winds to form a southwest-to-northeast jet, which crosses the Arabian Sea toward the Indian coast. The Somali jet is seasonal, forming in May, becoming strongest in July, and dissipating in October. Average peak surface winds are 12–16 meters per second over the northwest Indian Ocean. In the winter months, the flow reverses and heads south along the African coast.

Multidecadal studies of the Somali jet, and subsequently the Indian monsoon cycles, are needed to improve seasonal to interannual precipitation forecasts over the Indian subcontinent. The natural variations in the strength and timing of the monsoons are dependent on the strength, location, and structure of the Somali jet. Therefore, correctly measuring the Somali jet is critical to ensuring that future forecasting models accurately depict these monsoonal variations. Studies of the Somali jet rely, in part, on monthly average wind fields derived from individual wind observations reported by ships and buoys. Recent increases in piracy have disrupted and altered shipping routes in the northwest Indian Ocean, reducing the number of wind observations to a level that is insufficient to accurately identify the strength and spatial extent of the Somali jet, resulting in a discontinuity in the long-term record necessary for analyzing multidecadal variations in both the jet and the Indian monsoon cycle.

By S. R. Smith, M. A. Bourassa, and M. Long

Geopolitical Effects of Somali Piracy

Somalia has been in a state of civil war since the United Somali Congress overthrew the government of Mohamed Siad Barre in 1991. The resulting economic, governmental, and political instability has created an environment in which piracy thrives [*Draper*, 2009]. Ship hijackings have proven lucrative, and the number of attacks soared in 2008.

The increased attacks have led to a change in vessel operations. Vessels are advised to stay at least 600 nautical miles off the coast of Somalia; those sailing in the Gulf of Aden are advised to travel through the Internationally Recommended Transit Corridor, a narrow transect patrolled by representatives of the European Union, the North Atlantic Treaty Organization, and a multinational naval partnership called the Combined Maritime Forces. Some vessels travel around the Cape of Good Hope instead of through the Suez Canal to reach the Mediterranean Sea. This change in vessel traffic can be seen in representative maps of wind observations from 2008 and 2009 for the month of August (Figure 1), when the Somali jet reaches peak strength. In 2008 and for about 30 years prior, the primary route paralleled the African coast from the mouth of the Gulf of Aden southward between Africa and Madagascar, bisecting the core of the Somali jet. Since 2008, this primary route has been pushed roughly to the advised distance of 600 nautical miles off the coast of Somalia, with the majority of the vessels traveling east of Madagascar.

Additionally, the primary ship track from the Gulf of Aden to the southern tip of India shows fewer observations in 2009 (averaging 8–15 observations per month in 2009 versus 15–25 in 2008). The exact cause of this reduction is unknown; however, it may be that vessels continue to operate along this route and simply do not transmit their weather reports as a security precaution.

Piracy's Impact on Monthly Wind Analyses

The change in the primary ship routes because of pirate attacks and the subsequent reduction in data reporting frequency result in an undersampling of the core of the Somali jet. This can be readily seen through a comparison of monthly wind products created using only surface (ship and buoy) versus satellite wind observations.

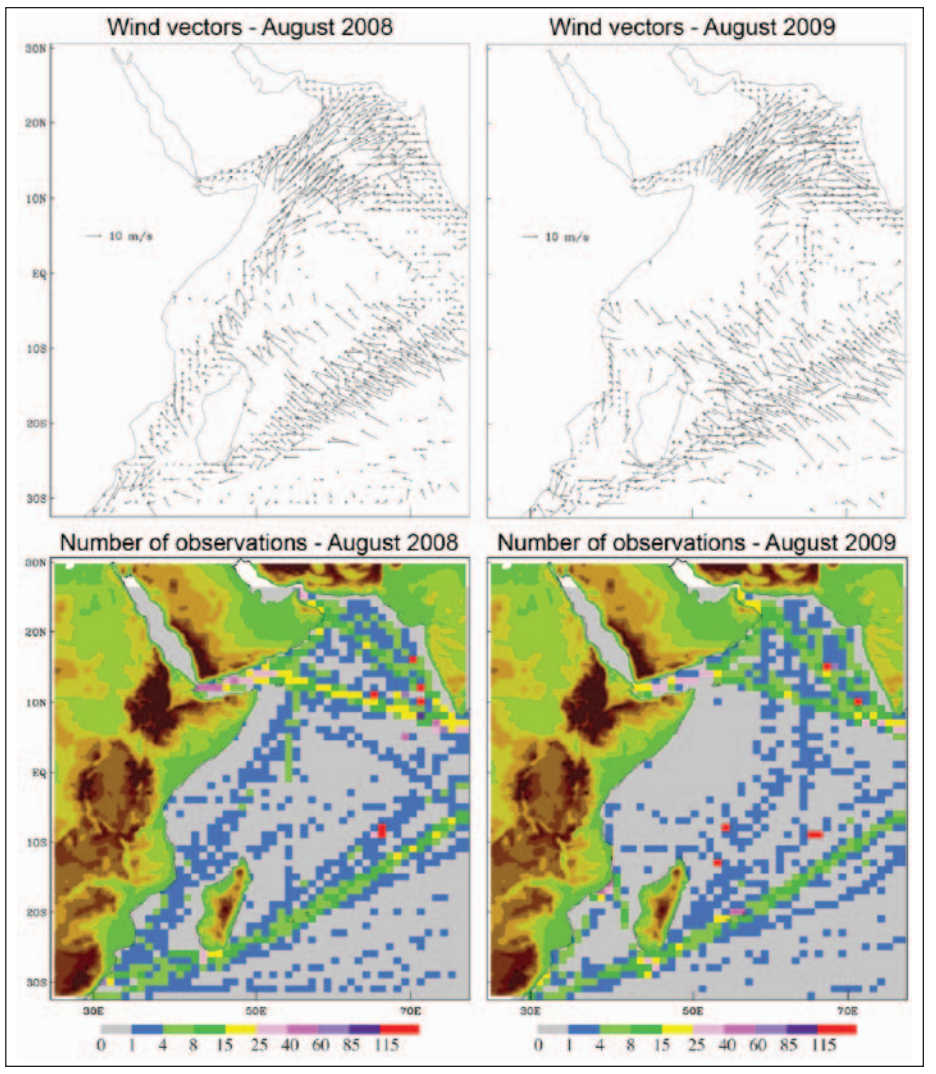

Fig. 1. A comparison of data coverage for August 2008 versus August 2009. (top) Monthly average wind vectors on a 1° grid are used to derive monthly objective fields. (bottom) The number of wind observations used to derive the averages (see color bar for scale) is displayed for each grid cell.

For background, the surface product is created by the Florida State University (FSU) and covers the period 1970 to present [*Smith et al.*, 2004]. Ships and the few moored buoys in the Indian Ocean are equipped with anemometers to measure the wind speed and direction. In some cases, merchant ships also estimate the wind speed and direction by examining the state of the ocean waves. For the FSU surface product, these individual observations are averaged in 1°, latitude-by-longitude bins. The resulting gridded fields (e.g., Figure 1) are combined with climatological winds through an objective analysis routine to fill holes where wind measurements are not available, producing a continuous gridded wind analysis (e.g., Figure 2). The satellite product is derived from wind measured by the SeaWinds scatterometer on the National Oceanic and Atmospheric Administration's Quick Scatterometer (QuikSCAT) satellite. A scatterometer uses microwave energy to measure the wind speed and direction at the surface of the ocean. Microwaves are sent from the satellite to the ocean surface, where the directional distribution of the scattered energy depends on the shape of the ocean surface, which is largely a function of wind speed and direction. The wind speeds and directions are inferred from the quantity of energy scattered back to the satellite [*Bourassa et al.*, 2003]. A similar objective analysis technique is used to produce a gridded monthly wind product using the QuikSCAT wind observations [*Morey et al.*, 2005].

The changes in shipping routes and the decreasing number of observations near the coast (Figure 1) have resulted in a decreased confidence in the FSU analyses derived from ship and buoy observations in the northwestern Indian Ocean. As an example, the surface wind analysis for August 2009 exhibited a region of anomalous northerly winds to the east of Somalia (Figure 2). These anomalies peaked at more than 7.5 meters per second and correspond in space almost identically to the void in ship observations (Figure 1). But the interpolation made by the analysis is an underestimate; a comparison between the mean wind vector fields derived from the surface and QuikSCAT data reveals that the surface product fails to resolve the core of highest winds (greater than 12 meters per second) extending along the eastern tip of Somalia in the QuikSCAT product. Normally there is quite good agreement between these monthly in situ and satellite products; however, the wind speeds along the coast of Somalia are on average 1.5 meters per second weaker in the surface product as compared to the QuikSCAT product.

Beware of Data Anomalies

In the modern era, many stakeholders interested in marine winds are able to rely on wind measurements from satellites, so why is the current void in surface observations a concern? Climate scientists interested in multidecadal data records for examining long-term variability of the Somali jet and/or the monsoon cannot rely on satellite observations, which gained high-resolution global coverage only recently. The satellite record of vector winds extends back only to 1991 and the recent end of the QuikSCAT data record has resulted in a discontinuity in the satellite wind products.

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As a result, ship-based wind observations continue to be an important resource for developing multidecadal wind products; however, it is important for users of these products to understand the adverse effects that current geopolitical events may have on their analyses. For example, a naive scientist might look at the wind anomaly fields and assume that the August 2009 northerly anomalies off Somalia have physical meaning. The evidence that piracy affects the long-term record of the Somali jet is a cautionary tale to those who are using surface-based analyses in the northwest Indian Ocean for the period beginning in mid-2008.

