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Fifty Years of Deep Ocean Exploration With the DSV *Alvin*

This week the Deep Submergence Vehicle (DSV) *Alvin*, the world's first deep-diving submarine and the only one dedicated to scientific research in the United States, celebrates its 50th anniversary.

Owned by the U.S. Navy and operated by the Woods Hole Oceanographic Institution (WHOI), *Alvin* has provided unprecedented access to the deep ocean, enabling extensive observations as well as data and sample collection for investigating physical, chemical, geological, and biological processes. Its pioneering work has led to rapid technological developments in deep submergence vehicles that have greatly expanded scientists' abilities to conduct research throughout this vast and remote environment.

Beginnings of a Human Presence in the Deep Ocean

Alvin was the dream of one individual who envisioned scientists using submarines for deep ocean exploration.

On 29 February 1956, 103 scientists met in Washington, D. C., to discuss how to investigate the ocean depths. A young WHOI geophysicist, Allyn Vine, suggested that people should go down into the ocean rather than try to conduct research by remote methods.

At the meeting, Bob Dietz from the Office of Naval Research (ONR) and Jacques Piccard (who had dived to a depth of almost 2 miles with his father in 1953 in the bathyscaph *Trieste*) gave presentations on *Trieste*'s capabilities. Despite mixed opinions, the participants passed a resolution to develop a national program "aimed at obtaining... undersea vehicles capable of transporting men and their instruments to the great depths of the ocean" [von Arx, 1957].

ONR sent a delegation, including Vine, to Italy to see *Trieste*, and in 1958, the U.S. Navy bought it for \$250,000. In this vehicle, with a new observers' sphere, Piccard and Navy lieutenant Don Walsh made their historic dive to the Mariana Trench in January 1960. However, *Trieste* soon proved too large and cumbersome for routine operations throughout the oceans. It became clear that a smaller, more maneuverable deep-diving vehicle was needed.

Design and Construction of Alvin

Alvin arose from a design by Harold "Bud" Froelich, an engineer from General Mills, for a vehicle named *Seapup*. The newly formed WHOI Deep Submergence Group as well as Charles Momsen (then the chief of undersea warfare at ONR) liked *Seapup*'s design, and WHOI requested bids to build a submersible

based on that design. The Deep Submergence Group had already started using the name *Alvin* for the new submersible to honor the vehicle's prime mover and inspiration, and the name stuck.

General Mills won the bid for \$498,500 to build a submersible to dive to 6000 feet (~2000 meters) and contracted Hahn and Clay in Houston, Texas, to fabricate three 6-foot diameter HY-100 steel spheres (the other two were later used for the Navy's *Sea Cliff* and *Turtle* DSVs). The six hemispheres were forged at Lukens Steel Company in Coatesville, Pa., in December 1962 and were welded into three spheres at Hahn and Clay.

On 5 June 1964, a commissioning ceremony for *Alvin* was held on the dock in Woods Hole, Mass. (Figure 1a). Deservedly, Vine and Froelich accompanied pilot Bill Rainnie on the first two dives.

The following year, *Alvin*'s first tender—a catamaran named *Lulu* after Vine's mother—was constructed from a pair of surplus Navy pontoons. *Alvin* sailed on *Lulu* until 1984 and then was modified to a single-point lift system to be transferred to the R/V *Atlantis II*. Since 1997, when that vessel was retired, *Alvin* has operated from the R/V *Atlantis*.

Alvin's Decades of Ocean Exploration

Alvin's first major undertaking was in response to an urgent request from the U.S. Navy in early 1966. An Air Force B-52 bomber had collided with a tanker over Spain, dropping a hydrogen bomb in the Mediterranean Sea. A 2-month search operating from a landing ship dock was successful and proved *Alvin*'s ability to conduct operations at the seafloor.

In 1971, the head of the French Centre National pour l'Exploitation des Océans proposed a joint U.S.-French expedition with WHOI to explore the Mid-Atlantic Ridge using human-occupied submersibles. In 1972, with the approval of the U.S. National Academy of Sciences but amid doubts by many scientists about how useful submersibles might be, funds were granted for Project FAMOUS (French-American Mid-Ocean Undersea Study) to dive to about 3000 meters on the Mid-Atlantic Ridge between 36°N and 37°N. In 1973, *Alvin*'s steel personnel sphere was replaced with a titanium one that extended *Alvin*'s diving range from 6000 feet (~2000 meters) to 12,000 feet (~3650 meters). This was the first time in history that scientists descended to a mid-ocean ridge [Ballard et al., 1975]. This successful project proved that submersibles could effectively explore the seafloor and marked the beginning of a new era of seafloor exploration.

Alvin is perhaps most celebrated for investigations in 1977 and 1979 of seafloor hydrothermal systems and their associated chemosynthetic ecosystems, including giant

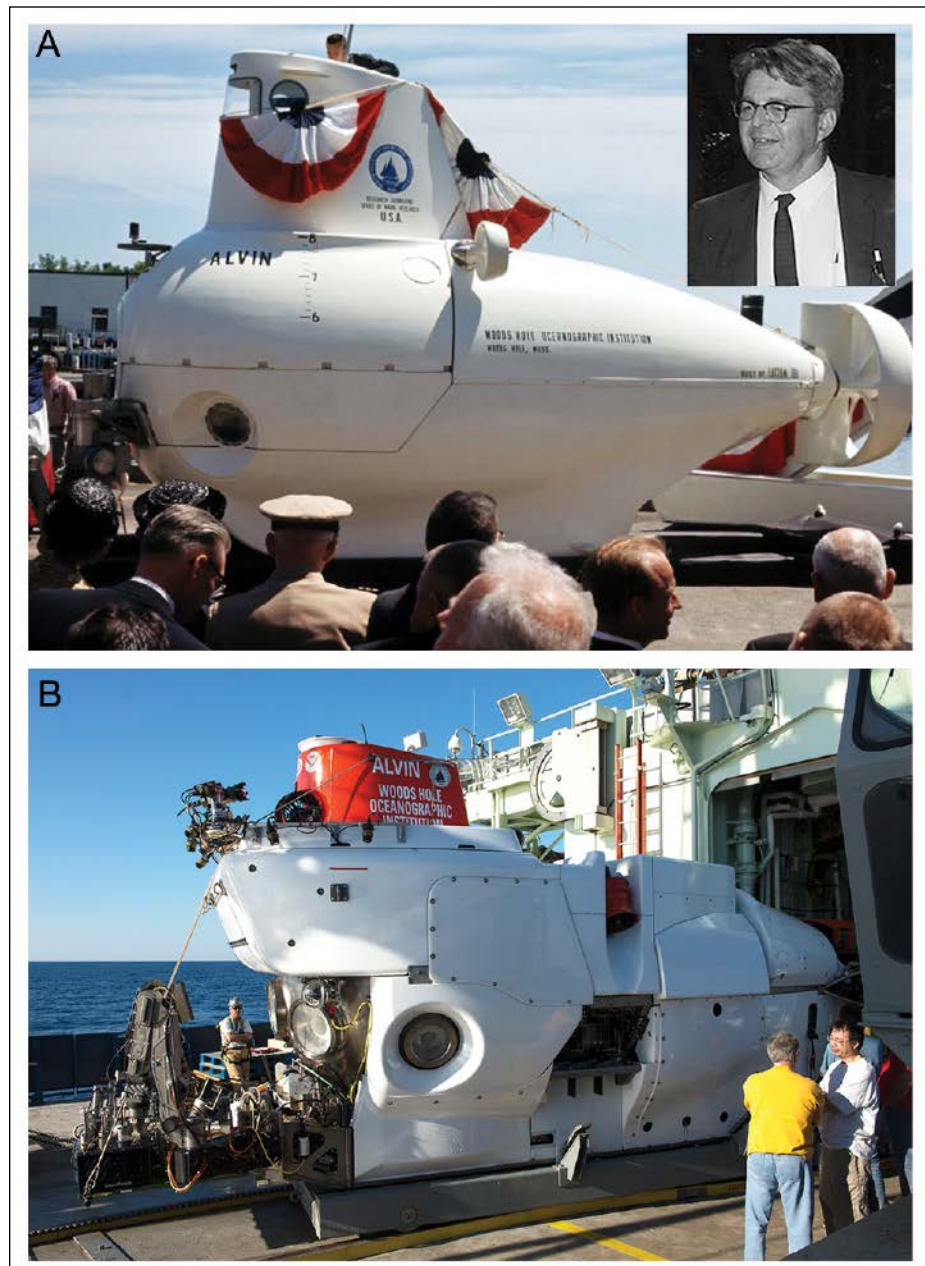


Fig. 1. (a) *Alvin*'s commissioning on the dock at Woods Hole Oceanographic Institution (WHOI) on 5 June 1964. Inset shows *Alvin*'s namesake, Allyn Vine, circa 1971. (Photos courtesy of WHOI Archives.) (b) *Alvin* returns to service in 2014 after undergoing a major upgrade. (Photo courtesy of C. Linder, WHOI.)

tubeworms and clams, on the Galápagos Rift, one of the most profound discoveries of the late 20th century [Corliss et al., 1979]. The existence of distinct seafloor chemosynthetic ecosystems (Figure 2a), which thrive on energy stored in reduced chemicals from the Earth rather than energy from the Sun, revolutionized our views of where and how life can exist on Earth and perhaps elsewhere in the universe.

