

A Civil War–Era Painting
of the Aurora Borealis

What Darkens the
Greenland Ice Sheet?

Dunes' Importance
on Planetary Surfaces

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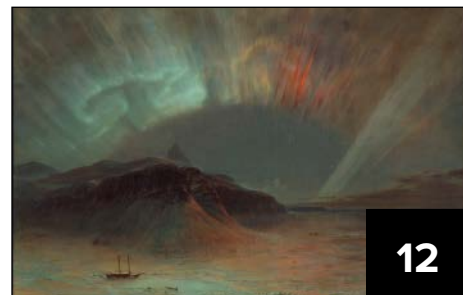
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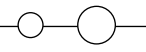
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Limited observational data sets and incomplete surface energy balance models constrain understanding of the driving processes for Greenland's ice sheet.

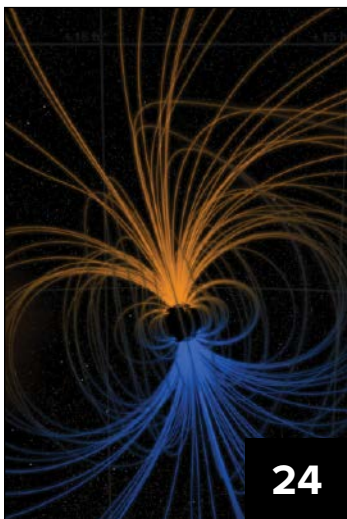
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Christine W. McEntee, Executive Director/CEO



Priorities for Antarctic Research: Glaciers, Genomes, and Cosmic Waves



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A new U.S. National Academies of Sciences, Engineering, and Medicine report recommends research priorities for the future of Antarctic and Southern Ocean research.

Understanding how melting sea ice contributes to sea level rise, learning how organisms evolve and adapt to changing environments, and using Antarctica's unique environment to study cosmic wave background radiation should be top research goals for Antarctic and Southern Ocean science. So says a report released 11 August by the U.S. National Academies of Sciences, Engineering, and Medicine (NAS).

"Change in Antarctica and the Southern Ocean has global ramifications for sea level rise," explained Robin Bell, a professor of geology and geophysics at the Lamont-Doherty Earth Observatory of Columbia University in New York and cochair of the report committee. "There are also key records of past change that inform our understanding of change in the future," she told *Eos*.

A *Strategic Vision for NSF Investments in Antarctic and Southern Ocean Research* (http://bit.ly/NAS_report)—which was commissioned by the National Science Foundation—emphasizes the need to study how loss of glacier mass affects sea level rise, to research how the genomes of organisms change with shifting environmental conditions, and to further understand the universe's "fossil light"—the cosmic microwave background that is more easily detected in the clear Antarctic skies.

The report maps out strategies to achieve these research goals over the next 10 years.

The report suggests studying how Antarctica's ice sheets are changing now and also examining new ice cores and sediment samples to understand how the ice sheets changed in the past. By sequencing genomes of species living in Antarctica and the South-

ern Ocean, scientists can begin to understand how living things are adapting to the changing environment, the report says. In addition, by installing new telescopes in the Antarctic's dry, stable atmosphere, scientists can investigate the universe's earliest moments, the report says.

The recommendations were developed following input from more than 450 scientists in 10 meetings in the United States and around the world and in a virtual town hall, Bell said.

The report also advocates for expanded access to remote areas, acquiring new heavy icebreakers for polar research, improved technology for data transmission, and a more open system of sharing and communicating data.

By **JoAnna Wendel**, Staff Writer

The Importance of Dunes on a Variety of Planetary Surfaces

The Fourth International Planetary Dunes Workshop: Integrating Models, Remote Sensing, and Field Data
Boise, Idaho, 19–22 May 2015



Dark dunes within Mars's Herschel Crater, most likely composed of basaltic sand. The dunes are barchans; steep faces on the bottom edges of these features show the dominant direction of prevailing winds. Pits and smaller ripples on the dunes point to complex interactions between multiple aeolian and other geological processes.

Scientists observe aeolian bed forms, or dune-like structures, throughout the solar system in a range of locations, from bodies with only transient atmospheres, such as comets, to places with thick atmospheres, such as Venus and the Earth's ocean floor. Determining the source of sand and the different dune formations that result is thus important to understanding solar system and planetary evolution.

Curiously, aeolian bed forms appear to maintain similar morphologies over a large range in size, from centimeter-scale sand ripples to kilometer-scale megadunes. Their occurrence across environments and their diversity in size suggest that a variety of processes all produce similar landforms. This phenomenon, called equifinality, requires an interdisciplinary approach to research.

To advance understanding of aeolian bed forms and processes, 60 scientists and students representing eight countries (from four continents) gathered in May 2015 in Boise,

Idaho, to discuss remote sensing observations, in situ studies, and computer models of aeolian activity.

The workshop, the fourth in a series focusing on planetary dunes, brought together terrestrial and planetary researchers from diverse backgrounds with the goal of fostering collaborative interdisciplinary research. The small-group setting facilitated intensive discussions of many aspects of aeolian processes on Earth, Mars, Venus, Titan, and even comets.

Transverse Aeolian Ridges

Especially noteworthy discussions were related to features called transverse aeolian ridges (TARs), aeolian bed forms on Mars that may have formed either as large ripples or small dunes. The research on TARs is ongoing, including the recent

hypothesis that TARs may have formed through deposition of dust carried by wind, in a manner comparable to antidunes in a fluvial setting on Earth.

The presence of vast sand seas of large, linear dunes on Titan highlights the importance of understanding megadunes in the solar system.

A field trip on 20 May to the Bruneau Dunes allowed workshop attendees to observe reversing dunes, another possible Earth analogue for TARs.

Importance of Megadunes

The presence of vast sand seas of large, linear dunes on Titan has highlighted the importance of understanding megadunes in the solar system, attendees noted. These landforms, reaching more than 1 kilometer in



Workshop attendee Devon Burr, walking in the saltation cloud on the summit of a dune during the workshop's field trip to Idaho's Bruneau dune field.

width, may be long-lived, yet currently active, and thus can dominate many locations on planetary surfaces.

Speakers highlighted how conditions required for megadune growth are not fully understood, although the importance of winds that elongate the dune through down-axis sand transport is becoming clearer. New studies using fieldwork as well as physical and mathematical modeling are quickly improving understanding of linear dune initiation and propagation.

The Search for Sand Sources

Sand sources for dunes remain an important topic for dune research, as these vary widely. Several talks focused on these diverse sources.

On Earth, most dunes are made from the slow, steady process of the creation of quartz grains through plate tectonics-related uplift and volcanism followed by erosion. On Mars, the sand is basaltic and likely from explosive volcanism, impact cratering, and the action of wind. On Venus there appear to be few dunes, perhaps because atmospheric constraints limit the volume of sand created by explosive volcanism and impact cratering. On Titan, sand production continues to be a question, but ultimately, these materials are thought to be derived from the photodissociation of methane in the upper atmosphere.

For more details, visit http://bit.ly/dunes_workshop.

By **Timothy Titus**, U.S. Geological Survey, Flagstaff, Ariz.; email: titus@usgs.gov; **James Zimbelman**, Smithsonian Institution, Washington, D. C.; and **Jani Radebaugh**, Brigham Young University, Provo, Utah

What Darkens the Greenland Ice Sheet?

Most of the massive ice sheet that covers roughly four fifths of Greenland melts at the surface in summer. As long as the ice sheet regains its mass in the winter, this is not catastrophic. However, if the ice sheet melted entirely, sea levels would rise by more than 7 meters, with obvious and severe consequences for human civilization.

Not surprisingly, scientists are working hard to determine if and when the ice sheet will transition (or if it has already transitioned) from a stable state to a net mass loss state. The impact of increasing greenhouse gas levels on the Greenland ice sheet (GrIS) depends on many complex and interacting factors.

One is the ice sheet's albedo—the fraction of incoming solar radiation that is reflected from the surface of the ice sheet. Indeed, scientists have determined that net solar radiation reaching the ice is the largest contributor to the energy balance driving melting [e.g., *van den Broeke et al.*, 2011]. Despite the crucial role of albedo in energy balance, we have yet to quantify the role of the different processes driving it. Such an understanding is crucial to determining the past behavior of the GrIS and projecting its future contribution to sea level rise.

Scientists seeking to quantify how much various factors contribute to ice sheet albedo face numerous challenges. These include intrinsic limitations in current observational capabilities (e.g., spatial and radiometric resolution of currently available spaceborne sensors) and limitations on how accurately surface energy balance models handle ice sheet albedo. Moreover, the sparseness in space and time of in situ observations of quantities such as impurity concentrations, biological processes, and grain growth impedes our ability to separate their respective contributions to broadband albedo (integrated over the entire spectrum).

Darkening: A Complex Suite of Processes

The GrIS albedo has declined substantially in recent decades [*Tedesco et al.*, 2014], attracting interest from both the scientific community and news media. Media reports, many using the term “darkening,” have emphasized that an increase in light-absorbing impurities, particularly black carbon and dust, in Greenland snow could be responsible for the observed albedo reduction. The idea is that such impurities absorb incoming sunlight, heating up and accelerating snow and ice melt.



Aerial photograph taken on 24 July 2015 over the southwest portion of the Greenland ice sheet, near Kangerlussuaq. The meltwater stream divides dirty ice on the left and metamorphosed snow with a relatively low amount of impurities on the right. Because ice grain growth can reduce albedo, the clean portion might actually absorb more solar radiation than the dirty side. The meltwater streams, the impurities on the ice surface, and the metamorphosed snow all contribute to the processes driving albedo changes.

Surface impurities can indeed reduce albedo in the visible part of the electromagnetic spectrum—light with wavelengths from 400 to 700 nanometers—and make snow and ice appear darker to our eyes. Images of “dirty” snow or ice are therefore visually appealing and can be powerful communication tools.

However, half the solar energy Earth receives is at near-infrared wavelengths (between 700 and 2500 nanometers), which is invisible to our eyes. At these wavelengths, other powerful means of albedo reduction become important. Hence, a comprehensive assessment of GrIS darkening must account for all processes that contribute to albedo reduction. Important factors include snow grain size, the impurity content of snow, biological activity, exposure of bare ice, formation

of melt pools, and the combined effects and feedbacks associated with all of these factors.

We briefly discuss these processes below. We assert that each is potentially significant enough that the scientific community must quantify its role in GrIS darkening. Because each process responds positively to warming (i.e., albedo decreases as warming increases), they are all likely to become increasingly important in the future.

Snow Grain Growth: An Invisible Effect on Albedo

Soon after snow falls, its grains begin to change shape and size. Snow grains become rounded. Large grains grow at the expense of small grains, so the average grain radius increases with snowpack age.



Marco Tedesco

Aerial photograph taken on 24 July 2015 over the southwest portion of the Greenland ice sheet, near Kangerlussuaq. (left) The turquoise color is characteristic of meltwater on the shore of a supraglacial lake. (middle) Area from which the lake water has receded, removing impurities and leaving bare ice. (right) Ice and snow covered by surface impurities.

At near-infrared wavelengths, coarse-grained snow has lower albedo than fine-grained snow. Warming accelerates this snow aging process, leading to further albedo reduction. In melting snow, grains become further rounded and clump into clusters. Thus, there is a positive feedback between warming, snow aging, increased solar absorption, and reduced albedo.

At infrared wavelengths, other powerful means of albedo reduction become important.

Since the reduction of albedo by grain growth is confined to the near infrared, it is mostly invisible to our eyes. This means that a clean snowpack (one with no impurities) that has melted at the surface can have a lower broadband albedo than a cold snowpack with impurities, despite the fact that the clean snowpack might still appear brighter to our eyes.

For pure snow, grain growth from new snow (grains around 0.1 millimeter in radius) to old melting snow (radius around 1 millimeter) can

reduce broadband albedo by around 10%. By comparison, adding 20 parts per billion of black carbon, a concentration typical of those that scientists have found in the top layer of melting GrIS snow in the percolation zone, reduces albedo by only 1% to 2%.