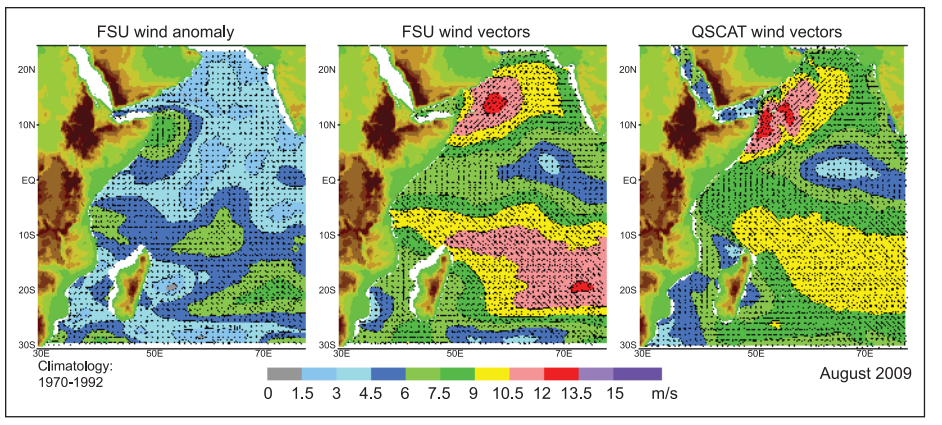

Fig. 2. Gridded wind fields for August 2009 in the western Indian Ocean, including (left) surface wind anomalies from the 1970–1992 average, calculated by scientists at the Florida State University (FSU); (middle) FSU average winds; and (right) average winds determined by the Quick Scatterometer (QuikSCAT) satellite. Winds are 3–5 meters per second weaker in the FSU average versus the QuikSCAT average east of the Horn of Africa. The location of this weakness corresponds to the area in the FSU wind fields that exhibits anomalies of greater than 7.5 meters per second; these anomalies result from the lack of ship wind observations off Somalia. Wind anomalies are created by subtracting the 1970–1992 August average wind field from the field for August 2009.

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NEWS

Symposium Focuses on Arctic Science and Policy Needs

The most important step the United States needs to take for the future of the Arctic is ratification of the United Nations Convention on the Law of the Sea (LOS), U.S. Senator Mark Begich (D-AK) told attendees at the 4th Symposium on the Impacts of an Ice-Diminishing Arctic on Naval and Maritime Operations, held 20–22 June in Washington, D. C. With the Arctic region undergoing rapid transformation due to climate change, scientists at the symposium provided details about diminishing ice and other concerns, while U.S. Naval and Coast Guard officers discussed research and operational needs and policy makers called for more resources to deal with Arctic issues and for LOS ratification.

Begich said that although some Senate colleagues oppose the treaty because they see it as a sort of United Nations takeover, LOS provides the basic framework for managing emerging issues in the changing Arctic. Among those issues are national security, shipping, seabed mining, energy development, environmental protection, marine scientific research, and ensuring U.S. rights to extended continental shelf claims. Begich said he hopes the treaty will come up for Senate debate, but he acknowledged that it is not at the top of the White House's full agenda.

"Even though you are talking about diminishing Arctic ice and climate change," Begich said about strategy related to potential Senate debate on the treaty, "our focus will be on how this [treaty] protects [U.S.] sovereignty. I think that will win over some colleagues who are not necessarily so enamored by the Law of the Sea treaty."

Begich also expressed concern about the nation's "critical lack" of ice-breaking ships, and he called for adequate funding to ensure resources for the U.S. Coast Guard and the National Oceanic and Atmospheric Administration (NOAA). With the diminishing ice opening up vast new areas for oil and gas drilling in the Beaufort and Chuckchi seas (which could contain about 28 billion barrels of oil and 38 trillion cubic feet of natural gas), Begich said he looked forward to new leases and sales but urged that exploration proceed carefully and safely.

U.S. Senator Lisa Murkowski (R-AK) said the pace of change in the Arctic "demands that greater attention be focused on the region. The implications of the dynamic changing Arctic for U.S. security, economic, environmental, and political interests depend on it." She added that she is committed to trying to move the Law of the Sea treaty through the Senate, to advocating for new ice breakers and infrastructure in the Arctic, to supporting Arctic research, and to encouraging the United States to continue increasing its role in the region and with the international Arctic community.

Also urging LOS ratification was Admiral Robert Papp, Jr., Coast Guard commandant. "We need to know with specificity and certainty what areas of our extended continental shelf constitute our sovereign territory. Doing so is just as important as knowing the delineation of any land border," he said.

Papp also expressed concern about the lack of sufficient polar ice-breaking vessels. He said that although the United States had eight polar ice breakers in 1957, the only one under way this summer is the Coast Guard Cutter *Bertholf*. He said the *Polar Star* is in a shipyard for reactivation in 2013, the *Polar Sea* will be decommissioned, and several other cutters are planned. The largest concern right now is that "we have no resources, we have no infrastructure in this vast Arctic region that we do in fact have responsibility for," he said at a news briefing during the symposium. "If I was to stay up at night worrying about something, it's probably how would we respond to an event up there. We're focused on oil and environmental concerns, but it could be a cruise ship" in distress.

He said another challenge in dealing with problems in the Arctic is that "maybe 9.5 out of 10 people in this country don't consider [the United States] to be an Arctic nation. The people in Alaska fully understand this. But I think people in Florida, Iowa, and California don't necessarily understand that at this point."

At the briefing, NOAA Director Jane Lubchenco said other concerns include the ability to provide partner agencies and individuals with a number of products for the Arctic, including weather and warnings, navigation charts, and oceanographic models. "We don't have the capacity in the Arctic that is at all what exists elsewhere," she said. "That's a matter of insufficient observing, insufficient information to do the modeling and forecasting. So there is a huge disconnect between what is expected we will be able to deliver and what we are actually able to provide."

Lubchenco said improving NOAA's scientific, service, and stewardship capabilities requires additional resources, which she acknowledged is difficult to come by given the downward pressures on federal agency budgets.

Lubchenco said national policies are beginning to catch up to the "reality" of climate change in the Arctic that is also affecting other parts of the world, and she cited a number of advances, including President Obama's National Ocean Policy and NOAA's Arctic Vision and Strategy. "However, our ability to deliver the technical and scientific information needed lags behind as a result of limited resources," she said.

At the symposium, Kathryn Moran, senior policy analyst with the White House's Office of Science and Technology Policy (OSTP), described a number of U.S. federal interagency efforts related to the Arctic, including the Interagency Arctic Research Policy Committee being moved to within the OSTP's National Science and Technology Council structure last year.

She stressed the research need for long-term observations. "Because of the complexity of the ocean, ice, and atmospheric system—because we don't fully understand the physics completely of how they interact—collecting observations will continue to help us with models and forecasting and predicting. That's what we really need. We need to be able to predict so that good policy can be developed."

Moran added that Arctic science is centrally based around the Arctic ecosystem. "Some of the scientists working in the Arctic and the Antarctic and in other parts of the planet where the climate is changing very rapidly are very nervous because at times the science they are doing doesn't always keep up with the changes they are seeing," she said. "This is one of the challenges we've had in developing policy for the Arctic."

James Overland, an oceanographer with NOAA's Pacific Marine Environmental Laboratory in Seattle, Wash., also discussed rapid changes in the Arctic and what he called a series of "surprises," changes that are larger than scientists had been predicting based on climate models or projections. "Five years ago, we were saying the ice is going away, it's going to get warmer. But now we know that the ice and the temperatures in the Arctic are interacting, and they're interacting with the larger global climate so that changes are happening faster than anyone expected, even a few years ago," he told *Eos*. "It makes what the changes are going to be 30 years from now probably faster, more severe than we thought."

The surprises Overland mentioned include a 42% loss of multiyear sea ice in the Arctic between January 2004 and 2008; large forest fires that are sterilizing the ground in some

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regions which makes it take longer for ecosystems to bounce back; a "warm Arctic–cold continent climate pattern," with what he described as the normal pattern of the "polar vortex" of west-to-east flowing winds that trap cold air in the Arctic having broken down in December 2009, allowing cold air to move south; and Greenland ice melt that is 4 times greater than estimated in 2007 by the Intergovernmental Panel on Climate Change.

"The bottom line," Overland told *Eos*," is that changes in the Arctic are large and real, and they're consistent with a global warming hypothesis that's being validated and that was brought up 20 years ago. That we are seeing these changes now. But the additional impact is that the loss of sea ice, the warming of the ocean, is having a feeding onto the atmosphere, which in turn affects both changes in the Arctic and changes further south where people live, and we're starting to see these changes now rather than 20 years in the future."

—Randy Showstack, Staff Writer

In Brief

Briefing highlights space weather risks to GPS Solar storms, which are expected to increase as the Sun nears the most active phase of the solar cycle, can disrupt a variety of technologies on which society relies. Speakers at a 22 June briefing on Capitol Hill in Washington, D. C., focused on how space weather can affect the Global Positioning System (GPS), which is used in a wide range of industries, including commercial air travel, agriculture, national security, and emergency response.

Rocky Stone, chief technical pilot for United Airlines, noted that GPS allows more aircraft to be in airspace, saves fuel, and helps aircraft move safely on runways. "Improvements in space weather forecasting need to be pursued," he said. Precision GPS has also "changed the whole nature of farming," said Ron Hatch, Director of Navigation Systems, NavCom Technology/John Deere. GPS makes it possible for tractors to be driven in the most efficient paths and for fertilizer and water to be applied precisely to the areas that most need them. Space weather–induced degradation of GPS signals can cause significant loss to farms that rely on GPS. Elizabeth Zimmerman, Deputy Associate Administrator for the Office of Response and Recovery at the Federal Emergency Management Agency (FEMA), described how FEMA relies on GPS for disaster recovery. The agency is developing an operations plan for dealing with space weather, she said.

Speakers at the briefing also stressed the importance of the Advanced Composition Explorer (ACE) satellite. From its unique vantage point, ACE provides advanced warning of solar storms headed toward Earth. At 14 years old, ACE has passed its planned life expectancy. Speakers urged Congress to provide funding for the launch of the Deep Space Climate Observatory (DSCOVR), which would replace ACE. ACE could be "an aging, single-point failure," said Kathryn Sullivan, Deputy Administrator of the National Oceanic and Atmospheric Administration and Assistant Secretary of Commerce for Environmental Observation and Prediction. "Our aim is to deploy DSCOVR before ACE fails."