Discovering Hydrothermal Vents and Photographing the Titanic

In 1979, at 21°N on the East Pacific Rise, scientists in *Alvin* discovered black smokers (Figure 2b) discharging high-temperature (350°C), acidic, reducing, and metal-rich fluids [Spiess et al., 1980]. This marked the beginning of numerous *Alvin* expeditions that discovered hydrothermal vents along the global mid-ocean ridge system in the Pacific and Atlantic Oceans.

One project particularly riveted the attention of the general public and made *Alvin* a household word: its photographic documentation of the wreck of RMS *Titanic* discovered in 1985 with a towed camera system. A year later, on its dives to the *Titanic* (Figure 2c), *Alvin* deployed a prototype remotely operated vehicle, *Jason Jr.*, that was able to penetrate the wreck and take stunning images of the sunken vessel.

Over the following decades, *Alvin* discovered new seafloor environments that

harbored other chemosynthetic communities. Since 1983, when scientists in *Alvin* discovered chemosynthetic communities at cold seeps on the Florida Escarpment [Paull et al., 1984], *Alvin* has supported numerous investigations of hydrocarbon and saline seeps on the continental slope of the Gulf of Mexico. Although the underlying conditions that drive seeps differ from those of hydrothermal vents, chemical-rich fluids at seeps similarly provide energy to sustain lush microbial mats and communities of tubeworms, mussels, and clams [Cordes et al., 2009].

The Lost City Hydrothermal Field

More recently, *Alvin* was part of an expedition that discovered the Lost City hydrothermal field on 1.5-million-year-old crust at 30°N, Mid-Atlantic Ridge, where seawater reacts with mantle rock (peridotite) to produce methane and hydrogen and build 60-meter-tall carbonate chimneys [Kelley et al., 2001]. Credit for these discoveries should be shared with the *Alvin* pilots whose experience from many dives positions them well to recognize something "different" at the seafloor.

In 2010, *Alvin* took part in a national response to the Deepwater Horizon oil spill disaster. The expedition examined dead and dying corals discovered just 7 miles from the well head. *Alvin* worked in tandem with the

BY S. E. HUMPHRIS, C. R. GERMAN,
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Alvin

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autonomous underwater vehicle *Sentry* to gauge the response of benthic communities to oil exposure in the deep Gulf of Mexico [White *et al.*, 2012] (Figure 2d).

Alvin in 2014 and Beyond

In December 2010, after 4664 dives, *Alvin* was taken out of service to undergo a major upgrade funded by the National Science Foundation and WHOI. A new, larger, titanium, 6500-meter personnel sphere with five, rather than three, viewports was integrated into *Alvin*'s modified

frame. The upgraded *Alvin* is equipped with fiber optic penetrators, a new command-and-control system, improved lighting and high-definition imaging, and increased data-logging capabilities. The new *Alvin* (Figure 1b) returned to service in March 2014, picking up where it left off with studies in the Gulf of Mexico. Diving to 6500 meters awaits development of batteries with greater energy density suitable for a human-occupied vehicle. Once that capability is realized, *Alvin*'s research potential will be expanded to being able to work in 98%, rather than 65%, of the ocean.

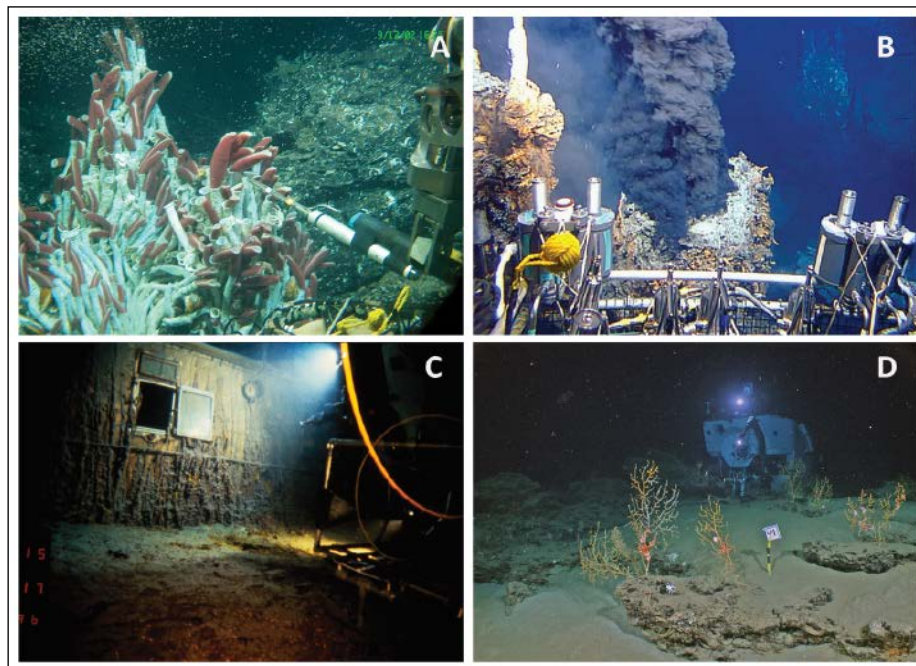


Fig. 2. Seafloor exploration with Alvin. (a) Using a probe among tubeworms at a hydrothermal vent at the East Pacific Rise. (b) Preparing to sample a black smoker hydrothermal vent at the East Pacific Rise. (c) Shining a light onto a deck bulkhead porthole of Titanic. (d) Investigating the effect of the Deepwater Horizon oil spill on benthic communities in the Gulf of Mexico. (Photos courtesy of WHOI Archives (Figures 2a–2c) and C. Fisher, T. Shank, D. Fornari, and the WHOI Multidisciplinary Instrumentation in Support of Oceanography (MISO) facility (Figure 2d).)

Toward a Drought Cyberinfrastructure System

Drought chokes ecosystems, strangles economies, and threatens human health [Wilhite, 2005]. In the United States, drought has recently forced states, including economic powerhouses like California and Texas, to declare a state of emergency. Complications such as an increase in fires, rising food prices, and water scarcity further compound the effects of drought [Pozzi *et al.*, 2013; Hao *et al.*, 2014].

Yet for many regions where drought is inevitable, human societies can learn to react quickly and efficaciously to minimize costs to production and health [Agha-Kouchak *et al.*, 2014]. A system for drought monitoring and prediction would be a vital tool to facilitate drought response while saving money, time, and lives.

The Global Integrated Drought Monitoring and Prediction System (GIDMaPS) [Hao *et al.*, 2014] was developed in 2012 by researchers at the University of California, Irvine. The system gathers and synthesizes land-atmosphere model simulations and remote sensing observations to generate 1- to 4-month-lead drought predictions. The system could help farmers, commodity investors, local governments, and global relief organizations plan for and react to droughts.

Defining Drought

For drought monitoring and prediction, the first challenge is in defining drought

itself [Dracup *et al.*, 1980]. Drought definitions for various applications encompass different indicators and variables such as precipitation levels, soil moisture, and runoff [Wilhite, 2005]. For example, agriculture may define drought by the soil moisture percentile or standardized soil moisture index (SSI) [Hao and AghaKouchak, 2013]. However, a meteorological study will typically rely on precipitation and its variability as the main drought indicator (e.g., using the standardized precipitation index (SPI) [McKee *et al.*, 1993]).

Drought indicators can be based on one variable or a combination of variables. Different indicators describe various aspects of droughts, and holistic, comprehensive drought assessments delve into multiple indicators. In addition, these indicators can be obtained from different sources, including satellite observations, model simulations, and reanalysis of past data. Different data sets have advantages and disadvantages and often show substantial discrepancies in geometrical patterns and magnitudes [Agha-Kouchak *et al.*, 2011; Sorooshian *et al.*, 2011].