Dirt on the Surface

Light-absorbing impurities such as black carbon, organic carbon, and dust are deposited

on the GrIS from the atmosphere. Over most of the central GrIS, however, the impurity content in cold snow is quite low—about an order of magnitude lower than in the low-altitude Arctic. This is because of the high elevation of the central GrIS: Pollutant fluxes are mostly confined to lower altitudes.

To date, the amount of black carbon in the region of the GrIS that is losing mass, known as the ablation zone, has not been quantified. Measurements here are complicated by com-

plex terrain and by the difficulty of separating black carbon from other particles (e.g., dust) in the snow. Although some scientists have hypothesized that dust may be darkening the ablation zone in southwest Greenland in particular, nobody has quantified the relative roles of black carbon, dust, and other darkening agents in these regions.

Additionally, insoluble impurities concentrate at the surface when snow melts since meltwater percolates down through the snowpack more efficiently than do particulates [e.g., Doherty *et al.*, 2013]. This further lowers the albedo and enhances melting, leading to more consolidation [Flanner *et al.*, 2007].

This positive feedback gives rise to high concentrations of impurities in the ablation zones in particular. Because of this feedback loop, in a snowpack that has partially melted, it is not possible to distinguish whether elevated impurity concentrations caused enhanced melting or resulted from enhanced melting (or both).

Life on Snow and Ice

Organisms on the ice sheet's surface also reduce the ice's albedo. Green, pink, purple, brown, and black pigmented algae can grow in melting snow and ice. On ice, cryoconite (a mixture of dust, pebbles, soot, and microbes) also absorbs sunlight. Furthermore, microbes can bind to particulates like black carbon, retaining them at the surface in higher concentrations than in the parent snow and ice.

As with black carbon, nobody has quantified the magnitude of this source of darkening. As the climate warms and melt seasons lengthen, biological habitats will expand, and their contribution to darkening will likely increase [Benning *et al.*, 2014].

Bare Ice and Water Pools

The exposure of bare ice and development of surface meltwater pools also reduces surface albedo, primarily in the near-infrared but also at visible wavelengths. The total albedo of clean glacier ice is around 60%, compared to 72% for clean melting snow.

Ice albedo decreases further, to between 20% and 50%, when it has high concentrations of impurities, as is common in the ablation zone. The albedo of melt pools is even lower, typically reaching values of 20%–30%.

Meltwater lakes on the ice sheet's margin have also expanded substantially inland to higher elevations with warming, decreasing albedo over sizable areas of the ice sheet [Howat *et al.*, 2013].

Recommendations

To determine exactly what causes the GrIS albedo to change, the scientific community

We need to communicate the important processes involved in albedo reduction to scientists and the general public.

must first quantify the contributions made by all of the processes described above. Currently, no such assessment exists. Instead, black carbon's role in reducing visible albedo has attracted most of the attention. We need to communicate the other important processes involved in albedo reduction to both scientists and the general public.

Remote sensing data can provide large-scale information, at high temporal resolution, on processes occurring on the ice sheet surface. Measuring and attributing albedo variations by means of satellite retrievals is challenging [Warren, 2013], however, because of the relatively low concentration of impurities on the surface of the GrIS and the relatively coarse spatial and radiometric resolu-

tion of satellite observations, among other things. We therefore need airborne campaigns or improved spaceborne sensors to collect finer spectral and spatial remote sensing data sets.

We also need in situ measurements in the GrIS's ablation zone that can distinguish the relative contributions of different impurity types (e.g., black carbon, dust, algae) to albedo reduction as well as models that accurately simulate the GrIS surface energy balance and mass balance. For example, regional climate models need to refine the modeling of snow grain size and exposure of bare ice and need to include impurities and biological activity in their albedo schemes.

A Critical Understanding

Given the role of warming in albedo change and the projections of increased warming and enhanced melting, future changes in the GrIS albedo will likely result largely from warming and associated feedbacks. We need to quantify and understand these feedbacks so that we can assess the energy budget at the ice sheet surface and predict future changes in ice mass.

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DRONE SQUADRON TO TAKE **EARTH MONITORING** TO **NEW HEIGHTS**

By John Selker, Scott Tyler, Chad Higgins, and Michael G. Wing



Drones can be a potentially transformative scientific tool, but operating them comes with numerous challenges.

One of the hottest technology trends of the past few years has been the emergence of the small remotely piloted aircraft commonly known as drones. Buzzing quadcopters have taken the Internet by storm with breathtaking aerial videos of their attempts to deliver packages, beer, and even marriage proposals—but they also have immense potential for Earth science by offering scientists an airborne platform to monitor the environment.

However, drones come at a cost, and they are often difficult for research teams to maintain. Operating them requires competent (and licensed) pilots, navigating relevant regulations (which are still in flux), and the money to purchase both the airframes and the equipment they will carry—all in addition, of course, to the scientific expertise of the researchers themselves.

To help scientists address these challenges, the Center for Transformative Environmental Monitoring Programs (CTEMPs;

<http://ctemps.org/>), a community user facility for environmental sensing supported by the National Science Foundation (NSF), is expanding its instrumentation this year to include drones—also known as unmanned aircraft systems (UASs). It will take on the operational burden and allow researchers to deploy UASs to their Earth study sites, freeing users to focus on their science.

UASs represent a significant advance in remote sensing, with the capability to rapidly deploy and to image terrain at very high resolutions in the visible and infrared spectrum. In particular, they have tremendous potential for environmental monitoring, as they can capture data at scales that are more detailed than traditional aircraft and broader than point sensors. This neatly fills a gap in current instrument capabilities.

Building a Scientific Drone Fleet

Since 2009, the NSF has funded CTEMPs to operate environmental sensing equipment to serve the scientific community, with centers at Oregon State University; University of Nevada, Reno; and Smith College. CTEMPs traditionally deploys fiber optic-based temperature monitoring systems to researchers' field sites across the United States and internationally.

As drones become more widely available, CTEMPs is seeking to expand its instrument suite to include drones capable of covering areas large enough for hydrologic and ecological field studies and observatories—roughly from 1 to 100 square kilometers. In December 2014, NSF awarded funds to CTEMPs, in the new “AirCTEMPs” service package, to add drone operations.

The CTEMPs campuses already have more than a dozen airframes, outfitted with laser terrain scanners (lidar), visible-light cameras, and infrared and thermal sensors. AirCTEMPs staff have obtained dozens of certificates from the U.S. Federal Aviation Administration (FAA) that authorize drone flights in states including Oregon, Nevada, Montana, and Oklahoma.

Drones on Demand

Drones can be a potentially transformative scientific tool, but operating them comes with numerous challenges.

First, UAS equipment is expensive. The current CTEMPs lidar costs almost \$30,000, the monorotor helicopter that carries the lidar is more than \$20,000, and the software to digest these data is another \$10,000.

Second, drones require teams to staff up—for example, currently, most FAA-approved UAS flights in the United States require that two pilots be present. This creates staffing challenges for most university researchers.

Finally, the FAA application process for a Certificate of Authorization to operate a UAS is highly technical and time-consuming. Programming flight paths, organizing the data, and interpreting results requires specialized technical skills that most Earth scientists do not have or need to use on a regular basis.

CTEMPs aims to acquire and operate expensive and sophisticated equipment that would normally be prohibitive for single investigators and make it widely accessible to the community. CTEMPs also focuses on instrumentation that is unlikely to be used continuously by



Chris Sladek tests a small drone at the Reno Remote Control Club's flying site in the Hungry Valley, north of Reno, Nevada. These drones will be sent to Mongolia to photograph giant trout for fisheries research.

David Calvert for Eos

any single investigator. By providing instrumentation when it is needed, the instruments can serve a much larger community.

A Proven Operating Model

CTEMPs launched 5 years ago, applying this operational model to a then new technology—distributed temperature sensing (DTS), which uses fiber-optic cables to record environmental temperatures. Whereas a traditional thermometer takes a measurement at a single point, DTS works by measuring how changes in temperature affect the fiber's optical properties along its entire length. In this way, scientists can obtain tens of thousands of simultaneous measurements to accuracies of nearly 0.01°C.

Although the technology might have great potential, its successful adoption often depends more on the people than the instrument. For example, to successfully use DTS, researchers must understand the optics, cables systems, cross-sensitivities, and performance trade-offs.

Therefore, from the start, CTEMPs has focused on training potential users and has presented 16 multiday hands-on training sessions that have introduced more than 300 users to this technology. To ensure successful instrument deployments, CTEMPs then supports all potential users with extensive online resources (e.g., training videos, data processing scripts, and a compen-

dium of key literature) and direct support from the CTEMPs technical team of engineers, as well as logistical and data support staff.

CTEMP's Scope

The focus on users pays off: Through work on all seven continents and over landscapes ranging from the Dead Sea to Antarctica, more than 60 projects using CTEMPs services and equipment have studied oceanic, atmospheric, geologic, and hydrologic systems. Such research efforts led to the publication of at least 27 peer-reviewed papers in 2014.

CTEMP's expansion into drones follows this same conceptual model and operational philosophy to develop successful deployment of instruments and to ensure that the instrumentation is continuously used. We hope that studies with drones can be as ubiquitous and as fruitful.

CTEMP will also comply with current and future U.S. flight regulations, including securing flight authorization and providing drone pilots and observers for each deployment. The regulatory environment for small drones is rapidly evolving in the United States, and CTEMPs plans to continually update its operational model as these new regulations are adopted.

Flight Tests

As an early test of CTEMP's capabilities combining drones and DTS, investigators from Oregon State University and

CTEMP exists for the benefit of the Earth and environmental science community.

the University of Nevada, Reno, brought a fleet of drones to an active wind farm. The drones lifted a DTS fiber to a height of 120 meters, gathering temperature profiles once every second at a resolution of 0.1 meters to quantify the dynamics of atmospheric mixing caused by large wind farms (see http://bit.ly/drone_video).

CTEMP anticipates having a fleet of three aircraft by late summer 2015 capable of 20- to 40-minute flights with payloads ranging from 2 to 4 kilograms. These aircraft will be capable of surveying regions as large as 200 square kilometers over the course of several days, with the exact flight time depending upon the user's resolution requirements. They will be able to carry lidar and thermal and multispectral sensors and also to capture high-resolution visible imagery.

Using CTEMPs for Your Research

CTEMP exists for the benefit of the Earth and environmental science community, and all workshops, instruments, and advice are available to the research community. It reports to an external advisory panel that includes the Consortium of Universities for the Advancement of Hydrological Sciences, Inc. (CUAHSI). CTEMP also collaborates with its sister facilities, including Incorporated Research Institutions for Seismology (IRIS), the University NAVSTAR Consortium (UNAVCO), the National Center for Airborne Laser Mapping (NCALM), and other federal agencies.

A UAS training workshop, focusing on all aspects of a UAS mission from planning to data analysis, was held on 23-25 June 2015, and CTEMP holds an annual DTS training workshop prior to AGU's Fall Meeting (scheduled in 2015 for 12-13 December).

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Robert Predosa

A remotely controlled quadcopter carries a temperature-sensing fiber-optic cable to investigate atmospheric mixing in an active wind farm.



The background of the page is a painting titled 'Aurora Borealis' by Frederic Edwin Church, 1865. It depicts a dramatic, dark landscape under a night sky filled with vibrant, streaking aurora borealis. The foreground shows a frozen body of water with a small schooner and a sled pulled by a dog, set against a backdrop of rugged, snow-covered mountains.

Aurora Painting Pays Tribute to Civil War's End

By Jeffrey J. Love

This year marks the sesquicentennial anniversary of the end of the American Civil War, a conflict that Abraham Lincoln called a “mighty scourge.” It was one of the most poignant periods in U.S. history, laying bare political, economic, social, and moral divergence between Northern and Southern states. The cause of the divergence that led to war was slavery [e.g., *McPherson*, 1988, chap. 3]—an institution that, by the 19th century, had been effectively abolished in the North but remained firmly entrenched in the South.