The briefing was cosponsored by the American Meteorological Society, University Corporation for Atmospheric Research, American Chemical Society, American Geological Institute, Weather Coalition, and AGU. —ET

Another call to increase STEM education As science, technology, engineering, and mathematics (STEM) education becomes increasingly important, U.S. students are lagging behind other nations on international assessments, according to a recent Trends in International Mathematics and Science study. A 22 June report from the U.S. National Research Council (NRC) calls for increasing the focus on STEM education in the United States.

"To make progress in improving STEM education for all students, policy makers at the national, state, and local levels should elevate science to the same level of importance as reading and mathematics," states the report, "Successful K–12 STEM Education: Identifying Effective Approaches in Science, Technology, Engineering, and Mathematics." It outlines several goals: expand the number of students who pursue advanced degrees and careers in STEM fields; expand the STEM-capable workforce, while also broadening the participation of women and minorities; and increase STEM literacy for all students, whether or not they pursue STEM-related careers or additional study in those areas.

Schools and districts can take a number of steps to support STEM education from kindergarten through 12th grade, according to the report, including devoting adequate instructional time and resources to science, ensuring that STEM curricula are rigorous and focus on the most important topics in each discipline, enhancing the capacity of K–12 teachers, and considering STEM-focused school models noted in the study.

"A growing number of jobs—not just those in professional science—require knowledge of STEM fields," said Adam Gamoran, chair of the NRC committee that wrote the report and professor of sociology and educational policy studies at the University of Wisconsin-Madison. "The goal isn't only to have a capable and competitive work force. We need to help all students become scientifically literate because citizens are increasingly facing decisions related to science and technology—whether it's understanding a medical diagnosis or weighing competing claims about the environment."

For more information, see http://www.nap.edu/catalog.php?record_id=13158. —RS

—Randy Showstack and Ernie Tretkoff, Staff Writers

FORUM

The Size of the 2011 Tohoku Earthquake Need Not Have Been a Surprise

The devastating 11 March 2011 magnitude 9.1 earthquake along the Tohoku coast of northeastern Japan reminded seismologists again of the adage, "It ain't what you don't know that gets you into trouble—it's what you know for sure that just ain't so."

Many seismologists—and hence disaster planners—thought that such huge earthquakes could not occur on this subduction zone [*Chang,* 2011; *Geller,* 2011]. Great earthquakes—magnitude 8—were expected and planned for. However, a giant magnitude 9 earthquake, which would release 30 times more energy, was not considered.

As illustrated in Figure 1a, a magnitude 9 earthquake involves more slip on a larger fault area, resulting in a larger tsunami because the maximum tsunami runup height is typically about twice the fault slip [*Okal and Synolakis,* 2004]. Thus, the March earthquake generated a huge tsunami that overtopped even 10-meter seawalls, causing enormous damage including crippling nuclear power plants.

With the wisdom of hindsight, it is worth considering why such a huge earthquake was not anticipated. The available history had no record of such earthquakes. This seemed plausible, given an analysis in 1980 of the largest known earthquakes at different subduction zones [*Ruff and Kanamori,* 1980]. These data (Figure 1b) showed a striking pattern: Magnitude 9 earthquakes occurred only where lithosphere younger than 80 million years old was subducting rapidly, faster than 50 millimeters per year. This result made intuitive sense, because both young age and speed could favor strong mechanical coupling at the interface between the two plates (Figure 1c). Because oceanic lithosphere cools as it moves away from a ridge and ages, young lithosphere is less dense and thus more buoyant. Similar, faster subducting lithosphere should increase friction at the interface. The stronger coupling was, in turn, assumed to give rise to larger earthquakes when the interface eventually slipped in a great thrust fault earthquake. By using the model, the maximum expected earthquake size could be predicted.

This model was widely accepted until the 26 December 2004 magnitude 9.3 Sumatra earthquake that generated the giant Indian Ocean tsunami. According to the model, this trench should have generated at most a magnitude 8 earthquake. However, reanalysis found a quite different picture [*Stein and Okal,* 2007]. The newer data set differed for several reasons. Better rates of plate motion were available from new GPS data. Additional information on maximum earthquake sizes came from new observations, including paleoseismic estimates of the size of older earthquakes such as the 1700 C.E. event at the Cascadia subduction zone [*Satake and Atwater,* 2007]. Moreover, it was recognized that although the largest trench earthquakes are typically thrust fault events, this is not always the case. With the newer data the proposed correlation vanished, as the 2011 Tohoku earthquake subsequently confirmed (Figure 1d).

Thus, instead of only some subduction zones being able to generate magnitude 9s, it now looks like many or all can [*McCaffrey,* 2008].

The apparent pattern resulted from the fact that magnitude 9s are so rare, on average, fewer than one per decade [*Stein and Wysession,* 2003]. These are about 10 times rarer than magnitude 8s. Thus, the short seismological record (the seismometer was invented in the 1880s) misled seismologists into assuming that the largest earthquakes known on a particular subduction zone were the largest that would happen.

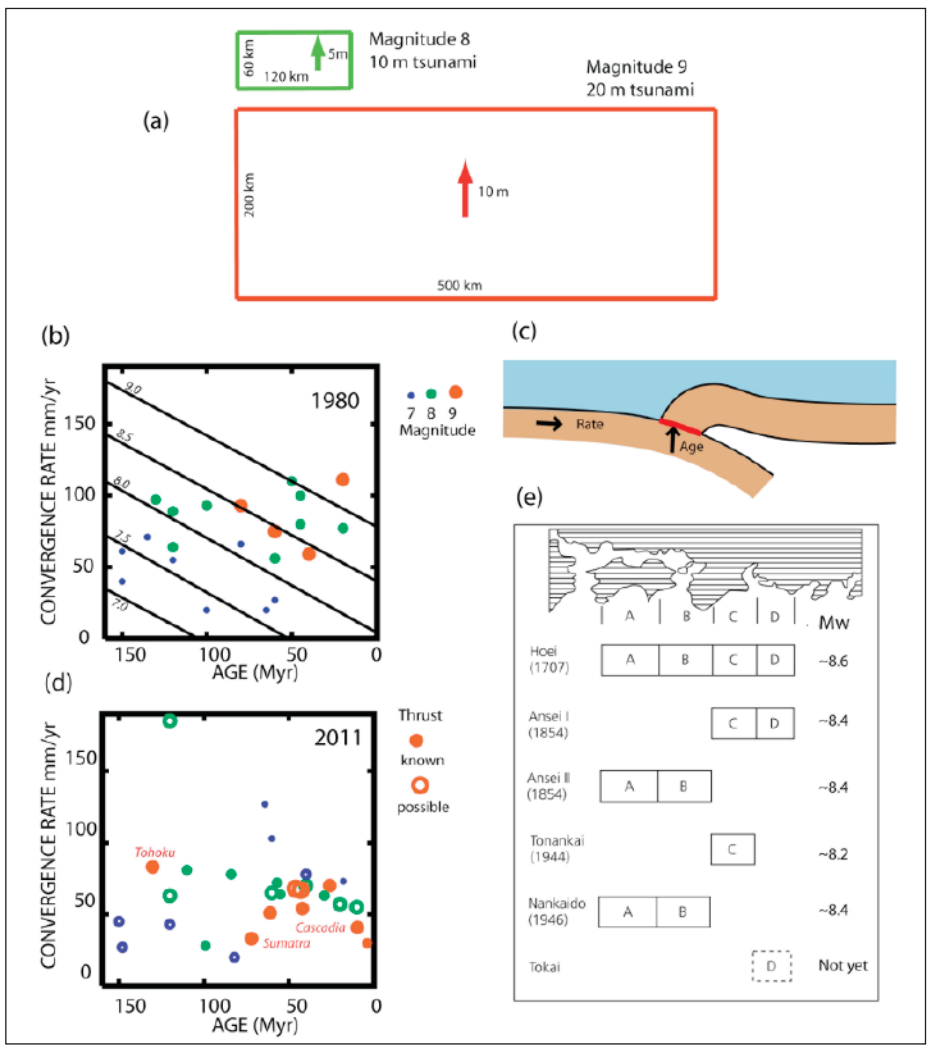

*Fig. 1. (a) Illustration of possible relative fault dimensions, average fault slip, and average tsunami runup for magnitude 8 and 9 earthquakes. (b) Data available in 1980 showing the largest earthquake known at various subduction zones. Magnitude 9 earthquakes occurred only where young lithosphere subducts rapidly. Diagonal lines show predicted maximum earthquake magnitude [*Ruff and Kanamori, *1980]. (c) Physical interpretation of this result in terms of strong mechanical coupling and thus large earthquakes at the trench interface. (d) Data available today, updated from* Stein and Okal *[2007] by including 2011 Tohoku earthquake. (e) Earthquake history for the Nankai trough area [*Ando, *1975] illustrating how the rupturing of different segments causes earthquakes of different magnitudes.*

This does not work, because subduction zone earthquakes rupture portions of a trench called segments. This effect is shown in Figure 1e for a portion of the trench south of Tohoku. Sometimes one segment ruptures, and other times more than one does. The more segments that rupture, the bigger the earthquake.

Thus, before December 2004, seismologists knew only of earthquakes with magnitude less than 8 [*Bilham et al.,* 2005] due to short ruptures along the Sumatra trench, making the much bigger multisegment rupture a surprise. Plate motion calculations show that earthquakes like 2004's would happen about 500 years apart [*Stein and Okal,* 2005], so the short history available did not include them. Paleoseismic studies have since found deposits from a huge tsunami about 600 years ago [*Monecke et al.,* 2008].

Similar variability is found at other trenches [*Satake and Atwater,* 2007]. For example, the 1960 magnitude 9.5 Chilean earthquake, the largest ever seismologically recorded, was a multisegment rupture much bigger than typical on that trench. Similarly, it appears that the very large Cascadia subduction zone earthquake in 1700 C.E. was a multisegment rupture and that smaller ones happen between the big ones [*Kelsey et al.,* 2005].