A Multi-index Drought Assessment Framework

For a thorough analysis, a drought information system should use multiple drought indicators and various input data sets. Given the combinations of input data sets and drought indicators, GIDMaPS faces a

challenge common to “big data” science [Sellars *et al.*, 2013]. The term “big data” refers to data sets that are too hard or costly to analyze, store, and visualize using traditional database management tools. Generating drought monitoring information involves collecting necessary input variables from different sources, computing drought indicators, and visualizing results.

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GIDMaPS is designed as a cyberinfrastructure system to facilitate drought analysis based on multiple indicators and input data sets (Figure 1). Here the word cyberinfrastructure refers to a research environment and facility that can support advanced data management, acquisition, storage, and visualization. The system integrates data from multiple institutions and provides historical and near-real time drought conditions as well as probabilistic future forecasts [Hao *et al.*, 2014].

Currently, the monitoring and prediction information are based on three indicators: SPI as a measure of meteorological drought, SSI as an indicator of agricultural drought, and the multivariate standardized drought index [Hao and AghaKouchak, 2014] as a composite agrometeorological drought indicator. GIDMaPS automatically integrates data from the following sources: the NASA Modern-Era Retrospective analysis for Research and Applications (MERRA-Land) [Reichle *et al.*, 2011], the NASA North American Land Data Assimilation System (NLDAS) [Kumar *et al.*, 2006], the NASA Global Land Data Assimilation System (GLDAS) [Peters-Lidard *et al.*, 2007], and observations from the Global Precipitation Climatology Project (GPCP) [Adler *et al.*, 2003] combined with near-real time satellite precipitation data [AghaKouchak and Nakhjiri, 2012].

From the main interface, users can select the input data, drought indicator, year, and month and visualize or download drought information (Figure 2a). The system allows users to view dry, wet, and both dry and wet conditions (Figure 2b). The seasonal prediction component of GIDMaPS is based on a statistical persistence concept commonly used in hydrology [Hao *et al.*, 2014; Lyon *et al.*, 2012]. In this component, users have the same choice of drought indicators as in the monitoring component and can use MERRA-Land and NLDAS as input data sets. The component outputs probability of drought below a certain threshold

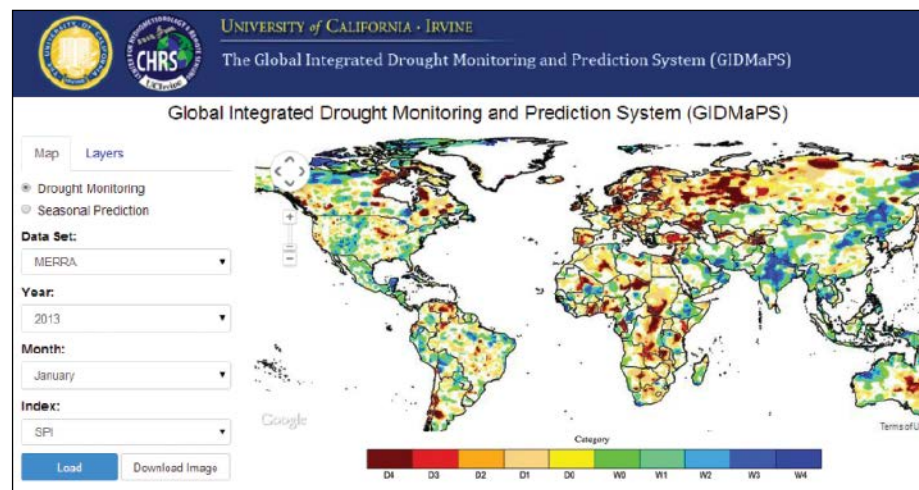


Fig. 1. Interface of the Global Integrated Drought Monitoring and Prediction System (<http://drought.eng.uci.edu/>).

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Drought

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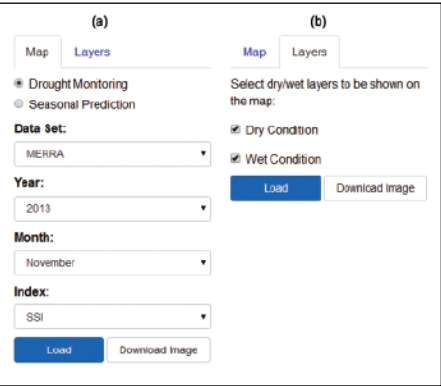


Fig. 2. (a) Drought monitoring and prediction options; (b) dry and wet condition layers.

(e.g., abnormally dry condition or moderate drought). For more details on the monitoring and prediction components of GIDMaPS, see Hao *et al.* [2014].

Evolving Drought Information System

Given a changing climate and increasing global connectivity, international organizations such as the World Climate Research Programme have recently emphasized the need for a global drought information system [Pozzi *et al.*, 2013]. GIDMaPS is designed to grow into a drought cyberinfrastructure system that can integrate multiple data sets from different institutions. The system is designed such that it would integrate and handle additional input data (model simulation and remote sensing observation) and drought indicators with ease. GIDMaPS is evolving and will include information on runoff and relative humidity in the future.

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NEWS

Congress Examines Efforts to Search for Life in the Universe

“It is not hyperbolic to suggest that scientists could very well discover extraterrestrial intelligence within 2 decades’ time or less, given resources to conduct the search,” Seth Shostak, senior astronomer with the SETI Institute, in Mountain View, Calif., testified at a 21 May congressional hearing held by the House of Representatives’ Committee on Science, Space, and Technology. He pointed to the progress in extrasolar planet discovery made possible by NASA’s Kepler space telescope, the enormous number of potential planets in the Milky Way and other galaxies, the increasing power of digital electronics to find and sort out radio and other signals, and other work related to exoplanets and astrobiology. It was the committee’s third hearing on astrobiology and the search for life in the universe in roughly 1 year.

Shostak explained that there are now approximately 2000 known exoplanets. Estimates indicate at least 70% of all stars are accompanied by planets, and recent analysis of Kepler data suggests that perhaps one in five stars will have Earth-sized planets in the habitable zone, he said. The Milky Way alone could be home to 10–80 billion Earth-sized planets, and there are another 150 billion galaxies can be seen with telescopes, Shostak added.

“The numbers are so astounding that if [the Earth] is the only planet in which not only life, but intelligent life, has arisen, then we are extraordinarily exceptional,” he said. “It’s like buying a trillion lottery tickets and none of them is a winner. That would be very, very unusual.”

The Race to Find Extraterrestrial Life

Shostak commented that there are “three horses” in a race to be the first to find some extraterrestrial biology. The first is looking for life nearby, including on Mars and on some moons in the outer solar system. “That’s where the big money is,” he said, noting that there could be at least a half-dozen solar system bodies that may have, or had, life. The second horse, he said, is building large instruments that can “sniff” the atmosphere of planets around other stars.

The third horse, on which he primarily focused during his testimony, is the search for extraterrestrial intelligence (SETI). That is the telescopic “eavesdropping,” he said, on potential signals that are either deliberately or accidentally leaked from some other

world. Such eavesdropping, Shostak stated, makes sense because humans have the technology to send bits of information across light years, and putative extraterrestrials theoretically could do so as well.

Scanning the Sky

“We have just begun to search” with SETI, he said, noting that telescopes have scanned much of the sky at fairly low sensitivity over a limited range of radio bandwidth. “The fact that we haven’t found anything means nothing. It’s like looking for megafauna in Africa and giving up after you have only examined one city block,” he commented.

Lack of federal funding is the reason the search has been so constricted, he said. “It is all privately funded.” He noted that at the height of NASA’s SETI program in 1992, the program’s budget was \$10 million but now the total financial support for radio SETI efforts in the United States is about 20% of that, with funding from either private donations or University of California research activities.

SETI relies on instruments including the Allen Telescope Array in Northern California, the National Radio Astronomy Observatory’s Robert C. Byrd telescope in Green Bank, W.Va., and the National Astronomy and Ionosphere’s 1000-foot-diameter telescope in Arecibo, Puerto Rico, according to Shostak and Dan Werthimer, director of SETI Research at the University of California, Berkeley, who was the other witness at the hearing. They outlined several SETI projects that employ radio, infrared, and optical searches of the skies, including SETI@home. The project at the Berkeley SETI Research Center uses several telescopes to survey the skies; several million volunteers in 226 countries have downloaded the screensaver to use their own computers in the search for extraterrestrial life.