War erupted in 1861 after a confederacy of Southern states declared secession from the Union of the United States. When the war finally ended in 1865, the Union had prevailed, and afterward, slavery was

Aurora Borealis, Frederic Edwin Church, 1865. Aurora silently illuminates a barren and frozen world of mountains, a schooner locked in sea ice, and a man with a dog-drawn sled in this richly symbolic landscape painting.

abolished throughout the United States. This outcome was obtained at the cost of 750,000 American lives and substantial destruction, especially in the South [e.g., Gugliotta, 2012].

In 1865, the same year the war ended, the American landscape artist Frederic Edwin Church unveiled *Aurora Borealis* (pictured on the previous pages), a dramatic and mysterious painting that can be interpreted in terms of 19th century romanticism, scientific philosophy, and Arctic missions of exploration. *Aurora Borealis* can also be viewed as a restrained tribute to the end of the Civil War—a moving example of how science and current events served as the muses of late romantic artists [e.g., Carr, 1994, p. 277; Avery, 2011; Harvey, 2012].

Background and Style

Frederic Edwin Church was born in 1826 in Hartford, Conn. His family's wealth enabled him to pursue his interest in art from an early age. When Church was 18, a family friend introduced him to Thomas Cole, a prominent landscape painter who had founded an important American romantic artistic movement known as the Hudson River School [e.g., Howart, 1987; Warner, 1989].

With Cole as his tutor, Church learned to paint landscapes in meticulous detail, emphasizing natural light. Other prominent artists within the Hudson River School included Albert Bierstadt and Thomas Moran, but Church became perhaps the school's most technically accomplished artist [e.g., Huntington, 1966]. In 1849, Church became the youngest artist ever elected as an associate of the National Academy of Design. Public showings of Church's major works were often accompanied by advance publicity and fanfare.

Church was well known for painting large panoramas with waterfalls, sunsets, and high mountains—scenes that appealed to many Americans of the 19th century. The United States was, at the time, seemingly destined for territorial expansion. And although the vastness of untamed wilderness was slowly diminishing, daily life for most Americans remained relatively close to nature. The majority of Americans lived in the rural countryside and worked on farms. Even for those living in cities, the starry beauty of the nighttime sky had not yet been completely obscured.

The Influence of Humboldt

Church's attentive depiction of nature on canvas was inspired in no small part by Alexander von Humboldt, the great Prussian geographer and explorer, who promoted a holistic view of the universe as one giant interacting system. In the early 19th century, Humboldt was a celebrity, and it is noteworthy that Church's personal library included a copy of Humboldt's masterwork *Kosmos* [e.g., Baron, 2005]. A multivolume treatise, *Kosmos* covers an amazing diversity of subjects, many of them scientific but some also historical and cultural. There is even a section devoted to aurorae, which Humboldt understood (correctly) to be related to magnetic storms.

Like other romantic intellectuals of the 19th century, Humboldt believed that one could obtain inspiration and understanding of one's place in the world by studying the cosmos and reflecting on its grandeur [e.g., Walls, 2009]. Humboldt devoted an entire chapter in *Kosmos* to land-



A portrait photograph of Frederic Edwin Church taken between 1855 and 1865.

Library of Congress, Brady-Handy Collection, Washington, D. C.

scape painting, which he said “must be a result at once of a deep and comprehensive reception of the visible spectacle of external nature, and of [an] inward process of the mind” [Humboldt, 1850, part I.II]. In other words, landscape painting can facilitate a contemplation of nature that Humboldt believed could be personally beneficial.

From 1799 to 1804, Humboldt traveled extensively in South America, mapping rivers, measuring mountains, and cataloging flora [e.g., Gillis, 2012]. Half a century later, Church followed some of Humboldt's journeys, visiting many of the places Humboldt had visited, painting many of the same mountains and waterfalls that Humboldt had seen and sketched. Subsequently, in his own continuous search for the sublime, Church turned his attention northward, visiting Labrador, Canada, in the summer of 1859, where he sketched and painted icebergs and, not surprisingly, witnessed beautiful aurorae [Noble, 1861].

The Scene of *Aurora Borealis*

After the Battle of Gettysburg in July 1863, it would have been reasonable to predict Union victory in the American Civil War [e.g., McPherson, 1988, chap. 21]. In that same year Church began working on *Aurora Borealis*, assembling elements taken from different sources to form what is essentially a fictional scene [e.g., Truettner, 1968]. The painting, oil on canvas, is physically large: 143 × 212 centimeters. From an elevated and exhilarating perspective, we look out over a far northern, nighttime scene. Auroral light casts a pale illumination across a still world of barren mountains and a broad expanse of frozen sea. In the fore-

ground, we see a small boat and a man with a dog-drawn sled.

Church never saw the landscape presented in *Aurora Borealis*. As it happened, Church taught the arctic explorer Isaac Israel Hayes the fine arts of drawing and painting. Church and Hayes became close friends, and the landscape in *Aurora Borealis* is based on drawings made by Hayes during an 1860 expedition [e.g., *Truettner*, 1968]. The ice-locked boat is Hayes's schooner, the *United States* [Hayes, 1867, p. 211]. The mountains are a depiction of those on Ellesmere Island, the northernmost land in Canada. And in the background is a sharp peak that Hayes called Church Peak (81.26°N, 65.62°W), named in honor of his friend and art instructor [Hayes, 1867, p. 351].

With respect to the auroral light depicted in *Aurora Borealis*, Church might very well have recalled the brilliant displays of aurora borealis that came before the war in August and September 1859. These were caused by solar and magnetic storm events that are now collectively called the Carrington event [e.g., *Clark*, 2007].

The 1859 aurorae were widely reported in newspapers and seen across the United States, even in the South, where some observers interpreted them as portending war [e.g., *Love*, 2014]. Still, it is worth recognizing that Church would have seen aurorae many times while living in New England and New York and during his trips to Labrador. Indeed, the shape of the auroral arc in *Aurora Borealis* is taken from a sketch that Church made in September 1860 while visiting Maine [e.g., *Truettner*, 1968, note 36].

Artistic License

When *Aurora Borealis* was first publicly displayed in March 1865, a reviewer described its depiction as “beauteously strange aerial phenomena ... rendered with wonderful vividness and delicacy of feeling” [Bayley, 1865, p. 266]. Church's artistic abilities were certainly impressive, but we can recognize that Church did not necessarily strive to depict nature with rigorous accuracy. He was an “interpreter of nature, rather than a transcriber” [Warner, 1989, p. 185].

Church painted the rays of the aurora converging toward a vanishing point on the horizon. Normally, auroral rays result from charged particles descending from the magnetosphere into the atmosphere, guided along the field lines of the Earth's magnetic field. On their way down, collisions between these particles and atmospheric molecules cause the charged particles to glow. The magnetic field lines descend at high latitudes and converge toward the magnetic poles. Thus, normal artistic perspective would show

aurorae near the horizon as curtains with vertical rays; otherwise, auroral rays would appear to converge to a vanishing point high overhead, essentially orthogonal to the depiction chosen by Church.

Perhaps Church was using the rays of the auroral arc to convey the sense of a broad panorama, with us, the observers, at its center. Or he may have simply intended to draw our attention from the heavens above down to the Earth and humankind below.

Some of Church's manipulation of form might reflect the fact that *Aurora Borealis* was executed simultaneously with another painting, *Rainy Season in the Tropics*, which shows a double rainbow over a Central American mountainscape. The two paintings, both crowned by curving arcs of light, are complementary [e.g., *Avery*, 2011; *Harvey*, 2012]—one shows night, the other day; one depicts a high-latitude scene, the other low; one is cold, the other warm.

Another curiosity is the color palette of *Aurora Borealis*. The dominant color in auroral light is usually green, emitted by atomic oxygen at a wavelength of 557.7 nanometers. Yet Church largely omits green from *Aurora Borealis*, placing emphasis on red, blue, and yellow light. Furthermore, auroral light is usually seen as a sort of vertical stack of colors, with red light on top, blending into green and then blue and sometimes dark red on the bottom. In contrast, Church shows an auroral arc with red light at the same horizontal level as blue.

Interpreting *Aurora Borealis* as a Civil War Icon

Aurora Borealis is thick with symbolism. The auroral arc of light encompasses a dark void in the sky that might represent the uncharted north or some greater unknown. Below this, and at the foot of dark mountains, Church depicts humanity—the forlorn man with his sled dogs—as tiny and seemingly insignificant (see detail). The challenge of exploring the unknown is represented by the placement of the schooner: locked in the ice, facing a vast frozen sea. Its crew might be in search of the Northwest Passage or the mythical ice-free polar sea [Hayes, 1867]. They may or may not succeed in their search; regardless, the universe will carry on. Still, despite seemingly overwhelming challenges, there is a small sign of optimism: light shines through a window on the ship.

Such a summary is straightforward and consistent with traditional romantic ideas, but it is possibly not the whole story behind *Aurora Borealis*. Some art historians see the social and political tension and turbulence in mid-19th century America reflected in landscape paint-



Smithsonian American Art Museum, Washington, DC/Art Resource, NY

Detail from *Aurora Borealis*, showing an ice-bound schooner and a man with a dogsled. In this painting, humanity is depicted as tiny and seemingly insignificant.

ings of the era [e.g., Harvey, 2012]. Although Church never commented on the meaning of his paintings and he left few written records, we can contemplate the possibility that Church intended to paint something rather profound in *Aurora Borealis*. Considering the circumstances of the time, it is not much of a stretch to interpret *Aurora Borealis* as a tribute to an expected end of the American Civil War.

If Church meant the light in *Aurora Borealis* to be a metaphor for the end of the Civil War, then he was in the company of poets. Herman Melville, author of the epic novel *Moby Dick*, penned a melancholy poem on the course of the war entitled “Aurora-Borealis” [Melville, 1866], writing of a supernatural march of a “million blades that glowed” and which had been disbanded with the rising Sun of the war’s end. Christopher Cranch, a preacher and fellow painter from the Hudson River School, wrote of the injury and seeming necessity of the war in “The Dawn of Peace” [Cranch, 1890]: “We wake to see the auroral splendors stream across the battle smoke from opening skies. The demon, shrieking, tears us as he flies exorcised from our wrenched and bleeding frame. O costly ransom!”

Church certainly harbored nationalistic feelings. This is vividly demonstrated in his 1861 painted sketch entitled *Our Banner in the Sky*, where an American flag is seen as a miraculous materialization in the sky from white

clouds, the red light of a sunrise, a convenient patch of blue sky, and a bright star. It was an unsophisticated, but popular, piece, resonating with the flag adulation emotion that had swept through the North soon after the war started [e.g., Burke, 1982; Avery, 2011]. But the war did not, as many had hoped, come to a quick and tidy end. Instead, it continued on until 1865, after the toll of destruction and death had reached frightening levels.

In contrast to the overtly nationalistic *Banner*, the message of *Aurora Borealis* is subdued, even ambiguous [e.g., Avery, 2011]. A visitor to Church’s studio who saw *Aurora Borealis* in March 1865 likened it to the frozen ninth circle of Dante’s *Inferno*, a terrible place for those who have committed treachery; the same visitor even suggested that such might be the fate for the entire nation [Barbone, 1865]. Some have suggested that the drapery of light in *Aurora Borealis* represents the American flag [e.g., Carr, 1994, p. 277]. If so, then it has been unfurled across a cold and barren landscape, not in extravagant celebration of the war’s anticipated end, but in subdued and somber recognition of the reality of postwar desolation and an uncertain future.