A striking comparison with Tohoku is what happens on the Kurile trench just to the north. The largest seismologically recorded earthquakes there are magnitude 8, which only account for about one third of the plate motion. Hence it had been assumed that most of the subduction there occurred aseismically [*Kanamori*, 1977].

However, more recently discovered deposits from ancient tsunamis show that much larger earthquakes had happened in the past [*Nanayama et al.,* 2003], accounting for much of the subduction that had been thought to

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occur aseismically. Thus, it is not surprising that the same thing just happened off Tohoku.

Seismologists recognized that large subduction earthquakes had occurred off Tohoku and would occur again [*Kanamori,* 1977; *Seno,* 1979]. Increasing attention was also being paid to data showing that large tsunamis had struck the area in 869 [*Minoura et al.*, 2001]., 1896, and 1933 C.E. GPS data were showing that the plate interface was accumulating more strain than would be expected if a large fraction of the subduction occurred aseismically [*Loveless and Meade*, 2010]. However, the revised ideas about maximum earthquake and tsunami size were new enough that they weren't fully appreciated. Moreover, it takes a long time for new scientific results to be translated into actual hazard mitigation practices. Usually, this is not a problem, because huge earthquakes are very rare. In this case, the devastating earthquake came too soon.

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—SETH STEIN and EMILE A. OKAL, Department of Earth and Planetary Sciences, Northwestern University, Evanston, Ill.; E-mail: seth@earth.northwestern.edu

ABOUT AGU

AGU Journals Increase in Importance According to 2010 Impact Factors

AGU journals continue to rank highly in many categories in the 2010 Journal Citation Report (JCR), which was released by Thomson Reuters on 28 June. JCR reports on several measures of journal usage, including a journal's Eigenfactor score, its Article Influence score, its Impact Factor, and its rank within a cohort of similar journals.

According to the 2010 statistics, AGU again has outperformed its larger competitors. Four different AGU titles are ranked in the top three journals in six different cohorts. The Impact Factor of several AGU journals increased significantly over the previous year.

The Impact Factor is calculated by dividing the number of citations in the JCR year by the total number of articles published in the 2 previous years. The Eigenfactor score is based on the number of times articles from the journal published in the past 5 years have been cited in the JCR year, but it also considers which journals have contributed these citations so that highly cited journals will influence the network more than lesser cited journals. The Article Influence determines the average influence of a journal's articles over the first five years after publication. It is calculated by dividing a journal's Eigenfactor score by the number of articles in the journal, normalized as a fraction of all articles in all publications.

Paleoceanography is a stellar performer in several categories; since 1995, *Paleoceanography* has been the top-ranked Paleontology category journal (of 48 titles in 2010) for Impact Factor (4.030). It holds the top rank for Article Influence in 2010, and it is second for Eigenfactor. In the Oceanography grouping (59 journals total), *Paleoceanography* ranks third in Impact Factor and Article Influence and moves up to fifth in Eigenfactor, this in a category where the number of journals increased by 18%.

Reviews of Geophysics, with an Impact Factor of 9.538 (an increase of 1.517 from the prior year's score of 8.021) ranks second in Geochemistry and Geophysics out of a total of 77 journals in this cohort. *Reviews* also ranks second in Article Influence. *Reviews* is joined in the top 20 Impact Factors in this cohort by *Geochemistry, Geophysics, Geosystems*, which is ranked tenth, and by *Tectonics*, which is ranked twelfth.

In the Geosciences, Multidisciplinary category, which includes 165 journals, AGU takes two of the top 10 slots and four of the top 20 slots in Impact Factor. *Global Biogeochemical Cycles* (*GBC*) moves up to fifth with an impact factor of 5.263, *Paleoceanography* remains eighth, *Geophysical Research Letters* (*GRL*) moves up to twelfth, and *Journal of Geophysical Research* (*JGR*) (all sections) moves up to fifteenth. AGU journals also stand out from the crowd when looking at other measures. *JGR* and *GRL* retain the top two spots in Eigenfactors, with *GBC* seventh and *Paleoceanography* twelfth. In the Article Influence scores, fourth and fifth place belong to *GBC* and *Paleoceanography*, with *GRL* ninth and *JGR* fourteenth. In this cohort, AGU holds 3% of the titles, publishes 23% of the articles, and garners 39% of the citations.

Water Resources Research (*WRR*) climbs to second place in the Water Resources group, which has a cohort of 76 titles, 10 more than in 2009; *WRR* ranks second in both Article Influence and Eigenfactor. *WRR* ranks second in another cohort, Limnology (18 titles), where the journal is ranked first in Eigenfactor and second in Article Influence.

These rankings are one indication of the excellent quality of the journals published by AGU. The journal editors and the AGU Publications Division staff remain dedicated to continuing this level of excellence and to continually improving the quality of AGU journals.

—BILL COOK, Director of Publications, AGU; E-mail: wcook@agu.org

Earth and Space Science Funding at Risk

With debt ceiling deadlines quickly approaching, U.S. lawmakers are still markedly divided over how to address the nation's economic and budgetary troubles. AGU is closely monitoring these debates and any cuts directed at funding for scientific research and development. Cuts beyond the already reduced levels from the current fiscal year 2011 continuing resolution have the potential to be devastating not only for the scientific community but also for the health, safety, and welfare of the public and America's economic competitiveness.

It is not clear how the current proposals would apply to cutting scientific research and development, but it is very likely that federal funding levels for fiscal year 2012 will be even lower than those seen in 2011, a trend that could continue for a number of years. The Obama administration and congressional leadership are reported to be negotiating up to $4 trillion in reduced expenditures, with cuts of at least $1.1 trillion being made in discretionary appropriations over the next 10 years, starting in fiscal year 2012. While it is possible that a smaller, interim deal could pass, which would bring another debt ceiling vote before November 2012, there is significant opposition to such a stopgap measure.

For several weeks, AGU has been actively communicating with Congress and the administration in an effort to educate key decision makers on the important role investing in science can and should play in America's economic stability and national security. This effort has also included coordinated outreach to members across the country, encouraging them to contact their legislators and local media to express concerns about the current threats to science funding. For more information on these efforts, including ways for AGU members to get involved, visit http://www.agu.org/sci_pol/.

—JOAN BUHRMAN, Manager, Strategic Communications, AGU; E-mail: jbuhrman@agu.org

Bowring and Keppler Receive 2010 N. L. Bowen Awards

Samuel Bowring and Hans Keppler each received the 2010 N. L. Bowen Award at the 2010 AGU Fall Meeting, held 13–17 December in San Francisco, Calif. The award recognizes "outstanding contributions to volcanology, geochemistry, or petrology."

Citation for Samuel Bowring

It is a pleasure to recognize Sam Bowring, whose career achievements have been focused on a better understanding of Earth history. Bowring's groundbreaking studies of the early Earth include the discovery and interpretation of the >4.0 Ga Acasta gneisses and the demonstration of how cratons are assembled and stabilized based on integrated mapping, geochronology, radiogenic isotope geochemistry, and xenolith studies.

The Acasta gneisses, discovered by Bowring, are still the oldest recognized rocks on Earth and preserve clear evidence for its early differentiation. He was able to show that the Acasta gneisses are not anomalous with respect to either other Archean rocks or Proterozoic and Phanerozoic continental arc rocks. This interpretation required that massive crust-mantle differentiation occurred early, which in the late 1980s was considered a radical departure from the conventional view. Bowring's original work should now be viewed as seminal in our understanding of the Earth's early differentiation.

In subsequent work on the stabilization of cratons he turned his attention to regional studies of the Proterozoic orogenic belt of the U.S. Southwest and the Kaapvaal craton of southern Africa, in addition to the Slave craton. An important aspect of understanding the stabilization of cratons concerns their thermal evolution, and thermochronologic studies of lower crustal xenoliths were used to deduce their thermal histories, from assembly to growth of a cold, buoyant lithospheric root.

In summary, Sam Bowring is a pioneer in this field who has left an indelible mark on our understanding of the history of Earth and its biosphere. Sam, along with his students and postdocs, has amassed a compelling wealth of data that chronicles the processes and history of events involved in differentiation of the early Earth. Norman L. Bowen, dedicated experimentalist who cut his teeth on Precambrian rocks in the Canadian Shield, would surely applaud Sam Bowring's receipt of the Bowen Award.

—JOHN P. GROTZINGER, California Institute of Technology, Pasadena

Response

Thanks, John, for the generous words. I met John on the shores of a mosquito- and black fly–infested lake in Wopmay orogen more than 30 years ago, and I was very happy to present today our most recent results from Wopmay. John, Kip Hodges, Tom Jordan, and Tim Grove convinced me to come to Massachusetts Institute of Technology (MIT), and I am still here, and grateful for my stimulating colleagues.

I arrived at the University of Kansas to work with Randy van Schmus, but before starting any work, I spent what was supposed to be 2 weeks with Paul Hoffman, Randy, and Robert Hildebrand in northwestern Canada—that turned into 6 weeks, and then another 10 or so field seasons. Randy taught me about mass spectrometers and isotope geochemistry, and Paul tutored me in plate tectonics, orogenic belts, baseball, politics, and music.

Any success I may have had is due to the amazing group of graduate students and postdocs from whom I have learned. My graduate students at Washington University, the late Todd Housh, Kevin Chamberlain, Ann Heatherington, Clark Isachsen, Jesse Dann, and Mike Villeneuve kept the lab lively. At MIT, Mark Schmitz, Dave Hawkins, Julie Baldwin, Becky Flowers, Blair Schoene, Anke Friedrich, and Karen Viskupic were instrumental in pushing me in new directions, and my current group, including Noah McLean, Seth Burgess, Terry Blackburn, and Erin Shea, exerts relentless pressure on me to keep up. Postdocs and research scientists Dan Condon, Drew Coleman, Matt Rioux, Jahan Ramezani, Jim Crowley, Mark Martin, Frank Dudas, and Robert Buchwaldt have been a pleasure to work with, and together we have explored some very exciting science.