The best search strategy employs a number of methods, Werthimer said. “We should be looking for all kinds of different signals and not put all our money in one basket,” adding, “It’s hard to predict what other civilizations are doing. If you had asked me 100 years ago what to look for, I would have said smoke signals. So we try to launch a new SETI project and new idea every year.”

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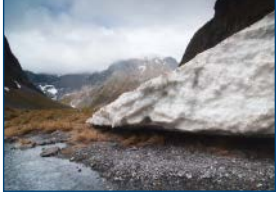
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News

cont. from page 183

Universe Could Be "Teeming" With Microbial Life

Werthimer put the chance of finding extraterrestrial life at 99%. "I suspect the universe is teeming with microbial life," he said. "It would be bizarre if we are alone, but I don't know that for sure. The intelligent life is going to be rarer, but because there are trillions of planets, I believe it is going to happen often. It's happened several times on this planet, and it's likely to arise elsewhere."

While most of the congressional hearing focused on the science of searching for life, the witnesses did fend off several questions related to unidentified flying objects. "UFOs have nothing to do with extraterrestrials," Werthimer said, noting that UFOs might be explained as being natural or manmade phenomena, hoaxes, or the result of active imaginations. "Even though I'm an optimist with life, there is no evidence for any of these [UFO] sitings," he said.

Shostak noted that about one-third of the public believes in UFOs and that the public is fascinated by the idea that the Earth may be visited by UFOs. "I certainly don't share the conviction that we are being visited," he said. "I think the pyramids probably were built by the Egyptians. I know that's a radical idea for some people."

In his testimony, Shostak noted that there is also "a certain giggle factor" to the search for extraterrestrial life. "It's very easy to make fun of this," he said, adding that it would have been easy to make fun of Ferdinand Magellan's idea to sail around the world or Captain Cook's idea to map the South Pacific. "It's exploration. That's what this is," he said. Finding life outside of Earth "would probably be the greatest discovery that humankind could ever make. And what's important is that this is the first generation that has both the knowledge and technology to do that."

—RANDY SHOWSTACK, Staff Writer

G E O P H Y S I C I S T S

Honors

The National Association of Geoscience Teachers (NAGT) has announced the winners of three of its awards, which will be presented at the NAGT and Geological Society of America (GSA) Geoscience Education Division Awards luncheon at the GSA annual meeting this fall in Vancouver, British Columbia, Canada.

Heather Macdonald, professor of geology at the College of William and Mary in Williamsburg, Va., has been awarded the 2014 Robert Christman Distinguished Service Award for her "commitment and service to NAGT."

Stephen Mattox, professor of geology at Grand Valley State University in Allendale, Mich., has been awarded the 2014 Neil Miner Award for his "exceptional contributions to the stimulation of interest in the Earth sciences."

David Montgomery, professor in the University of Washington's Department of Earth and Space Sciences in Seattle, has been awarded the 2014 James H. Shea Award for his "exceptional contributions in the form of writing and/or editing of Earth science information that is of interest to the general public and/or teachers of Earth science."

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White House Science Fair Emphasizes Importance of STEM Education

"I have a confession to make," U.S. president Barack Obama told the audience of young inventors and their mentors at a 27 May White House Science Fair ceremony in the East Room of the White House. "When I was growing up, my science fair projects were not as successful as the ones here." Recalling that during one of his experiments, "a bunch of mice escaped in my grandmother's apartment," Obama joked, "These experiments did not take me straight to the White House."

However, experiments by dozens of student winners of various science, technology, engineering, and mathematics (STEM) competitions did take them to the White House for a celebration honoring young scientists in grades K–12 and promoting science education. The winners included members of Girl Scout Troop 2612 of Tulsa, Okla., ages 6–8, who were inspired by the 2013 floods in Colorado to design a flood-proof bridge made of Lego pieces and to develop three simple computer programs that prompt the bridge to retract during floods. Olivia Van Amsterdam was part of a team of girls that built a search-and-rescue robot to assist diving teams in icy waters. Another winner,

Peyton Robertson, age 12, of Fort Lauderdale, Fla., invented a lightweight "sandbag" of polymer and salt to prevent saltwater damage from floods. He told *Eos* that STEM subjects need to be taught in a way that kids can understand the importance in relation to their own experiences, such as why baseball pitches curve or why microwaves work.

Obama noted that the Super Bowl football champion Seattle Seahawks were honored at the White House earlier in May. The science fair is more important, though, he said. "As a society, we have to celebrate outstanding work by young people in science at least as much as we do Super Bowl winners."

This year's science fair included a focus on encouraging girls in STEM fields. The president also announced several new initiatives, including a \$35 million Department of Education competition to support a White House goal to train 100,000 STEM teachers.

For more photos and information about the science fair, see http://sites.agu.org/wp-content/uploads/2014/05/95-22_WHScience_Fair.pdf.

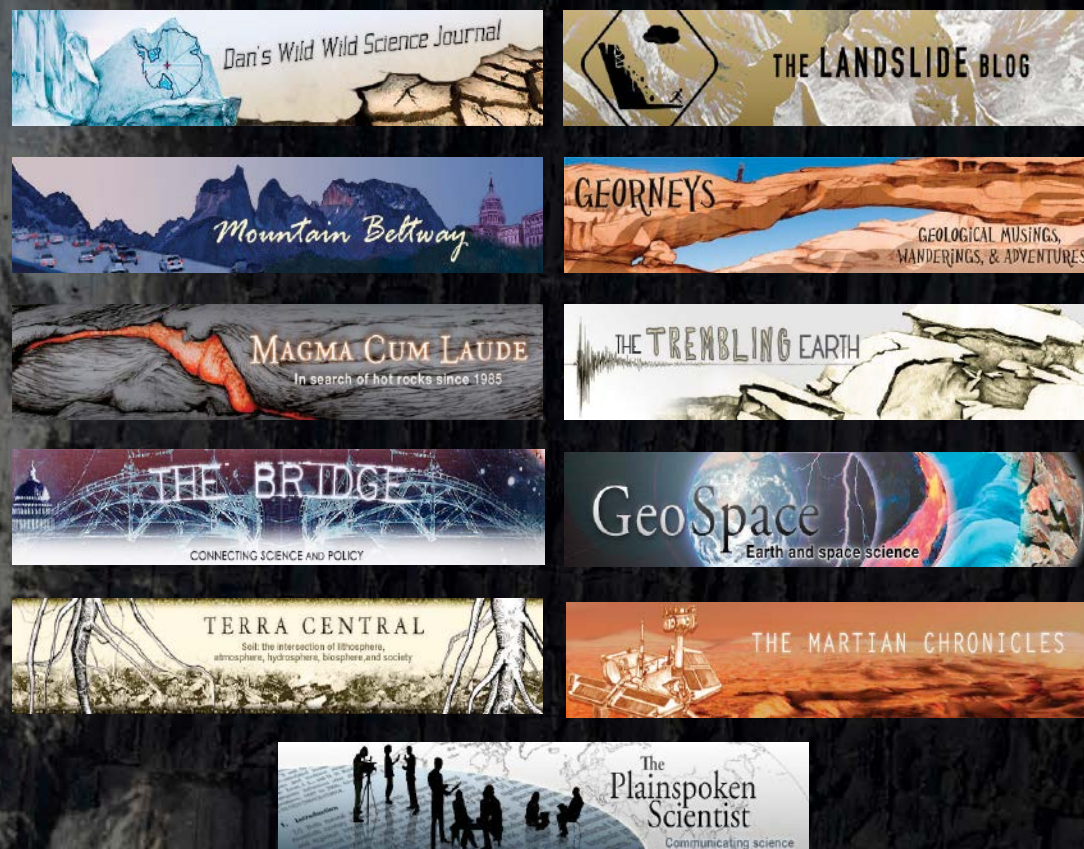
—RANDY SHOWSTACK, Staff Writer



President Barack Obama speaks at the White House Science Fair.

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MEETING

Addressing Climate-Related Challenges and Information Needs in Africa

Africa Climate Conference 2013; Arusha, Tanzania, 15–18 October 2013

The Africa Climate Conference 2013 (ACC-2013), which was organized by the World Climate Research Programme, the African Climate Policy Center of the United Nations Economic Commission for Africa, and the University of Dar es Salaam, brought together more than 300 participants, including decision makers, representatives of research funding agencies, scientists from various disciplines, and practitioners from Africa and around the globe.