Acknowledgments

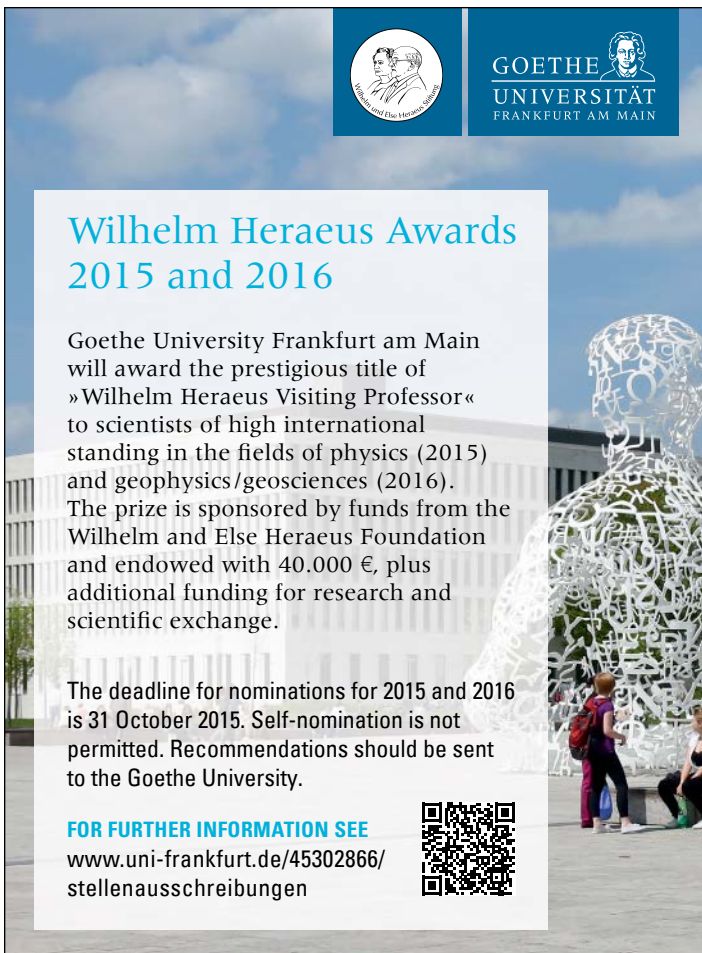
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Riding a “Roller Coaster” at *National Geographic*

The elevator dings and I step out, glancing one last time at the historical black-and-white photos lining the corridor one floor below the *National Geographic* offices. I wander down the dim hallway and enter an office with a sign marked “security.” Reluctantly, I hand over my credentials that identify me as a member of the *National Geographic* family.

“Is that it?” I ask the security guard at the desk.

“That’s it,” he says.

That moment marked the end of my roller coaster ride in a fellowship program with the American Association for the Advancement of Science (AAAS) in which scientists work summer stints as reporters in news outlets across the country.

Fellows in the AAAS Mass Media Science and Engineering Fellows Program (<http://bit.ly/MMFprogram>) learn how to communicate science to the public and, at the same time, lend valuable scientific expertise to newsrooms.

AGU sponsored me in this intense 10-week welcome to the ups and downs of journalism.

Need for Speed

Writing breaking news is a sprint: contacting experts, scanning published coverage, and pounding out 600 words or less in a matter of hours. My heart often raced as I wrote these

articles. One afternoon, with only a couple of hours to deliver a story about the Curiosity rover’s third anniversary on Mars, my editor and I worked on the document simultaneously: She edited each section immediately after I wrote it.

Writing about scientific papers moves at a slower pace, requiring finesse to transform complex research into conversational stories. As the reporter, I sifted through details, extracting only the most salient points and incorporating just enough background to help the audience understand the science.

Although more leisurely to produce than breaking news, these paper-centric stories don’t rank as the slow food of the journalism world. Reporters get access to peer-reviewed articles for only a short period at best before public release. Stories must be polished and ready to go as soon as any embargo lifts, else risk getting buried under a barrage of timelier pieces.

Across my *National Geographic* desk also came stunning photos or viral videos and the task of quickly explaining their underlying science in a light-hearted, punchy article.

Last, there were enterprise stories, as my editor called them—bigger projects like writing up a budding field of research or digging into some intriguing scientific question triggered by other discoveries. Those were the toughest

stories for me to discover and develop from the endless and ever-changing mass of scientific literature. But they could be the most rewarding to write.

Highs and Lows

Every flavor of story at *National Geographic* offered its own subtleties and joys. And I savored each one that came my way. (Visit <http://bit.ly/wei-haas> to read my stories from the *National Geographic* newsroom.)

I’m not saying the fellowship wasn’t a challenge. During this thrilling ride, there were definitely times when it seemed to go off the rails. For one week in the middle of the summer, everything ground to a halt. I just couldn’t find a story to write and ended each

I love using science to explain all the amazing and puzzling oddities of our world.

day with the sinking feeling that I was an imposter. But by the end of my 10 weeks as a reporter, I started to fall into a rhythm, savoring the anticipation of mounting each hill and then joyfully plunging into another madcap assignment.

To Do or Not to Do

On my last day at *National Geographic*, one of my editors asked me to write about one last viral video—this one of a great white shark that was supposedly the largest ever filmed. As I scrambled to find experts to interview and assembled my notes into a story, I kept thinking how I never wanted this to end.

I love doing science: the instruments quietly humming in the lab, with their promise of eye-opening data; the endless sizes and shapes of glassware, begging for creative experiments; the trials and tribulations of fieldwork in unspeakably gorgeous locations.

But this summer I discovered that even more than doing science, I love using science to explain all the amazing and puzzling oddities of our world to anyone willing to listen.

Though turning over my badge at the *National Geographic* security office felt like the end of an epic adventure, my story is not over yet. Last month I started as an assistant web editor for Smithsonian.com.



Greta Weber

Maya Wei-Haas holds up a copy of *National Geographic* at her desk at the magazine where she wrote science stories this summer as AGU’s 2015 Mass Media Fellow.

By **Maya Wei-Haas**, AGU 2015 Mass Media Science and Engineering Fellow; email: mweihaas@gmail.com

AGU Sections and Focus Groups Announce 2015 Awardees

Lu Receives the 2015 James R. Holton Junior Scientist Award

Chunsong Lu will receive the 2015 James R. Holton Junior Scientist Award at the 2015 AGU Fall Meeting, to be held 14–18 December in San Francisco, Calif. The award recognizes “outstanding research contributions by a junior atmospheric scientist within three years of his or her Ph.D.”



Chunsong Lu

Citation

The Atmospheric Sciences section of AGU is pleased to present the 2015 Holton Junior Scientist Award to Dr. Chunsong Lu, Nanjing University of Information Science and Technology, for “his original contributions in observational and modeling studies of cloud microphysics, turbulent mixing, and convective entrainment.”

Chunsong has demonstrated exceptional purposefulness, creativity,

and originality in the challenging and critical problems of convective entrainment, turbulent mixing processes, and their interactions with cloud/fog microphysics. Following from his Ph.D. dissertation, Chunsong has (1) proposed new dynamical and microphysical measures to quantify different mixing mechanisms that likely occur in ambient clouds, (2) developed a new parameterization for mixing mechanisms based on the relationship between the two measures, (3) elucidated the effects of secondary entrainment-mixing events on the new parameterization, (4) proposed an approach for distinguishing and linking entrainment mixing and collision coalescence in clouds, and (5) explored the scale dependence of mixing mechanisms. In the words of one of the supporting letters, Chunsong’s work “opens the door for possible routine monitoring of entrainment profiles using environmental soundings and surface-based microwave radiometer remote sensing of cloud liquid water content.” His research has tremendous implications for improving cumulus parameterization in global climate models, for improving the representation of intrinsic atmospheric convective processes from the diurnal cycle to the Madden-Julian Oscillation.

In his very young scientific career, Chunsong has already published a total of 35 peer-reviewed papers; for 18 of them, he has the prestigious role of first author. He is the principal investigator of many research projects and the recipient of numerous awards, including, among others, an AGU Outstanding Student Paper Award and the Meteorological Science Award for Young Scientists from Peking University, China. In summary, Chunsong’s accomplishments are truly outstanding on several fronts, including academic research and leadership, which epitomize the spirit of the Holton Award.

We are extremely pleased to present the Atmospheric Sciences section Holton Junior Scientist Award to Dr. Chunsong Lu.

—William K. M. Lau, *University of Maryland, College Park*

Response

It is a great honor to be selected as the 2015 Atmospheric Sciences section Holton Award honoree. The prestigious award named after James Holton is particularly inspiring at this early stage of my career.

I thank the Atmospheric Sciences section of AGU and the members of the award committee for the award. I am truly grateful to my two dissertation advisers; I thank Dr. Shengjie Niu at the Nanjing University of Information Science and Technology, China, for his constant and invaluable guidance

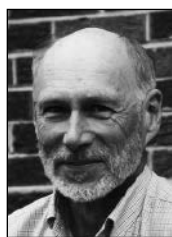
and help and Dr. Yangang Liu at Brookhaven National Laboratory, United States, for giving me the freedom and encouragement to explore the research topics of my interest. I am grateful to the two institutions and fortunate to have worked with many outstanding colleagues. I am also grateful to my family and my friends for their unconditional support at home as well as abroad.

I have been focusing on understanding entrainment-mixing processes, turbulence, and their interactions with cloud physics and trying to improve their representation in climate and weather prediction models. I regard the prestigious Holton Award as an encouraging message from the scientific community and will continue to pursue the challenges in atmospheric science.

—Chunsong Lu, *Nanjing University of Information Science and Technology, Nanjing, China*

Holben and Zerefos Receive 2015 Yoram J. Kaufman Unselfish Cooperation in Research Award

Brent Holben and Christos S. Zerefos will receive the 2015 Yoram J. Kaufman Unselfish Cooperation in Research Award at the 2015 AGU Fall Meeting, to be held 14–18 December in San Francisco, Calif. The award recognizes “broad influence in atmospheric science through exceptional creativity, inspiration of younger scientists, mentoring, international collaborations, and unselfish cooperation in research.”



Brent Holben

Citation for Brent Holben

The AGU Atmospheric Sciences section is pleased to present the 2015 Yoram J. Kaufman Unselfish Cooperation for Research Award to Brent Holben of the Goddard Space Flight Center, NASA, for “his seminal theoretical and experimental contributions to the remote sensing of clouds and aerosol properties, particularly in the development of AERONET.”

Brent’s vision and pioneering work led to the creation of the AERONET (Aerosol Robotic Network) project in which a worldwide network of Sun/sky radiometers enabled observations of the aerosol optical thickness, size distribution, and refractive index at numerous sites around the world. AERONET is the first and continues to be the only global network of ground-based aerosol measurements, embraced and supported by countries and scientists throughout the world. Throughout his illustrious career, Brent has taken special pride in working with students and collaborating with a large number of scientists in Europe, the United States, South America, Africa, and

Asia. He has published journal articles with over 700 different scientists, including scientists from more than 50 countries. As of March 2015, he has 27,970 article citations, with an h-index of 79, and his work has penetrated the communities of ground-based and satellite remote sensing of aerosol properties. Among his 372 publications to date, his singular AERONET overview paper of 1998 has garnered over 2420 citations alone—a rare record in the field of geosciences.

The following statements from one supporting letter succinctly summarize Brent’s spirit of unselfish collaboration: “Brent has always been exceedingly generous with his time, with his knowledge and with his resources. ... I was a recipient of Brent’s mentoring and encouragement, even through some tough times.”

Another supporting letter stated, “It is beyond my imagination what formidable tasks Brent has faced in establishing and operating all of these AERONET sites for the past two decades. The most challenging among all tasks is undoubtedly countless travels required to set up, inspect and trouble-shoot any problems that arise.”

We are extremely pleased to present the 2015 Kaufman Award to Brent Holben.

—William K. M. Lau, *University of Maryland, College Park*

Response

It is indeed a great honor for me to receive the Kaufman Award. I worked with Yoram, who shared his intellect, insight, and unbridled curiosity with all he touched. For me, this honor is an opportunity to recognize the very large and diverse community that shaped my oftentimes circuitous career through their generous cooperation. My work is most easily road-marked by the ground-based Aerosol Robotic Network (AERONET).

Although I can't possibly acknowledge all those who influenced my career, I would like to cite a few here, including my older brother, Rick, who blazed the path from farm to academia. My colleague Compton Tucker inspires science with art, humor, and friendship. Robert S. Fraser, a pioneer in the field of aerosol remote sensing, spent endless hours with me shaping my early understanding of remote sensing science at NASA. Yoram, from the Goddard Space Flight Center, and Didier Tarré, from Laboratoire d'Optique Atmosphérique (LOA), were ever present in the formative years of AERONET, and indeed, LOA remains an integral part of the global AERONET program today. The AERONET folks at Goddard are brilliant and dedicated, led by Tom Eck and Ilya Slutsker, who have been with the program from the beginning. Michael King, from the Earth Observing System (EOS) Project Science Office, provided the resources, intellect, and autonomy to allow the project to grow to a global resource for the remote sensing community.