Thanks to the VGP Bowen Award Committee and AGU for this award and all those who have supported me over the years. I am truly honored.

—SAMUEL A. BOWRING, Massachusetts Institute of Technology, Cambridge

Samuel Bowring

Citation for Hans Keppler

Hans Keppler and his research have profoundly influenced our understanding of the physical and chemical properties of fluids in Earth's interior, their interactions with melts and solids, and their controlling influence on geochemical budgets and material properties, all with a global perspective.

In his research, Hans combines experimental innovation with technical skill to pursue in situ observations of critical phenomena and in situ measurements of properties of nonquenchable materials. One of Hans's important contributions has been measuring and systematizing bulk hydroxyl/water solubility in important minerals in

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the upper mantle and transition zone. He combined these data on individual minerals into a model for the maximum water content of rocks at these depths. In a recent paper in *Science* he elegantly provided an explanation for the existence of the asthenosphere by considering the water budget, an approach that explains the rather sharp upper boundary of the asthenosphere combined with a relatively diffuse lower boundary.

In closing, let me return to my opening comment, namely, that Hans and his research have had an impact on our science. About 15 years ago, I had the good fortune to spend a year in Bayreuth working with Hans and Dave Rubie. Being 20 years older than Hans, I thought I would be the teacher and he the student. Not so. I remember clearly working through some aspects of thermodynamics as applied to our research. It was absolutely clear to me that Hans knew the answers to the questions with which I was struggling. It was Hans who was the teacher and I the student, as he patiently led me to discover the answers for myself and, in so doing, helped me embrace a much deeper understanding than would have been possible had he simply provided the resolution without my participation in the process.

—DAVID KOHLSTEDT, University of Minnesota, Minneapolis

Response

Thank you, David, very much indeed. Naturally, I feel deeply honored by the Bowen award, for two reasons. One is that the award is named after Norman Bowen, with whom I share many common beliefs, such as the belief in the need to carefully study simple systems and to fully understand the physicochemical principles behind Earth processes. The other is that this is an award of AGU. I owe a lot to America, and I would not be the person I am had I not spent 2 years as a postdoc at California Institute of Technology, working with Peter Wyllie and also with George Rossman.

In later years I benefited enormously from working with several people. I could now mention many names, but I will just mention two: Andy Shen, who introduced me to externally heated diamond anvil cells, and, of course, David Kohlstedt, who showed me the importance of water in olivine. When David came to Bayreuth, it was around the time of his fiftieth birthday. I looked at him and thought, "Wow, I have never seen anything like this before—a professor who is 50 years old and who is still doing his experiments all by himself!" This apparently left a long-lasting impression on me; today, my fiftieth birthday is not so far away, and I am still sometimes doing experiments all by myself—I hope that Norman Bowen would not be too disappointed about the way I do my experiments.

Hans Keppler

Thank you all again!

—HANS KEPPLER, Bayerisches Geoinstitut, Bayreuth, Germany

Dufek and Rust Receive 2010 Hisashi Kuno Award

Josef Dufek and Alison Rust each received the Hisashi Kuno Award at the 2010 AGU Fall Meeting, held 13–17 December in San Francisco, Calif. The award recognizes "accomplishments of junior scientists who make outstanding contributions to the fields of volcanology, geochemistry, and petrology."

Citation for Josef Dufek

It gives me great pleasure to introduce one of the Kuno Award recipients for 2010: Joe Dufek. Because his research work and his reputation precede him, most of you already know of Joe, which makes my task easier. Barely 4 years from completion of his doctoral work with George Bergantz at the University of Washington, Seattle, Joe has already published important and seminal work in the fields of volcanology and petrology. He's written on a wide diversity of subjects including particle-particle collisions and their effects on flow in volcanic conduits; the interaction between mafic dike injection and melting of the lower crust; multiphase transport processes of pyroclastic flows including the tracking and fate of individual phenocrysts; and thermomechanical coupling of crustal dynamics to magma chamber processes. Throughout, Joe has demonstrated that he is one of those rare Earth scientists who not only can recognize an important geologic problem but also knows how to investigate that problem in the field and how to creatively formulate and execute a model that contains enough physics and chemistry to generate results that are testable against observation. Joe has raised the bar in modeling pyroclastic eruption dynamics, and through the Kuno Award, the volcanology, geochemistry, and petrology (VGP) community has recognized the importance and relevance of his work in understanding the rock record. But, in addition to his research record, Joe is also well known for his modest character, his generosity of intellect, and his enthusiasm for sharing in collaborative research. Fellow VGP members, it is my honor and privilege to present Joe Dufek, this year's corecipient of the Hisashi Kuno Award.

—MARK S. GHIORSO, OFM Research, Inc., Seattle, Wash.

Response

Thank you, Mark, the Kuno committee, and the VGP community. I feel very fortunate. I have had the chance to interact with many excellent scientists over the past decade, and I really owe them a debt of gratitude.

While I was an undergraduate at the University of Chicago, Ray Pierrehumbert introduced me to the world of fluid dynamics. I also had the great fortune to meet Fred Anderson and started working in his lab. I cannot thank Fred enough for his patient explanations. Through Fred I was given the opportunity to interact with many excellent people at a young age, including Paul Wallace and Youxue Zhang.

During graduate school at the University of Washington, George Bergantz taught me a great deal about science and multiphase flow as we examined problems in the lower crust and eruption dynamics. While in Seattle, Mark Ghiorso, Olivier Bachmann, Ron Merrill, Kari Cooper, Stu McCallum, and Chris Newhall all were very influential to me, as were my excellent graduate cohorts.

I had the great luck to join the Miller postdoctoral program at University of California, Berkeley following graduate school, and my continuing collaboration with Michael Manga has been very fulfilling. Berkeley also introduced me to several amazing young scientists, two of whom, Chris Huber and Leif Karlstrom, have become close collaborators.

Over the past years I have had the opportunity to collaborate with many people who have taught me much, including Guil Gualda, Mark Ghiorso, Mark Jellinek, Bill Leeman, Dennis Geist, Karen Harpp, and Rob Lillis, among others. My colleagues at Georgia Institute of Technology have been absolutely supportive, and I thank my students who work hard and have much potential.

Mostly, I want to thank my parents and brother for their support, and my wife, Carol Paty, who has learned more geology and carried more rocks than she probably bargained for.

Josef Dufek

—JOSEF DUFEK, Georgia Institute of Technology, Atlanta

Citation for Alison Rust

Alison Rust is an igneous petrologist and physical volcanologist whose work has addressed some of the most basic processes that govern the generation, ascent, and eruption of magma. This includes the rheology of bubbly magma; how to determine deformation rate and history of magmas using microstructures; measurements and models of the permeability of pumice; degassing of magma and, in particular, the coupled degassing and brecciation of magmas; convection in magmas that have a yield strength; and the generation of seismic waves by flow through channels and conduits.

This range of topics is remarkable. More impressive, however, is the broad range of approaches she uses to answer these fundamental volcanological questions: lab experiments, analytical geochemistry, fieldwork, numerical modeling, and developing theoretical models. Especially noteworthy is her clever and insightful use of analog experiments to make the key link between observations and theory.

Moving beyond incremental advances in igneous petrology often requires quantitative integration of observations, experiments, and models coupled with a healthy dose of creativity and a willingness to question standard ideas. These are attributes Alison has demonstrated with her past work, and we look forward to more in the future.

Alison Rust

—MICHAEL MANGA, University of California, Berkeley

Response

It is an honor and a pleasure to receive the Kuno Award. There are, of course, so many people who deserve thanks, but I am especially indebted to my four enthusiastic advisors while I was a graduate student and postdoc: Kelly Russell, Michael Manga, Kathy Cashman, and Neil Balmforth. They were all very supportive but also gave me the space and freedom to make my own mistakes. I would like to thank Kelly for his contagious enthusiasm; Michael for his pithy, wise words; Kathy for bouncing ideas off everything; and Neil for teaching me things I didn't know I wanted to know.

I have landed at the University of Bristol, which is a remarkable environment in which to continue to develop as a researcher, although sometimes it's hard to get any work done with all the interesting discussions (thanks, Luca). I hope I can continue to find enjoyable collaborations and generate quality research worthy of the expectations of an early-career award.

—ALISON RUST, University of Bristol, Bristol, UK

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POSITIONS AVAILABLE

Atmospheric Sciences

Postdoctoral Position in School of Engineering and Applied Sciences/Harvard University. A postdoctoral position is available at Harvard University (visit us at http://acmg.seas.harvard.edu/people/faculty/mbm/index.html). The successful candidate will work on issues relating to the integration into the electric grid of renewable sources of energy notably wind and solar. Particular interest in an individual with experience with how the existing grid operates and how it might be enhanced to accommodate these sources. Applicants should have a Ph.D. in energy related science or related field. Please email a curriculum vitae, contact information for three references, and 1-paragraph statement of interest to Prof. Michael B. McElroy (mbm@seas.harvard.edu), School of Engineering and Applied Science, Harvard University. Harvard University is an equal opportunity/affirmative action employer.

Postdoctoral Scholar in Climate Change Science at UCLA. The University of California Los Angeles (UCLA) Department of Atmospheric and Oceanic Sciences seeks a postdoctoral scholar in the area of climate feedbacks. The postdoctoral scholar will collaborate with Professor Alex Hall. The project involves quantifying feedbacks in climate change simulations and constraining them with observations. It could also involve analyses of simulated and observed climate variability. The position is nominally for one year, though it is renewable for a period of up to three years subject to satisfactory annual progress. Applicants should have a Ph.D. in Atmospheric and Oceanic Sciences or a related field, and strong oral and written communication, analytical, and programming skills.

To apply, please submit via e-mail a brief statement of research interests and goals, with a complete CV, and contact information for three references to Dr. Xin Qu at xinqu@atmos.ucla.edu. Receipt of applications will be confirmed with an e-mail response.