The objectives of the ACC-2013 were to assess the state of knowledge of the African climate system and identify existing knowledge gaps; to develop an Africa climate research agenda that will address climate information needs; to develop a framework for mainstreaming climate information into planning and decision-making processes; and to establish networks to enhance the production and practical application of relevant information in areas such as agriculture and food production, water resources management, human health, climate risk management, and adaptation planning.

Following a series of plenary and parallel sessions, the conference participants endorsed several proposed action items and the Africa Climate Research for Development Agenda, which is summarized in the supporting information in the online version of this meeting report. Several existing and emerging structures and initiatives that will potentially provide the necessary enabling environment for the implementation of the action items and the development agenda were identified and are mentioned in the supporting information.

The endorsed action items included the following: (1) develop sustainable observational networks; engage in intensive observational campaigns; and recover, digitize, and analyze existing historical climate data; (2) develop impact data sets across climate-sensitive sectors to enable the development and evaluation of application models; (3) undertake research on processes and feedbacks relating to the carbon and water cycles, land-atmosphere coupling, and mechanisms communicating the climate change signal on temperature and rainfall in Africa; (4) undertake detection and attribution studies of past and future climate, particularly extreme events; (5) improve the understanding of local and remote drivers of climate variability at short to multidecadal time scales to improve climate prediction skill; (6) undertake multidisciplinary research involving social and natural scientists; (7) overcome barriers and limits to the flow of knowledge between scientists and user communities; and (8) build research capacity of African institutions.

The authors gratefully acknowledge the contributions made by the participants and the ACC-2013 Steering Committee members (listed in the supporting information) toward the success of the conference and in the preparation of this report.

—M. E. SHONGWE, South African Weather Service, Pretoria, South Africa; email: mxolisi.shongwe@weathersa.co.za; ANNA PIRANI, CLIVAR, Earth System Physics, The Abdus Salam International Centre for Theoretical Physics, Trieste, Italy; and SELESHI BEKELE, African Climate Policy Centre, United Nations Economic Commission for Africa, Addis Ababa, Ethiopia

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AGU GEOCALENDAR

This column announces upcoming meetings and symposia of interest to Earth and space scientists. To submit an announcement for the AGU GeoCalendar, go to <http://geocalendar.agu.org/submission-form/>. There is no fee for these brief listings.

- 3–5 June 2014 **71st Eastern Snow Conference**, Boone, North Carolina, USA. Organizer: Eastern Snow Conference. (Website: http://www.easternsnow.org/annual_meeting.html)

■ 15–19 June 2014 **Coastal Zone Canada 2014 Conference**, Halifax, Nova Scotia, Canada. Organizer: Coastal Zone Canada Association. (Website: <http://www.czca-zacc.org/czc-zcc2014/home.htm>)

■ 15–20 June 2014 **The 24th International Ocean and Polar Engineering Conference**, Busan, Korea. Organizer: The International Society of Offshore and Polar Engineers. (Website: <http://www.iso2014.org/>)

■ 23–27 June 2014 **IMBER Open Science Conference, “Future Oceans, Research for Marine Sustainability: Multiple Stressors, Drivers, Challenges and Solutions,”** Bergen, Norway. Organizer: The Integrated Marine Biogeochemistry and Ecosystem Research (IMBER) project. (Website: <http://www.imber.info/index.php/Meetings/IMBER-OSC-2014>)

■ 14–17 July 2014 **7th International Scientific Conference on the Global Water and Energy Cycle**, The Hague, Netherlands. Organizer: Global Energy and Water Cycle Exchanges Project (GEWEX) (Website: <http://www.gewexevents.org/>)

■ 28–31 July 2014 **IceTech14: International Conference and Exhibition on Performance of Ships and Structures in Ice**, Alberta, Canada. Organizer: The Society of Naval Architects and Marine Engineers. (Website: <http://www.icetech14.org/>)
- 2–10 August 2014 **40th Scientific Assembly of the Committee on Space Research (COSPAR)**, Moscow, Russia. Organizer: COSPAR. (Website: <https://www.cospar-assembly.org/>)

■ 4–17 August 2014 **Western Siberian Peatlands and Carbon Cycle: Past and Present**, Novosibirsk, Russia. Organizer: INTERACT – International Network for Terrestrial Research and Monitoring in the Arctic. (Website: <http://www.eu-interact.org/>)

■ 11–15 August 2014 **22nd IAHR International Symposium on Ice**, Republic of Singapore. Organizer: The International Association for Hydro-Environment Engineering and Research. (Website: <http://www.iahr-ice2014.org/>)

■ 16–21 August 2014 **World Weather Open Science Conference 2014**, Montreal, Quebec, Canada. Organizers: World Meteorological Organization, International Council for Science, Environment Canada, National Research Council Canada. (Website: <http://wwosc2014.org/>)

■ 17–22 August 2014 **International Workshop on Ice Caves**, Idaho Falls, Idaho, USA. Organizer: National Cave and Karst Research Institution. (Website: <http://www.iwic-vi.org/>)

■ 18–22 August 2014 **International Symposium on the Changing Arctic Cryosphere**, Edmonton, Alberta, Canada. Organizer: The International Glaciological Society. (Website: <http://www.igsoc.org/symposia/2014/alberta/>)

■ 21–25 September 2014 **ACCO's 4th Annual Defense, National Security & Climate Change Symposium**, Washington, D. C., USA. Organizer: Association of Climate Change Officers. (Website: <http://www.climatesecurity.us/>). Abstract submission deadline: 13 June 2014.

■ 24–26 September 2014 **Joint Workshop on High Pressure, Planetary, and Plasma Physics**, Rostock, Germany. Organizer: Universität Rostock Institut für Physik. (Website: <https://indico.desy.de/conferenceDisplay.py?confId=9404>). Registration deadline: 9 September 2014.

What's on the Web?

Read the latest offerings from the AGU Blogosphere:

Dan's Wild Wild Science Journal: “Big picture lessons from an unfortunate tweet” (<http://ow.ly/x7L5g>)

GeoSpace: “Snow photos sought to illuminate snowmelt puzzle” (<http://ow.ly/x9P9d>)

The Plainspoken Scientist: “Crafting your own visuals for science communications: Part II” (<http://ow.ly/x9CoS>)

The Landslide Blog: “Zenica: A spectacular landslide video from Bosnia” (<http://ow.ly/x65iN>)

The Bridge: “Applying science to natural resource policy issues: Social science joins natural and physical sciences” (<http://ow.ly/xbMw4>)

Dan's Wild Wild Science Journal: “Worth a read, and not just because I'm quoted” (<http://ow.ly/x65Fh>)



In The Plainspoken Scientist Ilissa Ocko demonstrates how you don't need fancy and expensive software to create first-rate science images. She shows how PowerPoint can be used to make illustrations like this landscape schematic.