Thus, my job was simple: use AERONET to understand aerosol properties for satellite validation. The project expanded, the collaborations grew, and research flourished. I have been extremely fortunate to be affiliated with NASA, researchers, educators, students, and movers of various types in over 80 countries. It is those people who have participated with me, the AERONET program, and like-minded researchers across the globe to foster aerosol research for the benefit of all. It is in recognition of those people that I humbly accept this honor inspired by Yoram and as a tribute to his legacy of selfless cooperation.

—Brent Holben, NASA Goddard Space Flight Center, Greenbelt, Md.



Christos S. Zerefos

Citation for Christos Zerefos

The AGU Atmospheric Sciences section is pleased to present the 2015 Yoram J. Kaufman Unselfish Cooperation in Research Award to Professor Christos Zerefos, Research Center for Atmospheric Physics and Climatology, Academy of Athens, for “his outstanding contributions in advancing the sciences of ozone, aerosols and ultraviolet radiation through international col-

laborations.”

Professor Zerefos is known internationally for his research in stratospheric ozone depletion and his studies demonstrating the interconnections between ozone, tropospheric aerosols, and ultraviolet radiation. Over the past several decades, he has been a leading force in developing and promoting ozone and ultraviolet radiation measurements in Greece and around the world.

Professor Zerefos has over 200 publications in peer-reviewed journals, about 25% of which are in AGU journals. These publications are only a small part of his contributions to the advancement of ozone science. Most important, throughout Professor Zerefos's career, he has worked tirelessly to train and promote young scientists, including developing numerous research programs at traditionally non-research institutions. He has organized several large international ozone conferences, including the 1988 and 2004 Quadrennial Ozone Symposia and a symposium to celebrate the 20th anniversary of the Montreal Protocol. In recognition of his leadership, he was elected president of the International Ozone Commission in 2008.

Professor Zerefos's record of research and service in ozone studies was recognized at the 10th anniversary of the Montreal Protocol with the award of the prestigious United Nations Environment Programme Global Ozone Award. In addition to his role as both scientist and mentor, Professor Zerefos has applied this scientific expertise in the service of the government of Greece and the European Union (EU). He served as an adviser at the ministerial level on ozone deple-

tion and ultraviolet B threats and as the science-policy interface at the EU with similar responsibilities.

In the words of one of the supporting letters, “his knowledge and enthusiasm in promoting atmospheric science were an inspiration for all who came in contact with him, particularly the young generations of atmospheric scientists.”

We are extremely pleased to present the 2015 Kaufman Award to Professor Christos Zerefos.

—William K. M. Lau, University of Maryland, College Park

Response

It is a great honor for me, and I am humbled to receive the 2015 Yoram Kaufman Award from AGU. I was even more touched when one of several supporters of my candidacy congratulated me by saying that “I think that you really deserve this recognition on a great research carrier and service to our community. It is very rare that a non-American wins such an AGU prize, making it even more special.”

Among other awards, I will particularly treasure this award because it will remind me of the decades of collaboration with both younger and elder colleagues in a period when man-made global changes have been on the front page in all international media. I would like to thank my colleagues who have offered me this honor, which also treasures the memory of an important scientist and colleague, who left us tragically in 2006, Yoram Kaufman.

Not only tragedy but also the science of the atmosphere and the observations of our environment have been invented and thoroughly studied in Greece in the past 25 centuries. My base of activities has always been in this beautiful, but unfortunate in history, country. Working always with the international community on the complex processes in nature kept me and still keeps me involved in the fast-growing scientific cloud of global change.

Today's research can be successful only through team work, something that I have incorporated in all my life. This is why I feel great respect for all the excellent scientists with whom I have collaborated over the past 40 years. As Socrates said, “γῆράσκω αἰὲ διδασκόμενος” (“As I age, I always learn”).

—Christos S. Zerefos, Academy of Athens, Greece.

Fan, Gettelman, Robinson, and Steiner Receive the 2015 Atmospheric Sciences Ascent Award

Jiwen Fan, Andrew Gettelman, Allen L. Robinson, and Allison L. Steiner will receive the 2015 Atmospheric Sciences Ascent Award at the 2015 AGU Fall Meeting, to be held 14–18 December in San Francisco, Calif. The award recognizes “research contributions by exceptional mid-career scientists in the fields of atmospheric and climate sciences.”



Jiwen Fan

Citation for Jiwen Fan

The Atmosphere Sciences section of AGU is pleased to award one of the four 2015 Ascent Awards to Dr. Jiwen Fan of the Atmospheric Sciences and Global Change Division, Pacific Northwest National Laboratory (PNNL) for “her outstanding contributions in improving understanding of fundamental physical processes in aerosol-cloud interactions.”

Jiwen's research covers a broad scope ranging from tropospheric chemistry to aerosol-cloud interactions. Among her most impressive contributions is her dedicated effort in providing better understanding of aerosol effects on deep convective clouds. Over the last 10 years, she conducted a series of seminal studies in which she used advanced methodologies and computationally intensive modeling tools to demonstrate how aerosols can impact convection, clouds, weather, and climate through various mechanisms. Of these studies, her findings that vertical wind shear is one of the key environmental factors deter-

mining whether aerosols invigorate or suppress convection and that aerosol microphysical invigoration is a dominant mechanism explaining the ubiquitously observed increase of cloud cover and cloud top height by aerosols are widely recognized. Additionally, Jiwen has also been at the forefront of addressing the challenge of improving cloud microphysics parameterizations, particularly on ice nucleation for models.

Her accomplishments and contributions are succinctly summarized in a statement in one of her supporting letters: “I consider that the combination of the breadth, productivity, and impact of her research most uniquely distinguishes her from most of her peers.” Another stated that “she is the most creative, productive, and diligent young scientist I have ever known and worked with.”

We are extremely pleased to present a 2015 Atmospheric Sciences Ascent Award to Dr. Jiwen Fan.

—William K. M. Lau, University of Maryland, College Park

Response

Thank you, Bill, for the generous citation. I am honored to be selected as one of the recipients of the Ascent Award. I am grateful to the AGU Atmospheric Sciences section and the selection committee for this recognition. I humbly accept on behalf of the many people who helped make this possible. Deepest thanks to Zhanqing Li for the nomination and to Daniel Rosenfeld, Bob Houze, and Gerald North, who wrote supporting letters.

I am extremely grateful to my Ph.D. dissertation adviser, Renyi Zhang, for introducing me to the atmospheric field, mentoring me in my efforts to become a scientist, and guiding my career development over the years. I extend many thanks to my postdoc mentors Jennifer Comstock and Mikhail Ovchinnikov for bringing me to PNNL and to the field of atmospheric observation.

I consider myself very fortunate to be able to sustain long-term collaborative relationships with several people through working on challenging problems in the field of aerosol-cloud-climate interactions. I would like to mention especially Zhanqing Li, Danny Rosenfeld, Ruby Leung, Alex Khain, Wei-Kuo Tao, and, more recently, Guang Zhang, Kuan-Man Xu, and Steve Ghan. Whatever success I have had in research is due in large part to them, as well as to my past and current postdocs, visiting scientists, and graduate students. I hope that we are able to keep working together in the future as well.

In my very early career, I learned a lot from colleagues in Renyi's group, Wei-Kuo Tao's group, and Zhanqing's group, and I appreciate their help and collaboration. I wish to thank my PNNL colleagues and managers for their help and support of my professional growth.

I also want to thank Department of Energy program managers Ashley Williamson, Sally McFarlane, Renu Joseph, and Dorothy Koch and PNNL project managers Ruby Leung, Steve Ghan, and Jerome Fast for their funding support of my research.

Finally, I want to thank my family, my parents, sisters, and brother and my husband and our two sons, for their love and support.

—**Jiwen Fan**, *Pacific Northwest National Laboratory, Richland, Wash.*



Andrew Gattelman

Citation for Andrew Gattelman

Andrew is best known for his powerful contributions to the understanding of exchange processes between the stratosphere and troposphere and the representation of clouds in global climate models. His work led to substantially improved understanding of the mechanisms responsible for the dehydration of air entering the

tropical stratosphere. His transformative studies on the tropical tropopause layer helped define a new research area. "Andrew's studies on tropical tropopause layer, cloud microphysics and aerosol-cloud interactions place him at the top of his field," stated one of the supporting letters. His nominator pointed out that "Andrew's work is unique in that it links basic processes and observations with global models. Andrew is an exceptional scientist: I know very few

atmospheric scientists at his stage of career whose accomplishments have Andrew's breadth and depth."

We congratulate Dr. Andrew Gattelman, winner of a 2015 Ascent Award "for outstanding contributions to the understanding of stratosphere-troposphere exchange and modeling and understanding of cloud effects in the climate system."

—**William K. M. Lau**, *University of Maryland, College Park*

Response

It is a great honor to receive this award. I have been fortunate in my career to have had the support and the opportunity to learn from some fantastic mentors. These include some who are no longer with us. I want to recognize the enduring impact of Professor Jim Holton, my adviser, and Dr. Byron Boville, one of my postdoctoral supervisors and mentors as a young scientist. I learned from them explicitly and by example not just how to do research but to conduct science collaboratively. Their examples taught me how to critically work with data and models together and also how to work with a community of researchers.

Science, particularly atmospheric science, does not take place in a vacuum. I have also been privileged to work with expert collaborators over the years as well, from whom I have learned much, including Qiang Fu, Bill Randel, Phil Rasch, Hugh Morrison, and Vincent Larson. I thank many different other mentors at the National Center for Atmospheric Research and beyond for believing in me and supporting my work and providing an exciting and amazing environment in which to conduct research and a platform for collaborating with and communicating that research to others.

I hope I can justify my colleagues' confidence in me with high-quality and impactful future research and by instilling in the next generation of scientists some of the things that I have learned from the previous generation.

Finally, I wish to thank my family, especially my wife, Francesca, and our kids, Fiona and Natalie, for their support and willingness to explore new opportunities and new places with me as I have collaborated with other researchers around the world.

—**Andrew Gattelman**, *National Center for Atmospheric Research, Boulder, Colo.*



Allen L. Robinson

Citation for Allen L. Robinson

Allen Robinson has transformed our understanding of primary aerosol emissions. Fine particles dominate uncertainties in climate forcing and health effects from pollution. Atmospheric evolution receives substantial focus, but sources are often neglected. This is a pity; without good emissions data, model results are guaranteed to be garbage. For whatever reason, particle nucleation is a hot topic generating frequent papers in *Science* and *Nature*, but primary emissions are an "engineering" problem. Robinson et al. (*Science*, 2007, doi:10.1126/science.1133061) is a counterexample. Allen's paper established that primary organic emissions are substantially semivolatile, with a great deal of evaporation happening while plumes dilute down to ambient conditions, along with simultaneous oxidation chemistry driving recon-

densation of organic oxidation products as secondary organic aerosol.

denation of organic oxidation products as secondary organic aerosol.

Allen and his research group have systematically explored this cycle of emission, evaporation, oxidation, and secondary condensation for major primary organic aerosol sources. Another paper in *Science* (Jimenez et al., 2009, doi:10.1126/science.1180353) put into context ambient observations using an aerosol mass spectrometer, which almost always reveal that most organic particulate matter is highly oxidized, with only a small fraction consisting of reduced material characteristic of primary emissions. This contradicts predictions by chemical transport models representing the state of the art in the mid-2000s that most organic aerosols were primary. The Robinson cycle was key to resolving this apparent contradiction. The same cycle also explains aerosol observations off of the Deep Water Horizon spill (de Gouw et al., *Science*, 2011, doi:10.1126/science.1200320).

Allen is a fantastic colleague and collaborator. Collaboration comes so easily that it is hard to write the detailed management plans for proposal calls that presume it is hard; "he sits on the couch in my office and we figure it out" does not always review well. He sees real-world problems with clarity and depth and makes the work easy and fun.