The application deadline is Monday, 15 August 2011.

For further information about Professor Hall's research, please visit his website at: http://www.atmos.ucla.edu/csrl/.

Research Associate Professor, Department of Atmospheric Sciences, University of Washington. The Department of Atmospheric Sciences at the University of Washington invites applications for a full-time Research Associate Professor in the area of remote sensing and related applications. This is a non-tenure track, permanent position that is contingent upon available funding. Applicants must hold a Ph.D. in a relevant field and must have more than five years of professional research experience by the start of the appointment and a demonstrated publication record in relevant peer-reviewed journals. Research professors are expected to develop an externally funded research program so an applicant must have a proven record of obtaining external funding. Additionally, while the candidate will be primarily engaged in research activities, all University of Washington faculty members may engage in teaching, research and service.

The successful candidate's research will focus on atmospheric remote sensing and the application of remote sensing data to the evaluation of global climate model physics, particularly cloud and aerosol properties. Research expertise must be demonstrated in (1) development of remote sensing retrieval algorithms using either, or both, ground and satellite instruments with a specific emphasis on the use of new technologies such

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as millimeter-wavelength radar; (2) application of remotely sensed data and data products to the evaluation of atmospheric models, particularly global climate models, in innovative ways that take full advantage of the capabilities of current instrument technology; and (3) development of new model physics based on model evaluation results. Expertise in instrument design and technology will be seen as an additional strength.

The Department of the Atmospheric Sciences resides in the newly formed College of the Environment, which fosters collaborations between the faculty, staff, and students engaged in the study of environmental sciences, engineering, and the human dimensions of environmental challenges. This position will offer opportunities for interaction with researchers in a wide range of disciplines, including oceanographers, hydrologic scientists, and polar scientists.

Applicants should supply a curriculum vitae and names and contact information of at least 3 professional references. Please submit your application packet either electronically (preferred) or hard copy by mail to the search chair Professor Qiang Fu via Debra Wolf at debbie@atmos.washington.edu, Department of Atmospheric Sciences, University of Washington, Box 351640, Seattle, WA 98195-1640. Send queries about the position to Professor Qiang Fu, search chair at qfu@atmos.washington.edu. Consideration of applications will begin immediately and continue until the position is filled. Priority will be given to applications received before August 12, 2011.

The University of Washington is an Affirmative Action, Equal Opportunity Employer. The University of Washington faculty engages in teaching, research and service. The University of Washington is committed to providing access and reasonable accommodation in its services, programs, activities, education and employment for individuals with disabilities. To request disability accommodation in the application process, contact the Disability Services Office at least ten days in advance at: 206.543.6450/V, 206.543.6452/TTY, 206.685.7264 (FAX), or dso@u.washington.edu.

Geochemistry

Laboratory Research Technician, (Stable Isotope Laboratory). Applications are invited for a full-time laboratory research technician (Stable Isotope Laboratory) at Tulane University, New Orleans. Duties will include operation and maintenance of a gas ratio mass spectrometer and semi-automated gas separations line, isotopic analysis (carbonates, sedimentary organic matter, and water), and general laboratory supervision (database management, inventory, and student usage scheduling). Opportunities to pursue both collaborative and independent research will exist.

Applicants should have experience in stable isotope techniques and/or high vacuum systems.

Please apply through https://tulanejobs.tulane.edu (Search "technician," "isotope.") Review of applications will begin immediately.

Tulane University is an EEO/AA employer.

Postdoctoral Fellow-Deep Carbon Observatory, Carnegie Institution of Washington. We invite applications for a postdoctoral research position applying radiogenic isotope and ion microprobe methods to investigate the origin and systematics of water, carbon and other volatiles in Hawaiian volcanoes. This research project will compare the radiogenic isotope geochemistry (Os, Sr, Nd, Pb, Hf, He) of Hawaiian shield volcanoes with their magmatic water and carbon contents obtained from submarine glasses and melt inclusions. Some field work will be required. The project is funded by a pilot grant from the Reservoirs & Fluxes Directorate of the Deep Carbon Observatory initiative (https://dco.gl.ciw.edu/), and the funding is for two years. Experience in clean lab techniques and SIMS, TIMS or ICPMS methods is highly desirable. To apply, please send CV, contact information, and names of at least two references familiar with your work to Erik Hauri by email (ehauri@ciw.edu); we will continue to accept applications until the position is filled. The Carnegie Institution of Washington is an equal opportunity educator and employer.

Postdoctoral Fellow-Deep Carbon Observatory, Carnegie Institution of Washington. We invite applications for a Deep Carbon Observatory postdoctoral fellowship position applying ion microprobe and FTIR analyses to investigate the flux of magmatic carbon delivered to the Earth's surface at mid-ocean ridges. The position is part of a collaborative project between Erik Hauri (Department of Terrestrial Magnetism/Carnegie Institution), Elizabeth Cottrell (National Museum of Natural History, Smithsonian Institution) and CNRS-Nancy, France. The project is funded from a pilot grant from the Reservoirs & Fluxes Directorate of the Deep Carbon Observatory initiative (https://dco.gl.ciw.edu/). The post-doc will be employed by DTM and the Smithsonian Institution to conduct SIMS analyses of CO_2 and other volatiles in ~700 MORB glasses, and volatile speciation (FTIR, Smithsonian) and carbon isotope analyses (SIMS, Nancy, France) on a subset of the same

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samples. Funding is for two years. Experience in SIMS, TIMS or ICPMS techniques is highly desirable. For further information, contact Erik Hauri (ehauri@ciw.edu) or Elizabeth Cottrell (cottrelle@si.edu). To apply, please send CV, contact information, and names of at least two references familiar with your work to Erik Hauri by email; we will continue to accept applications until the position is filled. The Carnegie Institution of Washington and the Smithsonian Institution are equal opportunity educators and employers.

Postdoctoral Fellowships in Geochemistry. Applications are solicited for two positions in the Department of Geoscience at the University of Wisconsin-Madison. A Ph.D. is required. One position is focused on stable Fe isotope studies of aqueous Fe interactions with clays and oxides; applications are sought from individuals from material science, chemistry, and geology who have experience in experimental studies. The second position involves stable and radiogenic isotope studies of natural materials using femtosecond laser ablation (LA) and MC-ICP-MS; applications are sought from isotope geochemists with a research record in low- or high-T geochemistry with prior experience in LA work. Both positions are available immediately, with an appointment of 1-3 years. Inquiries and applications should be sent to Prof. Clark Johnson (clarkj@geology.wisc.edu). Electronic submission of applications is preferred and should include a CV, copies of three publications, and contact information for four references. Positions will remain open until filled.

Postdoc Researcher in Boreal/Arctic Ecosystem Modeling and Abrupt Climate Change

The Earth Sciences Division at the Lawrence Berkeley National Laboratory is seeking a post-doctoral researcher to join our team studying the potential for abrupt climate change in the Arctic (http://esd.lbl.gov/research/projects/abrupt_climate_change/impacts/).

The post-doctoral researcher will improve and apply static and dynamic vegetation and biogeochemical models. The research will be performed within a team that studies coupled land-surface and climate interactions at regional, circumpolar, and global scales. Analyzing feedbacks between the atmosphere and terrestrial biosphere will be an important component of the research. The position is in collaboration with researchers at the Lawrence Livermore National Laboratories, the National Center for Atmospheric Research, and U.C. Berkeley.

The work will require an applicant with a wide range of skills, including: (1) ability to develop representations of vegetation and inter-related terrestrial ecosystem processes suitable for regional to global scale models; (2) use of state-of-the-art land-surface biogeochemical models (preferably CLM); (3) development and use of coupled atmosphere and land-surface models; (4) oral and written presentation of results; and (5) ability to work in a large and integrated team.

The applicant should have a recent Ph.D. in biogeophysics, biometeorology, hydrology, or closely related field.

Notes: This is a one-year term appointment with the possibility of renewal based on performance and continuation of funding. Salary is $5100/month. Should be available to start as soon as possible. Review of applications will begin immediately and continue until position is filled.

BERKELEY LAB
Lawrence Berkeley National Laboratory

To apply for this position, please visit **http://jobs.lbl.gov**
Search for job number 73245

Berkeley Lab is an affirmative action/equal opportunity employer committed to the development of a diverse workforce.

Stable Isotope Lab Manager, Yale University, New Haven, CT, http://earth.geology.yale.edu/escsis/. Yale University seeks a Stable Isotope Lab Manager to manage the operation and maintenance of a state-of-the-art multi-use isotope center. You will collaborate with principal investigators and students in method development, sample analyses, and data interpretation. You will also provide input in the form of technical guidance and direction on various phases of isotopic research.

Qualified candidates will possess a master's degree in a scientific discipline and 3 years of experience in a stable isotope laboratory. Experience running mass spectrometers or related analytical chemistry equipment required. Broad knowledge of instruments and research techniques, and prior experience managing standards and protocols for each instrument and technique in a facility also required. Must have good communication, time management, and people skills with the ability to teach users how to prepare and run samples, and reduce data into a useable form.

To learn more about this outstanding opportunity at Yale University, visit www.yale.edu/jobs and apply online using STARS requisition ID 13273BR. Yale University is an Affirmative Action/Equal Opportunity Employer.

Hydrology

Post-Doctoral Fellow-Ecohydrology of Mountain Meadows. Stanford University's Dept. of Environmental Earth System Science seeks applications for a post-doctoral fellow in ecohydrologic analysis of mountain meadow systems. The project involves development of regional and local-scale hydrologic and hydrogeologic models to better understand plant-water interactions, analyze the influence of climate change and snow accumulation as affected by forest density on downstream water availability, and quantify ecosystem services provided by meadows and surrounding regions. Understanding the impact of climate change on near-surface hydrologic response is a key research goal. The post-doctoral fellow will analyze field data and remote sensing imagery, apply existing hydrologic models, and develop ecohydrologic models to quantify influences on the regional water balance and explore the impacts of climate change on meadow hydrology. Applicants must have a demonstrated ability to generate new research questions, deal with large spatial data sets, and conduct hydrologic modeling investigations.