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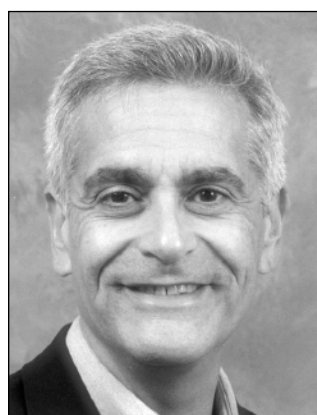
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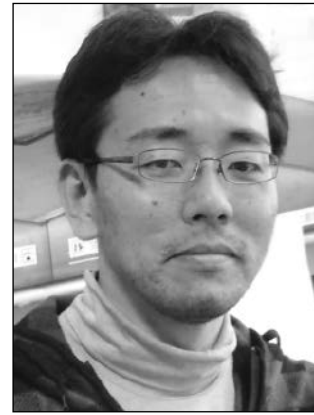
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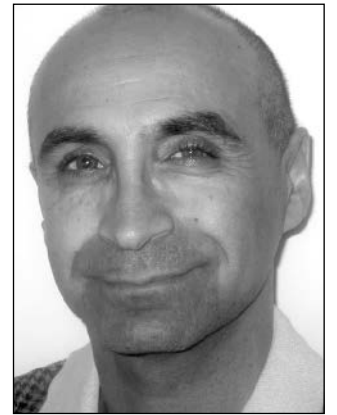
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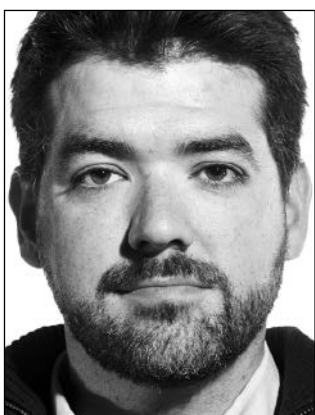
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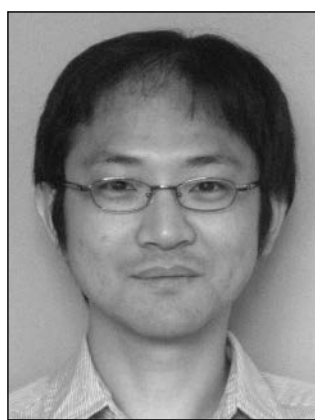
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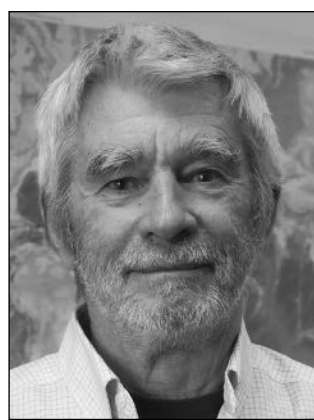
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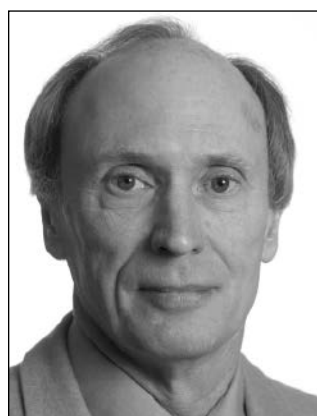
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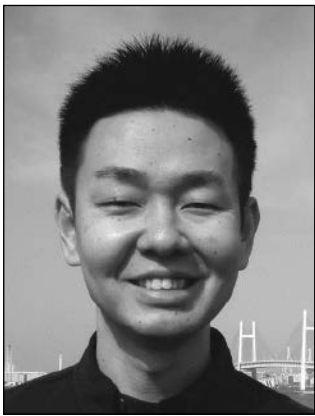
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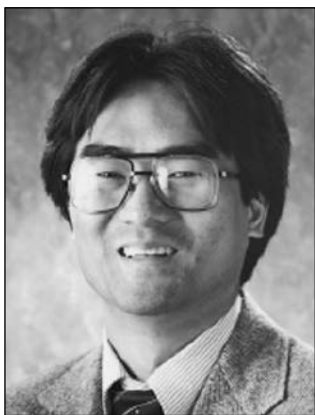
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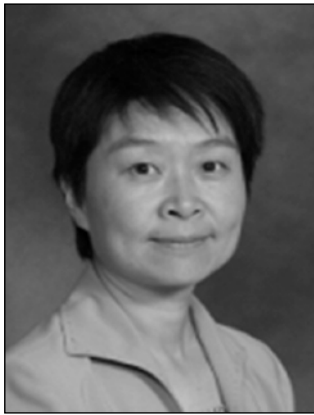
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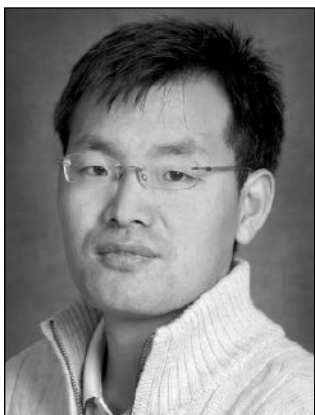
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with policy makers. AGU has online resources that provide members with information about regional issues and how to contact and visit legislators. Please consider making a special contribution to this fund. Your donation, large or small, will make a difference. To donate and find out more about AGU's Science Policy efforts, go to <http://giving.agu.org/campaign/capitol-cause/> or email development@agu.org. —CLAIRE HOWARD, Development Coordinator, AGU; email: choward@agu.org

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Eos is published every Tuesday, except the last week of December. For a classified or display advertisement to be published in a future issue of Eos, electronic copy must reach us by 11:59 PM. Eastern time, 9 days prior (Sunday) to publication, except around certain holidays, which have earlier deadlines. No cancellations accepted after deadline. For inquiries on advertising pricing and availability: E-mail: advertising@agu.org Phone: +1-202-777-7536 Facsimile: +1-202-777-7478

POSITIONS AVAILABLE

Geochemistry

Noble Gas Laboratory Specialist or Research Scientist position at the University of Michigan.

The University of Michigan Department of Earth and Environmental Sciences is seeking a senior laboratory manager/research scientist for an immediate opening in the Noble Gas Laboratory. The lab is undergoing significant expansion with the arrival of two new mass spectrometers (a Helix SFT and an Argus VI) and the construction of two new noble gas extraction and purification lines, the main one for fluids the secondary one for rocks. The lab analyzes most fluids (e.g., freshwater, gas, brine), hence an interest in fluids is important. The ideal candidate is a senior person of science with a minimum of 32 years of relevant lab experience: 5+ years are preferred. An in-depth knowledge of Qtegra and familiarity with our mass spectrometers is a great plus. General academic background is flexible but must have at least a master's degree in a recognized field of science: master's or PhD is preferred. Candidates must be comfortable in a diversity of programming environments and be proactive at finding solutions and developing new methodologies. Career family, level and salary will be based on the qualifications of the selected applicant. If interested, please send a single PDF containing a letter of interest, CV, brief statement of research interests, and the names and address of three references to Professor Clara Castro at mccastro@umich.edu. The University of Michigan is an affirmative action, equal opportunity employer. Women and minorities are encouraged to apply.

Solid Earth Geophysics

DIRECTOR OKLAHOMA GEOLOGICAL SURVEY UNIVERSITY OF OKLAHOMA.

Applications are being solicited for the position of Director, Oklahoma Geological Survey (OGS). The OGS is located on the University of Oklahoma campus in Norman, Oklahoma, and is under the direction and supervision of the Board of Regents of the University of Oklahoma. Organizationally, the OGS is located within the Mewbourne College of Earth & Energy, which also includes the ConocoPhillips School of Geology & Geophysics and the Mewbourne School of Petroleum & Geological Engineering. The Director of the OGS reports administratively to the Dean, Mewbourne College of Earth & Energy. If appropriate, the successful candidate may hold a dual appointment as a faculty member within the College as an Associate or Full Professor, renewable term or tenured. Candidates should hold a doctorate in geology, geophysics or a closely related field. Prior experience with a public agency would be beneficial. The objectives and duties of the Oklahoma Geological Survey include the following:

- (a) A study of the geological formations of the state with special reference to its natural resources, including coal, oil, gas, asphalt, gypsum, salt, cement, stone, clay, lead, zinc, iron, sand, road building material, water resources and all other mineral resources.
- (b) Management of the Oklahoma seismic recording network, and the reporting and analysis of earthquake activity in the state.
- (c) The preparation and publication of bulletins and reports, accompanied with necessary

illustrations and maps, including both general and detailed descriptions of the geological structure and mineral resources of the state. (d) The consideration of such other related scientific and economic questions that shall be deemed of value to the people of Oklahoma. The Director of the OGS has the responsibility of overseeing activities related to geological and geophysical studies of Oklahoma and adjacent areas, preparation of reports documenting the findings of these studies, and communication of these results to individuals, agencies and the general public as appropriate and/or required. The position requires supervision and administration of an organization of approximately 50 staff and associated facilities including offices, labs and the Oklahoma Petroleum Information Center (OPIC), which contains an extensive collection of rock cores and samples, other well information and selected facilities for the examination of these cores and samples. It is anticipated that the Director of the OGS will work with Oklahoma universities, state and federal agencies, industry and other entities to conduct research in areas of public interest, as well as providing advice and service in the areas of geology, geophysics and natural resources. One particular area of current high interest is the recent, significant increase in Oklahoma earthquake activity.

The successful candidate will have the demonstrated experience and ability to oversee these activities, while acting as the State Geologist of Oklahoma. Areas of experience that could be considered include an appropriate background with state or national surveys, administration in academia, experience in industry or research, or other related areas. Review of candidates will begin June 1, 2014 and continue until the position is filled. The anticipated starting date is January 1, 2015. Applicants are requested to submit a complete resume, statement of relevant experience and a list of five references who can be contacted, including names, phone numbers, e-mail addresses and complete

mailing addresses. Questions or requests for additional information may be addressed to Larry R. Grillo, Dean of the Mewbourne College of Earth & Energy, and Chair of the OGS Director Search Committee, at (405) 325-3821, or lrgillot@ou.edu. Applications and nominations should be addressed to OGS Director Search Committee, University of Oklahoma, Sarkeys Energy Center, 100 East Boyd Street, Room 1510, Norman, OK 73019-1008. The University of Oklahoma is an Affirmative Action, Equal Opportunity Employer. Women, minorities, protected veterans and individuals with disabilities are encouraged to apply.