—**Neil M. Donahue**, *Carnegie Mellon University, Pittsburgh, Pa.*

Response

I am grateful for and humbled by the acknowledgement of this award. Thank you to my nominators and the AGU Atmospheric Sciences section awards committee for this honor.

I have so much appreciation for all of those who have influenced my path, starting with my mother, my uncle (Nick Latham), and my grandfather (Allen Latham Jr.). They instilled a love for the outdoors and engineering. I was introduced to environmental engineering as student at Stanford and Berkeley. As a postdoctoral fellow at Sandia, I learned about combustion and emissions. I am grateful for sage advice from my mentors (Gil Masters at Stanford, Rich Sextro and Bill Nazarroff at Lawrence Berkeley National Laboratory/University of California, Berkeley, and Larry Baxter at Sandia).

My career took a strong turn toward the atmosphere when I joined the faculty at Carnegie Mellon. The Environmental Protection Agency had recently promulgated a new standard for fine particulate matter. I can still remember my lunch with Spyros Pandis that started me down the path of characterizing particle emissions from combustion systems. I cannot thank my colleagues at Carnegie Mellon enough—Spyros Pandis, Cliff Davidson (now at Syracuse), Neil Donahue, and Peter Adams. I attribute much of my success to our vigorous collaboration. I especially want to thank Neil, with whom I have explored problems ranging from organic aerosols to bike wobble. He is an incredible colleague. I also want to thank my many other colleagues at Carnegie Mellon and other institutions with whom I have worked and from whom I have learned over the years. Finally, none of this would have been possible without the many fantastic students and postdocs with whom I have had the honor to work. It really takes a village.

To my amazing and supportive wife, Kathy, and our two sons, Jack and Gus, thank you for being a constant source of joy.

—**Allen L. Robinson**, *Carnegie Mellon University, Pittsburgh, Pa.*



Alison L. Steiner

Citation for Allison Steiner

The Atmosphere Sciences section of AGU is pleased to award one of the four 2015 Ascent Awards to Professor Allison Steiner, Department of Atmospheric, Oceanic and Space Sciences, University of Michigan, for "her outstanding contributions to interdisciplinary studies encompassing biosphere-atmosphere interactions, regional climate, air-quality and chemistry-

climate connections."

Dr. Steiner is a world leader in the field of biosphere-atmosphere interactions. She employs a variety of tools and techniques involving both physical and chemical process models, regional chemistry-climate models, and laboratory measurements. With these tools, she has positioned her research group for decades of discovery at the intersection of fields often considered separately, including climate, atmospheric chemistry, air pollution, and land-biosphere-atmosphere exchange. Allison's scientific leadership, communication skills, and engaging personality make her a highly sought after speaker at major conferences and workshops. As a testimony to her stature in the field, she was invited by the National Science Foundation and the National Research Council to serve on a highly visible National Academies of Sciences, Engineer-

ing, and Medicine panel tasked to help chart the future path for the atmospheric chemistry discipline.

In addition to her outstanding research contributions, Allison has also been a pioneer and leader in strengthening the geoscience community. Examples include serving as founder and leader of the Earth Science Women's Network and as editor for *Journal of Geophysical Research: Atmospheres*, with special responsibility in biosphere-land-atmosphere areas.

We are extremely pleased to present a 2015 Atmospheric Sciences Ascent Award to Professor Allison Steiner.

—William K. M. Lau, *University of Maryland, College Park*

Response

Thank you very much for this award, and I am very grateful to my nominators and the Atmospheric Sciences section awards committee for this honor. I pursued a degree in atmospheric sciences as a way of trying to understand the world around me—looking up at the sky, watching the trees, and visualizing the chemistry of these interactions are a constant source of inspiration to me.

This award is particularly meaningful to me as I realize that this pursuit is as much about the scientific community as it is about the science, and I would not be at this point without this community support. I would like to thank my dissertation adviser at Georgia Tech, Bill Chameides, for allowing me to find my own scientific path and providing an

amazing example of the ingenuity and commitment required for this career. I thank my postdoctoral advisers at the University of California, Berkeley, including Allen Goldstein, Ron Cohen, and Rob Harley, as well as Inez Fung for providing an extremely exciting and rewarding place to be a postdoc. I would also like to thank my colleagues at Michigan and members of my research group over the past 10 years for helping me to grow as a scientist and develop the research that is being honored today. And perhaps just as important as the formal mentors has been my peer network, including the founding members of the Earth Science Women's Network (ESWN). ESWN grew out of conversations at a 2002 AGU meeting, and these women continue to advise and inspire me throughout my career.

Finally, a special thank you to my family and my husband, Deryl Seale, for his constant support and covering childcare to enable me to take "just one more trip."

—Allison L. Steiner, *University of Michigan, Ann Arbor*

Visit <http://eos.org/agu-news> to read more announcements of AGU section and focus group awards.

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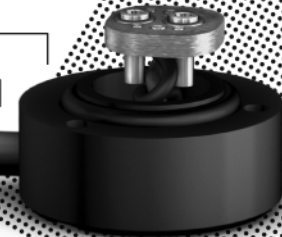
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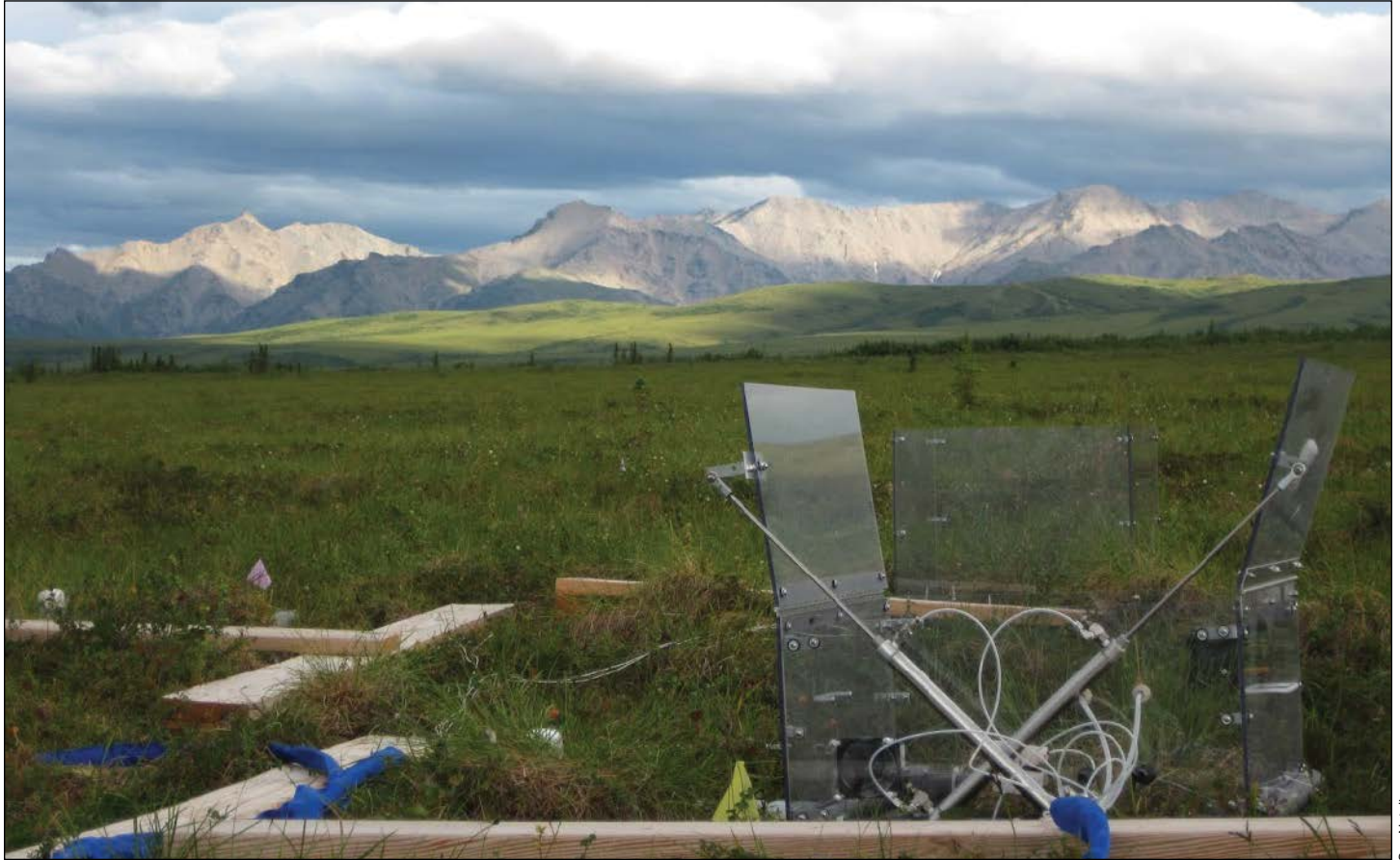
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Simulating a Warmer, Drier Arctic



Sue Natali

An automated flux chamber collects continuous measurements of carbon dioxide exchange at a drying and permafrost thaw experiment in Alaskan subarctic tundra.

The Arctic tundra is a natural carbon sink. As temperatures continue to rise around the globe, more vegetation will spring up in the frigid region, potentially pulling even more carbon dioxide from the atmosphere due to increased plant productivity.

However, the warming carries other consequences too. Even though carbon uptake during the growing season increased in recent years, observations show annual net losses of carbon to the atmosphere—as Arctic soils thaw, a vast reservoir of carbon locked up in the permafrost can be released to the atmosphere as greenhouse gases. Continued releases could shift the region from a carbon sink to a source by the end of this century.

Previous research has shown that soil moisture plays a critical part in both permafrost thaw and carbon exchange with the atmosphere—as the permafrost breaks down, surface water may drain away to deeper soil layers, leaving the topsoil high and dry. How-

ever, this kind of soil drying is often overlooked in research on the impacts of thawing permafrost.

Recognizing this oversight, *Natali et al.* took a first look at how thawing permafrost and soil moisture dynamics combined will affect carbon in the Arctic tundra. The team documented carbon dioxide exchange during 3 years of growing seasons in an upland tundra ecosystem in the northern foothills of the Alaska Range.

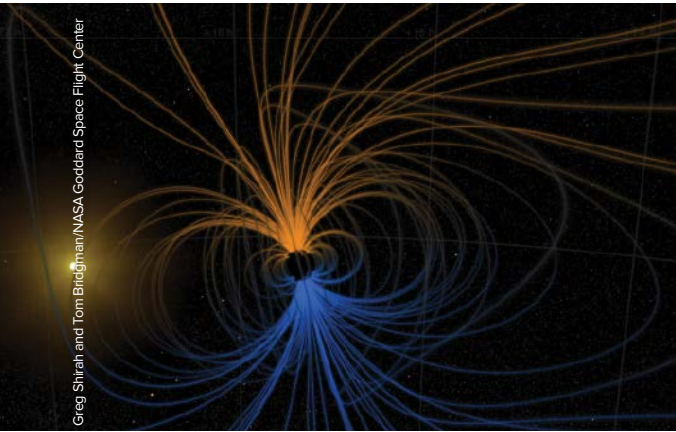
Critically, the research team manipulated some plots to experimentally induce warming and drying. They simulated winter warming by insulating vegetation with increased snowpack and summer warming by covering plants with open-topped greenhouses. They also manipulated water table levels with an automated pumping system. The team then measured the effects of their changes on fluxes of both carbon dioxide and methane.

The warming treatment increased ground thaw by approximately 15% compared to con-

trols and caused an increase in carbon dioxide released from plant and microbial respiration. The authors found that, together, warming and drying increased ecosystem respiration by 20% over the 3-year experiment, the same amount that warming and drying increased respiration individually. The results indicate that temperature and moisture levels may disparately affect carbon release from plants and microbes within the plots when they work in concert.