Stanford University is an equal opportunity employer and is committed to increasing the diversity of its staff. It welcomes nominations of and applications from women and minority groups, as well as others who would bring additional dimensions to the university's research, teaching and clinical missions.

Interested applicants should email a CV, college and graduate transcripts, one relevant publication, a one-page statement of past and present research goals, and the names and addresses of three references to Professor Steven Gorelick (gorelick@stanford.edu) by July 29, 2011.

Ocean Sciences

Post-Doctoral Position in Physical Oceanography. The successful applicant to this 2 year position will participate in a comprehensive research program that integrates the analysis of satellite-derived data of the ocean surface with in situ observations of the vertical structure in the ocean and analysis of model output from two OGCMs, HYCOM and ECCO-2, to study the quasi-zonal banded structures that we and others have observed in all mid-latitude oceans. Process oriented numerical modeling experiments that test various theoretical hypotheses for the existence of these banded structures will be a central component of the research. The program, directed by Professors Cornillon and Rothstein, also includes 2 Ph.D. students.

To apply and view complete details for this position visit: https://jobs.uri.edu, job posting #6000480. Review of applications will begin 18 July 2011 and continue until the position is filled.

Science Center Director, U.S. Geological Survey, Pacific Southwest Area, Pacific Coastal and Marine Science Center. The U.S. Geological Survey (USGS) invites applications for a full-time permanent position located in Santa Cruz, California. The USGS seeks an established scientist of national reputation with demonstrated ability to develop, lead, and administrate a coastal and marine research center. The Pacific Coastal and Marine Science Center conducts a broad spectrum of research to develop scientific understanding of coastal and marine geologic systems of interest to the Nation as they affect the health, safety and welfare of the public. Ph.D. or equivalent experience is required. Candidates need a strong background in the use of state-of-the-art approaches and technologies in marine research focused on processes and mapping in deepwater and coastal seafloor environments. Candidates need to be knowledgeable in the use of state-of-the-art acoustic, optical, and other seafloor and coastal mapping technologies. Familiarity with data analysis and digital geologic map (GIS database) construction is advantageous. For detailed vacancy announcement, including specific qualification requirements and application procedures for this opportunity go to: http://www.usajobs.gov/. Applicants must be United States Citizens to apply.

Refer to: Vacancy Announcement: WR-2011-0070 open to all U.S. citizens, WR-2011-0071 open only to current/former Federal employees

Deadline for applications: July 25, 2011 The USGS is an Equal Opportunity Employer.

Solid Earth Geophysics

Postdoctoral Position in Exploration and Environmental Geophysics. The Applied and Environmental Geophysics Group at ETH (Swiss Federal Institute of Technology) has an immediate opening for an ambitious and talented scientist at the post-doctoral or senior researcher level. The appointment will be for an initial period of two years with the possibility of extension for up to 6-8 years. We invite applicants conducting world- leading research in areas of applied geophysics including wave-equation based modeling and inversion methods and/or innovative applications in the field of exploration and environmental geophysics.

Regional-scale Earth System Modeling Post-Doctoral Positions Available

A partnership of universities and agency affiliates seeks post-doctoral associates for interdisciplinary research on the coupled land-atmosphere-aquatic environmental and economic systems of the Northeastern U.S. Focus is on regional system dynamics with respect to energy demand and production, biofuels and land use, water pollution, ecosystem services and economic sustainability. The work considers a century timeframe, from contemporary to future, through application of regional economic, environmental policy, technology adoption, and broader global change scenarios. Positions are supported by a grant from the National Science Foundation to enable successful candidates to further develop their strengths within the context of a major national effort to forward regional integrated modeling. A three-year commitment to complete the work and publish results is expected. Capacity to work in a large and diverse team at several professional levels, from students through senior scientists, is essential.

Qualifications: Eligible candidates should have a recent PhD. Please apply directly to one of the collaborating institutes below, with subject line: "**Post-doctoral Position--Regional Modeling**". Include curriculum vitae, statement of research interests and contact information for three references.

- **CUNY Environmental CrossRoads Initiative:** Integrated assessment models; hydrology; atmospheric physics or chemistry, simulation frameworks; experience in model-building, data infrastructure, GIS, and/or computer programming. *Contact: Prof. C. Vörösmarty <crossroads@ccny.cuny.edu>.*
- **Ecosystems Center, Marine Biological Lab (Woods Hole)**: Terrestrial biogeochemistry modeling; experience in model building, data management and GIS. *Contact: Dr. J. Melillo <jmelillo@mbl.edu>.*
- **Rensselaer Polytechnic Institute**: Economic modeling, especially input-output data and models; environmental applications; data management, GIS, and/or computer programming. *Contact: Prof. F. Duchin duchin@rpi.edu*
- **University of New Hampshire:** Aquatic biogeochemistry and ecosystem services modeling. *Contact: Prof. W. Wollheim <wil.wollheim@unh.edu>.*
- **Brookhaven National Laboratory:** Energy systems modeling and analysis, long-term energy, environment and economic planning and policy, energy-water-climate change nexus. *Contact: Mr. V. Bhatt <vbhatt@bnl.gov>.*

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TENURE-TRACK FACULTY POSITION AVAILABLE in APPLIED GEOPHYSICS
Department of Geological Sciences and Geological Engineering, Queen's University

The Department of Geological Sciences and Geological Engineering at Queen's University, seeks individuals with outstanding research and teaching capabilities to apply for a tenure-track position, starting on January 1, 2012, or July 1, 2012, as an Assistant Professor in Applied Geophysics. The successful candidate will hold a P.Eng., or will be eligible to apply for a P.Eng., immediately by virtue of having graduated from an accredited engineering program. The candidate will build on the existing applied geophysics program which is focused in the Geological Engineering program, but is of interest to students in Geological Sciences and other departments at Queen's. The candidate is expected to carry on an active, externally funded research program of international calibre and to supervise graduate students at the M.Sc. and Ph.D. levels. A willingness to engage in collaborative research with Departmental colleagues will also be considered in the selection process. For more information about faculty research interests, the full range of undergraduate and graduate teaching programs, and our laboratory facilities, visit www.geol.queensu.ca.

The University invites applications from all qualified individuals. Queen's University is committed to employment equity and diversity in the workplace and welcomes applications from women, visible minorities, aboriginal people, persons with disabilities, and persons of any sexual orientation or gender identity. All qualified candidates are encouraged to apply; however, Canadians and permanent residents will be given priority. Academic professionals at Queen's University are governed by the *Collective Agreement* between the Queen's University Faculty Association (QUFA) and the University, which is posted at http://www.queensu.ca/vpac/FacultyRelations/CollectiveAgreements.html. Remuneration will be in accordance with the *Collective Agreement*, which considers qualifications and experience.

Applications should include a complete and current curriculum vitae, letters of reference from three (3) referees of high standing, a statement of teaching experience, a statement of research interests and future plans, and samples of research writing. **Please arrange to have applications and supporting letters sent directly to: Dr. D.J. Hutchinson, Head, Department of Geological Sciences and Geological Engineering, Queen's University, Room 240 Bruce Wing, Kingston Ontario Canada K7L 3N6**. Applications will be accepted until August 26, 2011, or until a suitable candidate is identified. The final appointment is subject to budgetary approval.

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The successful candidate will be expected to (i) initiate and perform his/her own research projects; (ii) co-supervise undergraduate- and graduate-level thesis projects; and (iii) contribute to the teaching of applied, engineering and environmental geophysics courses. In particular, he/she will participate in the teaching of the IDEA League Joint Master's Programme in Applied Geophysics (http://www.idealeague.org/geophysics). Good knowledge of English is essential and, although not essential, basic understanding of German is an advantage. At the time of the appointment, the successful candidate must have a doctoral degree in geophysics or a related subject.

We can offer a dynamic work-place with access to excellent computational facilities, a broad range of state-of-the-art geophysical equipment and data. ETH offers world-class high performance computing (HPC) facilities. In addition, our group owns dedicated HPC hardware, which will be significantly expanded in the near future. The Applied and Environmental Geophysics Group at ETH Zurich is embedded in a vibrant Earth Science department, which will offer many opportunities for collaborative projects.

Interested candidates should send their Curriculum Vitae and the names and addresses of three referees by August 15, 2011 to: Prof. Dr. Hansruedi Maurer Institute of Geophysics ETH-Zürich Sonneggstrasse 5 CH-8092 Zurich, Switzerland maurer@aug.ig.erdw.ethz.ch

More information on the ETH Applied and Environmental Geophysics Group can be obtained at http://www.aug.geophys.ethz.ch.

STUDENT OPPORTUNITIES

Graduate Student Assistantship, Aquatic Biogeochemistry and Microbial Ecology. A graduate research assistantship is available at Portland State University, Oregon, in the area of aquatic biogeochemistry and microbial ecology. The candidate will take part in an NSF funded project to assess the role of coastal wetlands on the emission of methyl halides to the atmosphere. The primary study site is the Florida Everglades. The candidate will be part of the Department of Biology graduate program but there will be ample opportunities to interact with faculty from the Department of Physics. Interested students should contact Dr. Ronald Jones at jonesrd@pdx.edu.

SERVICES, SUPPLIES, COURSES, & ANNOUNCEMENTS

United States Polar Rock Repository. Rock samples are available as no-cost loans for research, teaching & museum use. http://bprc.osu.edu/emuwebusprr.

BGI Bayerisches Geoinstitut

UNIVERSITÄT BAYREUTH

Full Professorship (W3) in Experimental Earth Sciences

The position is available from October 1, 2011. We are looking for an internationally renowned scientist from the fields of experimental geochemistry, experimental geophysics, and materials science. Applications from related and emerging new areas, such as high-pressure geomicrobiology or research in planetary materials by advanced analytical methods are also encouraged. Research activities should make a major contribution towards understanding Earth and planetary interiors. The successful applicant will be expected to participate in teaching, particularly in the education of graduate students, in the Master Course "Experimental Geoscience" and in basic courses for geoecology students. A strong commitment to the development of international cooperation is expected.