Research Faculty position in seismology.

The Geophysical Institute (GI) at the University of Alaska Fairbanks is hiring a new seismology faculty member at the rank of Research Assistant Professor or Research Associate Professor. We seek a scientist interested in building a long-term research program that leverages the extensive facilities and personnel of the Seismology Lab and GI. We value an ability to work collaboratively with other faculty and a motivation to help lead our graduate student program. To foster these connections, the new hire will work with the Alaska Earthquake Center and/or the Alaska Volcano Observatory. These affiliations, together with core university funding, are expected to provide approximately eight months of support annually for this twelve-month position. After an initial startup period, the new hire will be expected to raise additional support through external grants and contracts of their own. We invite candidates from a wide range of seismology backgrounds. Candidates should have broad research interests with applications in regional tectonic settings and/or volcanoes. Applicants are encouraged to address this in their statement of research. Candidates will be evaluated, in part, on their ability to capitalize on the diverse assets of the Geophysical Institute and on

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Contribute to Eos!

Give the geophysics community an update on your project, program, or research experience: Contribute a brief report to Eos. To learn more, visit [http://onlinelibrary.wiley.com/journal/10.1002/\(ISSN\)2324-9250/homepage/ForAuthors.html](http://onlinelibrary.wiley.com/journal/10.1002/(ISSN)2324-9250/homepage/ForAuthors.html).

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The International Continental Scientific Drilling Program, ICDP invites scientists from upcoming scientific drilling projects to apply for the



ICDP Training Course
on Active Fault Zone Drilling

to be held from October 6-10, 2014 in New Zealand. This training will touch upon relevant aspects of scientific drilling in active fault zones, including project planning and management, pre-site studies, drilling engineering, sample handling and storage, on-site analysis, downhole logging, permanent downhole seismic monitoring, and data management. The training course is recommended for graduate students and post-doctoral scientists involved in upcoming scientific drilling. Applications should include a letter of interest, CV, and at least two letters of support. Preference will be given to applicants involved in ICDP drilling projects, applicants from ICDP member countries, developing countries, and those from countries considering ICDP membership. For the successful candidates, costs including those for travelling, visa, accommodation and meals will be covered by the ICDP.

Please submit your application to icdp-outreach@gfz-potsdam.de until June 30, 2014. Decisions will be communicated by mid July.



Colorado School of Mines
Department of Geophysics
C.H. Green Professor of
Exploration Geophysics

Colorado School of Mines invites applications for the C.H. Green Chair in Exploration Geophysics, which is anticipated to be filled at the rank of Full Professor.

The successful candidate will conduct a vigorous research program that includes (a) building strong collaborative relationships with industry, academic, research, and/or government institutions; (b) generating research funding; (c) supervising graduate students; and (d) maintaining a strong record of scholarly publishing. The successful candidate will teach at both the undergraduate and graduate levels, and participate actively in the international geophysics community.

Candidates must possess a PhD in geophysics or a related field. Applicants for the Professor level are expected to possess national and international professional recognition and a record of excellence in teaching, research, and professional service.

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

Mines is an EEO/AA employer.

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the scientific opportunities afforded by the active tectonic environment of Alaska.

The new hire will join a dynamic group of two dozen faculty, postdocs, staff and students dedicated to advancing the field of seismology. Our research emphasizes earthquakes, volcanoes, tsunamis, glaciers and tectonics in Alaska and around the world. We track earthquake and volcanic activity across Alaska in partnerships with federal and state agencies. The Seismology Lab houses the Alaska Earthquake Center and is a core component of the Alaska Volcano Observatory. The tremendous rates of tectonic and volcanic activity make Alaska an unparalleled laboratory for seismology. We apply this real-world experience to research projects with global implications. Current emphasis on Alaska from the EarthScope and GeoPRISMS programs make this a particularly exciting time. Abundant seismoacoustic research opportunities also exist through collaboration with the GI-based Wilson Infrasound Observatories.

The University of Alaska Fairbanks values diversity among its students, staff, and faculty. We encourage applications from women, members of minority groups, and others who would bring additional dimensions to the university's research, teaching and service missions.

To apply go to www.uakjobs.com/applicants/Central?quickFind=84168. Application review will start on July 1, 2014. Refer questions to Doug Christensen (doug@giseis.alaska.edu).

Visiting Professor/Post-doc position Earthquake Research Institute, the University of Tokyo.

The Earthquake Research Institute, the University of Tokyo, invites applications for Visiting Professor / Post-doctoral Fellow positions in the research fields of earthquakes, tsunamis, their engineering, volcanoes, and physics of the earth's interior. The period of each position will be from three to twelve months between 1 April 2015 and 31 March 2016.

The successful candidates are expected to carry out research at ERI as an employee of the University of Tokyo. Monthly salary, ancillary expenses including partial housing costs and commuting allowance will be paid following the rules of the University and ERI.

While priorities are given to the first-time visitors, we also consider second-time applications if he/she is willing to contribute to education by teaching a course or co-tutoring graduate students with our faculty members.

Candidates are requested to submit the following set of documents as attached files to e-mail (address: intl-office@eri.u-tokyo.ac.jp).

- (1) CV with birth date and detailed account of academic activity
- (2) List of academic publications
- (3) Summary of research that the candidate has conducted (300-500 words)
- (4) Title of research and research proposal at ERI (300-500 words)
- (5) Desired length of stay; from three to twelve months

Candidates are also requested to nominate a host researcher of ERI. If you need more

information on host researchers, please visit <http://www.eri.u-tokyo.ac.jp/eng/>. Prior contact to an ERI faculty member is desirable, but not mandatory.

The deadline for this application is 27 August 2014.

If you need further information regarding this position, please visit our website <http://www.eri.u-tokyo.ac.jp/kokusai/english/index.html> or feel free to contact the address below.

Kenji Satake
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Earthquake Research Institute, the University of Tokyo
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Phone: +81-3-5841-0219 Fax: +81-3-3814-5507
E-mail: intl-office@eri.u-tokyo.ac.jp

Space Physics

Jovian Magnetic Field and Magnetosphere Post-doc Researchers.

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. Minority candidates are encouraged to apply.

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

Juno Magnetometer
CREST/UMCP
Mail Code 660.8, NASA/GSFC
Greenbelt, MD 20771, or
Via e-mail to 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/. For information on CREST and the UMCP's Department of Astronomy, please contact Tracy Huard (thuard@astro.umd.edu). The position will remain open until filled.

The University of Maryland is an equal opportunity employer. All applications received by September 26, 2014 will receive full consideration.

Interdisciplinary/Other

Research Associate III.

The Delaware Geological Survey, located at the University of Delaware, invites applications for a full-time, limited term (2 year) position to

participate in an offshore sand resource characterization and geologic mapping project focused on the Atlantic offshore Delaware. We are seeking an energetic, motivated scientist to develop and implement a research plan for offshore geologic mapping, to include sand resource identification and quantification. Experience in the collection, compilation, and interpretation of seismic data, sediment core, seafloor texture, and seafloor morphology are desirable. The position also requires the analysis and interpretation of complex data using Geographic Information Systems (GIS), database management, and the development of metadata. Opportunities for collaboration exist with scientists in the College of Earth, Oceans, and the Environment (CEOE) who are conducting research relevant to the objectives of this project. The successful candidate will also be expected to prepare reports, and coordinate and communicate with cooperating partners by presenting findings related to potential sand resources, and interact with Federal, State, and private partners for data sharing and transfer. The position requires a Bachelor's degree and four years' experience, or Master's degree and two years' experience, or Doctorate, in geology or related field with concentration in marine geology, geologic mapping, seismic stratigraphy, or resource analysis.

The position requires work at a computer work station in an office setting, in a sample processing and examination laboratory, and possible field work aboard a marine research vessel in open ocean conditions. Job requires some physically demanding work outdoors in hot/cold/wet conditions, including lifting samples and equipment up to 50 pounds. Travel to attend meetings with collaborators, perform field work, and present research in professional forums is required.