In addition, the amount of decomposition in the top 10 centimeters of soil was nearly 2 times greater in the warming condition and in the dry condition compared with controls. The study also detected methane emissions—which can have a much larger impact on global warming than carbon dioxide—across all plots, even controls, but emissions were highest for the warmed plots. (*Journal of Geophysical Research: Biogeosciences*, doi:10.1002/2014JG002872, 2015) —**Kate Wheeling, Freelance Writer**

Predicting Space Weather on a Satellite Superhighway



Greg Shirah and Tom Blighman/NASA's Goddard Space Flight Center

Scientists hope a new model of electron and ion fluxes will benefit spacecraft orbiting in Earth's magnetosphere, a giant magnetic bubble that surrounds our planet.

More than 400 satellites sit in geosynchronous orbit far above our planet's surface, where the spacecraft, orbiting at the same rate that our planet is spinning, occupy a fixed region in Earth's sky. This region—some 36,000 kilometers above the Earth—marks the boundary of Earth's inner and outer magnetosphere.

There disparate forces from the two regions act on clouds of electrically charged gas particles known as plasma. Charged particles can interfere with satellite functioning, so spacecraft users and operators need to understand the plasma environment in this popular path for military, scientific, and communications satellites.

Scientists, for the most part, create current models of the plasma environment with satellite operators in mind. They focus on predicting how fluxes of energetic electrons and ions, which can cause a buildup of charge on spacecraft materials, will affect satellite systems.

Denton et al. sought to create a more comprehensive picture by examining how factors such as solar wind and geomagnetic activity can influence these fluxes in plasma.

The study looked at the largest existing data set of electron and ion fluxes. The measurements were collected by magnetospheric plasma analyzer instruments on board Los

Alamos National Laboratory satellites over 17 years and one and a half solar cycles. Because the spacecraft are closely calibrated, the authors combined the data sets from seven satellites for a total of 82 satellite years of observations.

The authors analyzed the massive database along with data on solar activity, geomagnetic activity, energy, and local time to create an empirical model that is capable of much improved ion and electron flux predictions at geosynchronous orbit. As the model matures, the authors hope it will eventually be used to predict fluxes for satellites in geosynchronous orbit as a function of solar wind speed and magnetic field orientation.

To validate the model, the authors compared its predictions with spacecraft data collected by another set of satellites during a 5-day period of both calm and active space weather. They found that the new model's predictions of plasma flux generally agreed with the satellite observations.

The team has already made a beta version of the model freely available. The authors hope that the new model will be useful for scientists as well as spacecraft operators. (*Space Weather*, doi:10.1002/2015SW001168, 2015) —**Eric Betz, Freelance Writer**

Cool Downdrafts in Large Thunderstorms Captured by Satellite

The burst of cool air you feel on a hot summer day can be the final warning before a thunderstorm arrives with heavy rainfall. The air you feel is cooled by evaporating raindrops and descends in the interior of the storm before spreading outward.

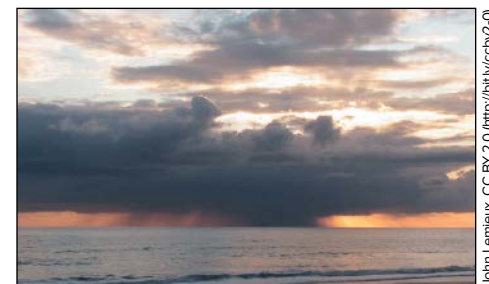
These cool downdrafts form an integral part of the bigger thunderstorms known as mesoscale convective systems (MCSs), which produce a large proportion of tropical rainfall and play a crucial role in the global atmospheric circulation. Accordingly, it is important for scientists to understand the flow of air and energy through MCSs, and now *Kilpatrick and Xie* report that satellites can be used to gather data about the storms' inner workings.

Mesoscale convective systems contain two main patterns of airflow: warm, moist updrafts that “feed” the systems and cool, dry downdrafts that form the “exhaust.” The cool downdrafts can trigger new storms in

neighboring regions, setting off a chain reaction. In this study, scientists detected the cool downdrafts over the ocean with the Advanced Scatterometer satellite, which calculates surface wind speed and direction by shooting microwaves at the ocean surface and measuring the reflected signal.

Using this technique, the team was able to identify more than 1300 of the cool downdrafts from 2009 to 2014. The scientists confirmed that the wind signals are real by comparing them to data from ocean buoys. According to their analysis, the satellites are able to identify the mesoscale (50–300 km) downdrafts that make up the bulk of a storm, but the technique broke down near the storm's narrower leading edge, where rainfall was the most intense.

Scientists have observed the airflow around ocean thunderstorms before, from ships and small airplanes. However, the satellite scatterometer allows a global view, offering an



Thunderstorm over the Pacific Ocean. Satellite scatterometers now provide a global view of the cool downdrafts in thunderstorms.

unprecedented opportunity to study how these storms interact with their environment. (*Geophysical Research Letters*, doi:10.1002/2015GL063025, 2015) —**David Shultz, Freelance Writer**

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Atmospheric Sciences

COLORADO STATE UNIVERSITY ATMOSPHERIC SCIENCE TENURE TRACK FACULTY POSITIONS COL- LEGE OF ENGINEERING

The Department of Atmospheric Science at Colorado State University invites applications for two tenure-track faculty positions at the assistant or associate professor level. We solicit candidates in the research areas of (1) clouds and mesoscale processes, and (2) surface-atmosphere interactions - with expertise in land-atmosphere coupling preferred.

Further information about the open positions and details on how to apply can be found at <http://jobs.colostate.edu/postings/17728>.

Applications and nominations will be considered until the positions are filled; however, applications should be received by October 31, 2015 to ensure full consideration. Applicants should submit a cover letter, one to two page statements on research and teaching interests, curriculum vitae, and the names of four references.

CSU is an EO/EA/AA employer.

Colorado State University conducts background checks on all final candidates.

Tenure-track position in Climate Dynamics, University of Colorado, Boulder

The Department of Atmospheric and Oceanic Sciences (ATOC) at the University of Colorado Boulder, invites applications for a tenure-track faculty position in climate dynamics. We are seeking a person who will develop a vibrant research program complementing existing strengths within ATOC, on the Boulder Campus, and in the Boulder research community, and who is committed to excellence in undergraduate and graduate teaching. The position will be filled at the Assistant Professor level. Review of applications will begin on Nov. 15, 2015, and will continue until the position is filled. A Ph.D. in Atmospheric Science, Oceanography, or a related field is required at the time of appointment, and post-doctoral experience is preferred. Informal inquiries can be made to the chair of the search committee, Jeffrey Weiss, at ClimateDynamicsATOC@colorado.edu. The University of Colorado is an Equal Opportunity/Affirmative Action employer.

Applications are accepted electronically at <http://www.jobsatcu.com/postings/107586>.

After November 4th, you will be redirected to CU Careers, our new career site. In order to access this posting, please use the keyword search for posting #Fo2886.

The Department of Earth & Environment at Boston University invites applications for a tenure-track assistant professor in remote sensing, beginning on July 1, 2016.

We seek candidates that build upon and expand our existing remote sensing group, which is focused in the optical domain. We welcome applicants with expertise in any domain of remote sensing, but encourage applications from candidates with expertise in active or passive microwave, InSAR, LiDAR, thermal, or hyperspectral remote sensing, including airborne remote sensing from aircraft or unmanned aerial vehicles. The scientific focus for this position is open, and includes any thematic area related to physical, chemical or biological function of the earth system, including processes in oceans, the atmosphere, or on land. We particularly welcome candidates whose expertise complements our growing program in climate change science. Opportunities exist for collaboration in many domains, including land change science, natural resource management, crustal and land surface processes, terrestrial ecology, hydrology, and marine sciences.

The successful applicant will be expected to supervise graduate research in Ph.D. programs, teach at all levels in the Earth & Environment curriculum, and maintain an externally funded research program. We seek applicants whose research complement strengths in the Department and around the University. For more information about the Department, see <http://www.bu.edu/earth>. A Ph.D. at the time of appointment is required.

Please apply online at <https://academicjobsonline.org/ajo/jobs/6256>, including a curriculum vitae, a cover letter, a statement of research and teaching interests, and the names and addresses of at least three referees. Should you have questions about the position, please feel free to contact Mark Friedl, Search Committee Chair, Department of Earth and Environment, Boston University, 685 Commonwealth Ave, Boston MA 02215; email: earth@bu.edu. Review of applications will begin on Nov 10, 2015. Women and underrepresented minorities are particularly encouraged to apply.

Boston University is an equal opportunity employer and all qualified applicants will receive consideration for employment without regard to race, color, religion, sex, national origin, disability status, protected veteran status, or any other characteristic protected by law. We are a VEVRAA Federal Contractor.

Geochemistry

Postdoctoral Fellowship Positions in Geochemistry, Cosmochemistry, and Astrobiology

Carnegie Institution, Department of Terrestrial Magnetism, Washington, DC

Openings are available beginning Fall 2016 for postdoctoral fellowships

in the fields of geochemistry, cosmochemistry, and astrobiology that provide support for creative independent research of the applicant's choosing. Details on DTM research staff, laboratory facilities, and ongoing research can be found at dtm.carnegiescience.edu. Fellowships are for one year and are normally renewable for a second year.

Applications should be submitted online at <https://jobs.carnegiescience.edu/jobs/dtm> and should include a curriculum vitae and list of publications, description of thesis research, a short (2-3 page) statement of research plans for the fellowship period, and three letters of recommendation by those familiar with your work. Submission details are available when you click on "Apply Now." Creativity in the proposed research figures heavily in the evaluation of the application. Review of the applications will begin on December 1, 2015. Address any questions you have to geochemfellowship@dtm.ciw.edu. Carnegie Institution is an Equal Opportunity Employer. All qualified applicants will receive consideration for employment and will not be discriminated against on the basis of gender, race/ethnicity, protected veteran status, disability, or other protected group status.

Tenure-track Faculty Position in Mantle Processes

The Department of Geological Sciences seeks an outstanding scientist to lead a vibrant research program in the broadly defined area of Mantle Processes. Specific areas of interest include (but are not limited to) the composition, structure, and evolution of our planet over varying length and time scales. We are particularly interested in those who seek to make connections between deep and shallow processes (examples include how the dynamically flowing and recirculating mantle interacts with its crust, hydrosphere, and atmosphere). Research approaches should encompass some combination of field, laboratory, and modeling. The appointment will preferably be at the junior level (Assistant or untenured Associate Professor), but applications from scientists at all career levels will be considered. The successful applicant will be expected to develop a world-class independent program of research, interface where appropriate with existing programs in the Geological Sciences and in the School of Earth, Energy, and Environmental Sciences, and teach at the undergraduate and graduate level.

Applications should include a cover letter, curriculum vita, a statement of research and teaching interests, three recently-published representative papers, and the names and email addresses of three individuals from whom the search committee can request letters of reference. Please apply at: <https://academicjobsonline.org/ajo/jobs/6199>

Review of applications will commence October 31, 2015. The position will remain open until filled. Questions can be directed to. Lauren Nelson at lmnelson@stanford.edu

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

University of Tennessee, Knoxville Faculty position in planetary petrology/mineralogy/geochemistry

The Department of Earth & Planetary Sciences at The University of Tennessee seeks to fill a faculty position in petrology/mineralogy/geochemistry with emphasis in planetary geoscience. The position is for an open-rank (tenure-track or tenured); we would prefer to select a candidate at the Associate or Full Professor level, but welcome applications for Assistant Professor. The position begins August 1, 2016. The University of Tennessee, Knoxville is a Research I University and the flagship campus of the UT system. The Department (<http://eps.utk.edu>) focuses on geology and has an active emphasis on planetary

research through its Planetary Geosciences Institute (<http://web.utk.edu/~pgi>). Requirements for the position are: Ph.D. in geology or a related field, and demonstrated research experience in planetary geoscience.

The successful candidate is expected to conduct a robust, funded program of planetary research, mentor graduate students, effectively teach courses in petrology and/or mineralogy at the undergraduate and graduate levels, and collaborate in department research dealing with petrology, mineralogy, geochemistry, and solar system exploration. Salary and benefits are competitive and commensurate with experience. The Knoxville campus of the University of Tennessee is seeking candidates who have the ability to contribute in meaningful ways to the diversity and intercultural goals of the University.