In addition to a Ph. D., applicants should have appropriate experience in research and teaching. Candidates must be less than 52 years old upon appointment. Women and handicapped people are especially encouraged to apply.

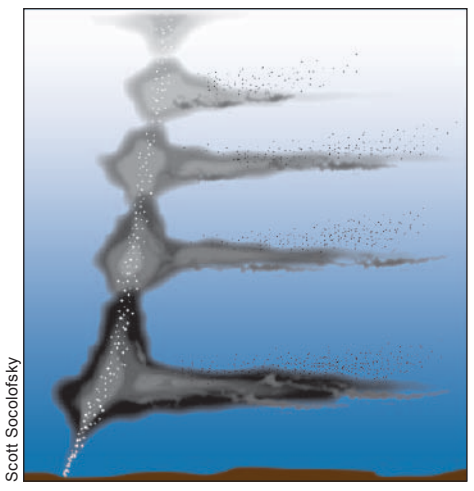
Applications, accompanied by a curriculum vitae, publication list, copies of university certificates, a statement on teaching experience and an outline of proposed research should be sent before July 31, 2011 to the Dekan der Fakultät für Biologie, Chemie und Geowissenschaften der Universität Bayreuth, 95440 Bayreuth, Germany.

RESEARCH SPOTLIGHT

Highlighting exciting new research from AGU journals

Formation of oil and gas intrusions after the Deepwater Horizon oil spill

After the Deepwater Horizon oil spill in 2010, hydrocarbons were released into the Gulf of Mexico. These hydrocarbons were found to have formed large subsurface horizontal intrusions. *Socolofsky et al.* studied the dynamics of the formation of these intrusions, looking at observations from the Deepwater Horizon blowout, and adapted relationships developed from lab experiments to describe the mechanisms underlying the formation of the intrusions. The authors found that the intrusions form from density stratification of multiphase plumes containing dissolved gas and oil as well as small liquid drops. They developed a method for estimating intrusion elevation and found that their estimates agreed well with observations that the intrusions were primarily between 800 and 1200 meters in depth. The models could help researchers studying the fate of subsurface oil and gas. (*Geophysical Research Letters,* doi:10.1029/2011GL047174, 2011) —ET



Scott Socolofsky

A schematic view of horizontal intrusions formed from dissolved gas and oil.

Cold snaps still a threat despite global warming

Long stretches of extreme cold weather can cause serious damage to agriculture as well as to transportation, water, and energy infrastructure. Cold snaps have the potential to kill people, with deaths attributed to cold weather often outpacing those caused by extreme heat. With climate projections anticipating at least 2°C increases in global average temperature by the end of the century, some regional planners may be taking solace in the idea that the threat of cold weather extremes could fade as the world warms. Research by *Kodra et al.*, however, suggests that on a global scale the intensity and duration of extreme cold weather events will persist and in some regions will possibly even increase by the end of the 21st century.

The researchers used climate projections from nine global circulation models running a moderate emissions scenario to compare the occurrence of extreme cold weather for the period 2091–2100 against the events of 1991–2000. The authors counted three main measures of cold weather: the average maximum temperature of each year's three coldest consecutive days (intensity), the number of days in a row in which the minimum temperature dropped below 0°C (duration), and the total number of days in each year with a minimum temperature below freezing (frequency). The authors found that while the patterns held globally, increases in the intensity and duration of cold weather extremes were seen most strongly for midlatitudes, predominantly affecting South America, the Middle East, and the western United States. The researchers caution that despite the anticipated increases in global average temperature throughout the next century, infrastructure intended to combat extreme cold weather must be maintained. (*Geophysical Research Letters,* doi:10.1029/2011GL047103, 2011) —CS

Hydroclimatic mechanisms of cholera transmission in the Bengal Delta

Cholera, a deadly waterborne disease, remains a major threat in many areas of the world, including the Bengal Delta region. In this region, cholera outbreaks have two annual peaks; the first occurs during the dry season in the spring, and the second occurs in the fall following the wet season. However, the large-scale hydroclimatic processes underlying the propagation of the disease have not been well understood.

Akanda et al. show that cholera outbreaks in the Bengal Delta region propagate from the coast to inland and from spring to fall following two distinct transmission cycles. The first outbreak begins in the spring near the coast when northward movement of plankton-rich seawater and increasing salinity promote the growth of cholera-causing bacteria in rivers, which are used for irrigation, sanitation, and consumption. The second outbreak begins in the fall, after summer floods and monsoons affect sanitation conditions that aid in bacterial transmission by contaminating waters over much of Bangladesh.

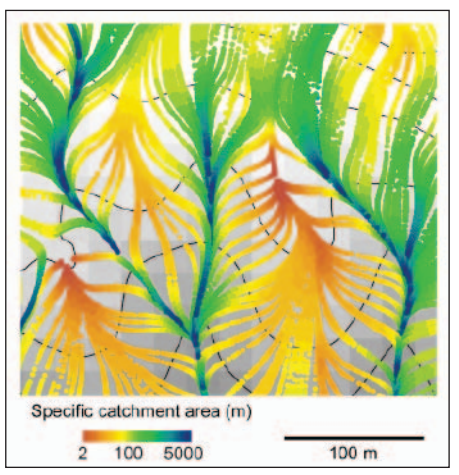
The researchers found that although spring cholera outbreaks appear to affect further outbreaks in the subsequent fall season, fall outbreaks do not affect cholera outbreaks in the following spring. This analysis could help in using dry season water management as a tool for reducing cholera burden throughout the year, developing climate-based warning of cholera outbreaks, and informing prevention and intervention strategies in affected regions. (*Water Resources Research,* doi:10.1029/2010WR009914, 2011) —ET

Calculating specific catchment area

Specific catchment area, defined as the area of land upslope of a width of contour, divided by the contour width, is a commonly used quantity in hydrology to describe complex terrain for analyzing water flow on hill slopes; it can be a surrogate for water discharge per unit flow width. Although specific catchment area is important in hydrological, ecological, and geological studies, it can be difficult to estimate.

Gallant and Hutchinson provide a simple differential equation that describes the rate of change of specific catchment area along a flow path. The equation can be directly integrated to calculate specific catchment area at any point on a digital elevation model. The method avoids use of catchment area and width estimates, which have errors.

Although the method is more computationally intense than most methods for calculating specific catchment area, it can be used as a reference against which other methods can be tested. (*Water Resources Research,* doi:10.1029/2009WR008540, 2011) —ET



Specific catchment area (colored points) integrated along flow lines derived from a 25-meter-resolution digital elevation model (background gray squares, darker is lower elevation). Black lines are contours at 10-meter intervals.

How North Atlantic cooling alters Southern Ocean wind

At least seven times during the last ice age, large portions of the polar glaciers crumbled, sending rafts of ice floating into the North Atlantic Ocean. When these icebergs melted, the resultant injection of cold freshwater was enough to drive down ocean temperatures by as much as 12°C. These so-called Heinrich events are associated with rising atmospheric carbon dioxide (CO_2) levels, but a mechanism to explain the connection convincingly has yet to arise. One proposed explanation sees the melting-iceberg-triggered North Atlantic cooling tied to increases in CO_2 venting from the Southern Ocean, which surrounds Antarctica, through increased wind-driven upwelling. To test this hypothesis, which was initially proposed by researchers in 2009 based on paleoclimate evidence, *Lee et al.* ran ocean-atmosphere coupled climate simulations to determine the physical mechanism that could support this cross-hemisphere connection.

Using their simulations, the authors showed that cooling the North Atlantic would cause the Intertropical Convergence Zone (ITCZ; an atmospheric band where equatorward flows from the Northern and Southern hemispheres come together) to be pushed south of its normal position. This change to the ITCZ weakens the southern Hadley cell (a large-scale atmospheric circulation pattern), in turn altering the structure of the eastward jet stream in the Southern Hemisphere. A consequence of this is a strengthening of the surface eastward winds over the Southern Ocean that increases the upwelling of deep ocean waters, pulling stored CO_2 up from the depths and allowing it to vent into the atmosphere.

In all, the authors suggest that the proposed mechanism would result in a 20- to 60-parts-per-million increase in atmospheric CO_2, consistent with changes seen in Antarctic ice core samples matched to Heinrich events. (*Paleoceanography,* doi:10.1029/2010PA002004, 2011) —CS

Mapping the magnetic mayhem in the heliosheath

When Voyager 1 passed into the heliosheath in 2004, it became the first human-made object to explore the remote edge of the Sun's magnetic influence. The heliosheath, between 1.5 and 15 billion kilometers thick and starting roughly 14 billion kilometers from the Sun, is where the outgoing flows of solar wind start to be pushed back by interstellar particles and magnetic fields that are heading toward the solar system. While passing through the heliosheath, Voyager 1 experienced many sudden and drastic changes in the surrounding magnetic field driven by structures called current sheets.

Using Voyager 1's ongoing measurements of the magnetic field, *Burlaga and Ness* identified three distinct types of current sheets. The structures, appearing as proton boundary layers (PBLs), magnetic holes or humps, or sector boundaries, were identified by characteristic fluctuations in either magnetic field strength or direction as the spacecraft crossed nearly 500 million kilometers of heliosheath in 2009. PBLs are defined by a rapid jump in magnetic field strength, with one observed event resulting in a doubling of the field strength in just half an hour. Passing through a sector boundary led to a sudden change in direction of the magnetic field. Magnetic holes saw the field strength drop to near zero before returning to the original background strength. Magnetic humps consisted of a sudden spike in strength and then a return to initial levels.

The firsthand detections made by Voyager 1 could help researchers decide between current leading theories for the source and structure of current sheets. (*Journal of Geophysical Research-Space Physics,* doi:10.1029/2010JA016309, 2011) —CS

—Colin Schultz and Ernie Tretkoff, Staff Writers