For more detailed information or to apply please visit www.udel.edu/udjobs. Reference Job ID 102069

The University of Delaware is an Equal Opportunity Employer which encourages applications from Minority Group Members, Women, Individuals with Disabilities and Veterans. The University's Notice of Non-Discrimination can be seen at: www.udel.edu/aboutus/legalnotices.html

Research Geologist, U.S Geological Survey (USGS) Eastern Geology and Paleoclimate Science Center, Reston, Va.

The USGS invites applications for a permanent research position in the field of Holocene paleoclimate and paleoenvironmental studies. The position will be filled at the GS 12 (salary is \$75,621 to \$98,305 per annum).

The successful candidate for the position will synthesize, generate, and interpret data from new and existing Holocene sedimentary records from North America and adjacent oceans to facilitate understanding of regional and continental-scale climate variability and change over the last 15,000 years. The successful candidate will also be an expert in one or more of the following to analyze and interpret data from sediment cores collected in terrestrial, estuarine, or marine settings: paleontology, micropaleontology, geochemistry, geochronology, sedimentology. Experience with statistics, data synthesis, and assimilation techniques also is preferred.

Detailed vacancy requirements and applications procedures can be found in our online

vacancy announcement at the links listed below. This position will be filled as a Research Geologist, with a full promotion potential of GS-15. The vacancy announcement can be found on the Office of Personnel Management's USAJOBS website at www.usajobs.gov or you may directly link to the vacancy announcement on USAJOBS using one of the links below.

-For candidates who have never worked for the Federal Government (Announcement Number ATL-2014-0534): <https://www.usajobs.gov/GetJob/ViewDetails/369385100>

-For current status employees or reinstatement eligible (Announcement Number ATL-2014-0533): <https://www.usajobs.gov/GetJob/ViewDetails/369384500>

Applications must be submitted online by midnight Eastern time, June 13, 2014, to be considered. It is important that candidates view the Vacancy Announcement in its entirety to be sure that all required documents are submitted. Incomplete application packages cannot be considered. U.S. citizenship is required. The USGS is an Equal Opportunity Employer.

Samples and Laboratories Manager (100%) Wisconsin Geological & Natural History Survey.

The Wisconsin Geological & Natural History Survey (WGNHS) invites applications for a Samples and Laboratories Manager. We seek candidates with experience in the area of geologic sample analysis and laboratory management. Our academic atmosphere, focus on research and outreach, and compact size sets the WGNHS apart from most geological research organizations; take this opportunity to grow with us. For more information, please visit <http://wgnhs.uwex.edu/>. Applications must be submitted by July 1st, 2014.

For details on how to apply visit: <http://www.uwex.edu/ces/hr>

We are an AA/EEO employer

Student Opportunities

The Office of Science and Technology Policy Fall 2014 Policy Internship Program.

The Office of Science and Technology Policy is currently accepting applications for its Fall 2014 Policy Internship Program. The application deadline is 11:59pm, Friday, Jun 20. Students who are U.S. citizens and who will be actively enrolled during the Fall 2014 semester are welcome to apply.

More information and application instructions are available at <http://www.whitehouse.gov/ostp/about/student/>.

About OSTP. The Office of Science and Technology Policy advises the President on the effects of science and technology on domestic and international affairs. The office serves as a source of scientific and technological analysis and judgment for the President with respect to major policies, plans and programs of the Federal Government.

About the Internship Program. Interns are accepted for one of three annual terms (Spring, Summer, or Fall), which each last no more than 90 days. While these positions are without compensation, the assignments provide educational enrichment, practical work experience, and network opportunities with other individuals in the science and technology policy arena.

For questions, please contact Rebecca Grimm rg Grimm@ostp.eop.gov.

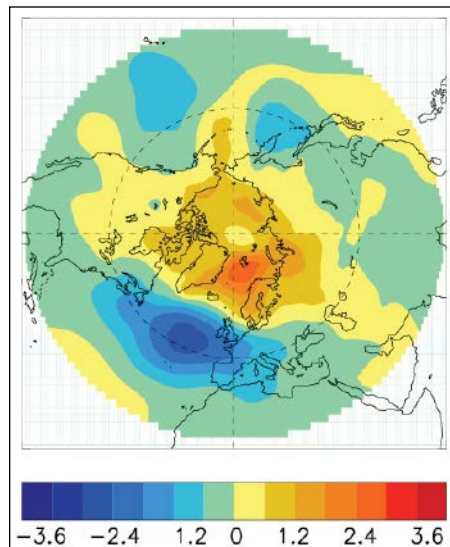
RESEARCH SPOTLIGHT

Highlighting exciting new research from AGU journals

Quasi-biennial oscillation predictable on multiannual time scales

The quasi-biennial oscillation (QBO), a quasi-periodic oscillation of easterly and westerly winds in the tropical stratosphere that is known to affect winter surface weather in the midlatitudes, is predictable several years into the future, according to a new modeling study by *Scaife et al.*

Using model simulations to produce retrospective forecasts of the QBO, the authors found that the QBO is predictable on time scales of 3 or more years into the future, which is considerably longer than most



Winter sea level pressure difference (hPa) between the easterly and westerly phases of the quasi-biennial oscillation.

atmospheric processes. The authors also found that not all climate models are able to reproduce the surface weather effect of the QBO, so improving this aspect could lead to better long-range predictions of winter surface weather in the midlatitudes. (*Geophysical Research Letters*, doi:10.1002/2013GL059160, 2014) —EB

How the Madden-Julian Oscillation affects North American weather

The unusual weather in the United States during the winter of 2013–2014—when the West stayed hot and dry, the Northeast was battered by Arctic winds, and the South was blanketed in snow—was caused in part by an atmospheric phenomenon that blocked normal weather patterns from reaching the West Coast. The jet stream, forced to flow around a stable high-pressure system, became curvier than normal. Over the eastern Pacific, the jet stream flowed far to the north before turning south over Alaska, bringing cold Arctic air to the Midwest.

The set of atmospheric conditions that caused the curvy jet stream is known as the positive phase of the Pacific–North American pattern (PNA). The PNA cycles intraseasonally and is a strong influence on climate variability in the Northern Hemisphere.

Previous research has shown that the oscillation of the PNA is weakly attributed to the El Niño–Southern Oscillation. In a new model simulation, *Bao and Hartmann* identified a mechanism through which the PNA could also be physically connected to the Madden-Julian Oscillation (MJO), an intraseasonal climate system marked by a migrating heat source that initiates in the Indian

Ocean and propagates eastward into the western Pacific.

According to the authors' model, when the migrating MJO heat source is over the Philippines and Indonesia, it perturbs the air over the eastern Pacific, which, in turn, causes a semistationary anomaly to form in the jet stream. As the MJO heat source moves into the Pacific, the jet stream anomaly creeps eastward. When the anomaly reaches the western United States, it strengthens, setting the stage for the positive phase of the PNA. (*Geophysical Research Letters*, doi:10.1002/2013GL057683, 2013) —CS

Beaufort Gyre sea ice thins in recent decades, impacts climate

The accumulation and melting of sea ice in the Arctic has an enormous impact on local climate, which in turn can affect global climate. As the climate warms and Arctic sea ice retreats, it has become crucial to understand the complex ice-atmosphere-ocean dynamics within the Arctic. One major component in this dynamic is the Beaufort Gyre, a wind-driven sea ice circulation and freshwater reservoir in the Arctic's Beaufort Sea.

This gyre is a notoriously dangerous area to observe because of its hostile conditions. Working around this, *Krishfield et al.* set out to investigate recent rapid sea ice decline in the Beaufort Gyre using data already collected between 2003 and 2012. The authors used data from moorings, ship-based surveys, and satellite radiometers to estimate ice thickness, which, when combined with satellite estimates of ice extent, can give an estimate of sea ice volume.



Richard Krishfield

Recovery of a mooring top float with upward pointed ice thickness sonar in September 2010 amid pancake ice in the Beaufort Sea of the Arctic Ocean.

The authors found a net sea ice decline over the 9 years studied, with record minima of ice volume in 2007 and 2012. Freshwater export from this region during the past 3 years was also observed. These data indicate that an anticyclonic climate regime that has been persistent in the Beaufort Gyre since the late 1990s may be weakening, which may lead to a relatively warmer and wetter climate locally but could produce cooling in the North Atlantic. (*Journal of Geophysical Research: Oceans*, doi:10.1002/2013JC008999, 2014) —JW

—ERNE BALCERAK, Staff Writer, COLIN SCHULTZ, Writer, and JOANNA WENDEL, Staff Writer