To apply, please email the following to mcsween@utk.edu: C.V., cover letter describing research and teaching experience and plans, and names of 4 references with contact information. Applications received by December 15, 2015 are ensured review, but earlier submission is encouraged. The position will remain open until filled. Questions about the position should be directed to H. McSween.

The University of Tennessee is an EEO/AA/Title VI/Section 504/ADA/ADEA institution in the provision of its education and employment programs and services. All qualified applicants will receive equal consideration for employment without regard to race, color, national origin, religion, sex, pregnancy, marital status, sexual orientation, gender identity, age, physical or mental disability, or covered veteran status.

Hydrology

Assistant Professor of Hydrology - New Mexico Tech

The Department of Earth and Environmental Science at New Mexico Institute of Mining and Technology (NMT) invites applications for a tenure-track Assistant Professor position in the Hydrology Program. This will be a joint appointment between Academic Affairs and the Geophysical Research Center.

Applicants should have a Ph.D. in Earth Science, Civil Engineering, Environmental Engineering, or a related field at the time of appointment. We seek candidates with a specialty in vadose-zone hydrology. Candidates with additional expertise in hydrologic remote sensing, land-surface/atmosphere interaction, and land-surface dynamics will receive preference. Potential for excellence in teaching and research are the most important qualifications. Women and underrepresented minorities are encouraged to apply.

Responsibilities will include developing an active program of extramu-

ally funded research, supervising and supporting graduate students, and teaching two graduate or undergraduate courses per year.

The successful candidates will join a group of five hydrologists including four full-time hydrology faculty, two emeritus faculty, eight adjunct faculty, and 25 graduate students. The Department of Earth and Environmental Science has 16 faculty and about 50 undergraduate and 65 graduate students. NMT is the academic partner of the National Cave and Karst Research Institute (NCKRI), based in Carlsbad, NM. Additional geoscience professionals on campus include over 30 staff members of the New Mexico Bureau of Geology and Mineral Resources, plus faculty and researchers in the Petroleum Recovery Research Center, the Petroleum and Mineral Engineering departments and the IRIS PASSCAL Instrument Center. For detailed inquiries, contact search committee chair, Mark Person (mperson@nmt.edu).

Applicants should submit a letter of interest, resume, a statement of teaching and research interests, one representative publication and the names of three references to Hydrology Search, Box 136, Human Resources, New Mexico Institute of Mining and Technology, 801 Leroy Pl., Socorro, New Mexico 87801. College transcripts will be required if selected to interview. Review of application material will begin on October 1, 2015. The search will remain open until the position is filled. Email applications are not accepted. New Mexico Tech is an equal opportunity/affirmative action employer.

Ocean Sciences

Department of Marine, Earth, and Atmospheric Sciences Assistant Professor - Marine Microbiology

The Department of Marine, Earth, and Atmospheric Sciences (MEAS) at North Carolina State University (NC State) is seeking to fill a tenure-track faculty position at the Assistant Professor level in the area of marine microbiology. Expertise is desired in prokaryote ecology and molecular diversity with interests in genetic and biogeochemical methods for examining community composition and function in marine systems. Possible associated research areas include: biogeochemical-based ecosystem modeling; climate change; elemental cycling; extreme environments; food safety/security/public health; or water quality. A research focus on experimental and field studies using state-of-the-art molecular techniques is preferred, as are experience and a strong interest in interdisciplinary collaborations across and beyond the geosciences.

The position is available 1 August 2016. Applicants must hold a Ph.D. degree in the oceanographic or related

sciences. The successful candidate must demonstrate strong potential for outstanding accomplishments in research, research supervision, and teaching. Specific course offerings may include undergraduate or graduate biological oceanography or marine microbiology, or other classes commensurate with the candidate's interest and expertise. An interest in participating in the Department's capstone undergraduate coastal processes field course also is desirable. MEAS places a high value on excellent instruction and the use of innovative teaching methods.

Located within the College of Sciences at NC State, MEAS is one of the largest interdisciplinary geoscience departments in the nation. Opportunities exist for disciplinary and interdisciplinary interactions with more than 30 marine, earth and atmospheric scientists. MEAS is one of six departments across three colleges with a presence at the NC State Center for Marine Sciences and Technology (CMAST), a coastal and marine science research facility located on Bogue Sound in Morehead City, NC. Additional information about the department and its facilities can be found on the web page: <http://www.meas.ncsu.edu> and <http://www.cmast.ncsu.edu> NC State also hosts large programs in microbiology and biotechnology: <http://www.microbiology.ncsu.edu/> & <http://biotech.ncsu.edu/> and has recently established the Center for Geospatial Analytics: <http://geospatial.ncsu.edu>.

Review of applications will begin on 10 October 2015; the position will remain open until filled. Applications, including cover letters, curriculum vitae, teaching and research statements, and contact information for three references must be submitted online at <https://jobs.ncsu.edu/postings/56255>.

Founded in 1887, NC State is a land-grant institution distinguished by its exceptional quality of research, teaching, extension, and public service. Located in Raleigh, North Carolina, NC State is the largest university in North Carolina, with more than 34,000 students and 8,000 faculty and staff. National rankings consistently rate Raleigh and its surrounding region among the five best places in the country to live and work, with a highly educated workforce, moderate weather, reasonable cost of living, and a welcoming environment. A collaborative, supportive environment for business and innovation and research collaborations with area universities and the Research Triangle Park are compelling reasons for relocation to the area. NC State is an equal opportunity and affirmative action employer. All qualified applicants will receive consideration for employment without regard to race, color, national origin, religion, sex, sexual orientation, age, veteran status, or disability.

Assistant Professor, Geophysics California State University, Long Beach

The Department of Geological Sciences invites applications for a tenure track faculty position in Geophysics at the rank of Assistant Professor to begin in August 2016. Teaching duties include Geophysics and related subjects at undergraduate and graduate (M.S. degree) levels. The area of research should be in applied, shallow-earth geophysics using seismic reflection and other remote sensing techniques. Qualifications include demonstrated commitment to working successfully with a diverse student population and demonstrated potential for developing and sustaining an independent, externally funded research program involving students. The full position description and application requirements are available at web.csulb.edu/divisions/aa/personnel/jobs/posting/2316/index.html. Review of applications to begin December 4, 2015.

Applications from women, minorities, and persons with disabilities are encouraged.

Research Position: Modeling US landfalling hurricane and storm surge risk under global warming conditions

The Atmospheric and Oceanic Sciences Program at Princeton University in cooperation with NOAA's Geophysical Fluid Dynamics Laboratory (GFDL) seeks a postdoctoral research associate or more senior scientist to explore U.S. landfalling hurricanes and their associated storm surge risk under present-day and future warm-climate conditions. As part of a new NSF funded project, the researcher will collaborate with an interdisciplinary team of scientists from GFDL/NOAA, Princeton University, and MIT to investigate how various aspects of projected 21st century climate change may alter storm surge risk for the mainland U.S. coast. The incumbent will use dynamical hurricane modeling frameworks developed at GFDL, including the GFDL hurricane model, together along with established storm surge modeling techniques to explore future projections. Research is needed to better understand how surge risk is likely to change due to influences of changes in sea level, with a particular emphasis on improved understanding of projected changes in hurricane cli-

mate (tracks, intensity, storm structure, etc.) that can affect storm surge risk. Scientifically sound information on these issues, including assessments of remaining uncertainties, are urgently needed to help inform decision-making for risk management, adaptation, and policy responses.

Candidates with strong quantitative and analytical backgrounds in atmospheric science, including dynamical modeling and the analysis of large data sets and/or model output, are particularly encouraged to apply. This is a full-time, one year position (subject to renewal after the first year contingent upon satisfactory performance) based at GFDL in Princeton, New Jersey. Interested candidates may contact Thomas Knutson (Tom.Knutson@noaa.gov) or Gabriel Vecchi (Gabriel.A.Vecchi@noaa.gov) for further information. Complete applications, including a CV, publication list, 3 letters of recommendation, and a one-to-two page statement of research interests should be submitted by November 15, 2015 for full consideration, though evaluation will be ongoing until a suitable candidate is identified. Applicants should apply online to <http://jobs.princeton.edu>, Requisition #1500773.

This position is subject to the University's background check policy. Princeton University is an equal opportunity employer and all qualified applicants will receive consideration

for employment without regard to race, color, religion, sex, sexual orientation, gender identity, disability status, protected veteran status, or any other characteristic protected by law.

Solid Earth Geophysics

Postdoctoral Fellowship Positions in Geophysics, Volcanology, Planetary Science

Carnegie Institution, Department of Terrestrial Magnetism, Washington, DC
Openings are available beginning Fall 2016 for postdoctoral fellowships in the fields of terrestrial or planetary geophysics and volcanology. These fellowships provide salary, travel, and research support for creative independent research of the applicant's choosing. Details on DTM research staff, laboratory facilities, and ongoing research can be found at dtm.carnegiescience.edu. Fellowships are for one year and are normally renewable for a second year.

Applications should be submitted online at <https://jobs.carnegiescience.edu/jobs/dtm> and should include a curriculum vitae and bibliography, description of thesis research, and a short (2-3 page) statement of research plans for the fellowship period. Applicants are also encouraged to contact a current staff member to discuss research plans. Creativity in the proposed research figures heavily in

the evaluation of the application. Three letters of recommendation by those familiar with your work should also be submitted online. Submission details are available when you click on "Apply Now." Review of the applications will begin on December 1, 2015. Please email any questions you have to geofellowship@dtm.ciw.edu. Carnegie Institution is an Equal Opportunity Employer. All qualified applicants will receive consideration for employment and will not be discriminated against on the basis of gender, race/ethnicity, protected veteran status, disability, or other protected group status.

Postdoctoral Scholar Position/ Earthquake Inversion/Jet Propulsion Laboratory (JPL), California Institute of Technology (Caltech)

The California Institute of Technology Postdoctoral Scholars Program at JPL invites applications for a postdoctoral scholar position at the Earth Science section.

The research will focus on studying major earthquake processes using geospatial measurements, such as high-rate GPS data, seismographs, and GRACE measurements. Modeling earthquake fault parameters for tsunami early detections is the key part of the project. Processing real-time data streams, analyzing historical data sets, and model results are necessary. However, the specific scientific focus



THE UNIVERSITY OF ARIZONA

Earth System Remote Sensing - Earth Dynamics Observatory Cluster Hire Announcement

To respond to global challenges in Earth, environmental, and planetary science, The University of Arizona announces coordinated hiring of five faculty in Earth system remote sensing to establish the Earth Dynamics Observatory (EDO). EDO will combine mission operations and planetary science capabilities of the Lunar and Planetary Lab with remote sensing research in Earth and environmental programs and instrument development. EDO faculty will contribute to interdisciplinary research and education with the goals of instrument/mission development and leading new applications research. We welcome applications for EDO positions focused in five areas. Candidates may seek appointments in one or several departments/colleges within UA. EDO seeks faculty who promote diversity in research, education, and outreach, and who have experience with a variety of collaborative, teaching, and curricular perspectives. More information and details of application processes are available at: www.geo.arizona.edu/EDO

Instrument/Mission Leadership: We seek a scientist with experience in instrument and/or mission development and leadership in Earth remote sensing for an open-rank position to lead collaborative projects across a variety of platforms, methods (multi/hyperspectral, radar, laser, gravity, etc.), and applications.

Remote Sensing Land-Water-Climate/Geospatial Analysis: We seek a scientist with expertise in remote sensing, modeling, and data analysis of land surface, water, resource, and hazards assessment using active and passive source methods, multi- and hyperspectral data, LiDAR, and other technologies.

Atmospheric remote sensing: We seek a scientist with expertise in atmospheric observing systems including passive and active sensing of precipitation, clouds, water vapor, aerosols, and trace gases, development and application of retrieval algorithms and methods or dual-polarization Doppler radar measurements, and data assimilation.

Comparative planetology: We seek a scientist with expertise in remote sensing of planetary surfaces, atmospheres, and/or interiors with relevance to multiple planets (including exoplanets) or solar system objects and to astrobiology, to provide context for understanding the Earth.

Satellite Geodesy: We seek a scientist with expertise in space geodetic techniques across a range of geophysical, hazards, and resource applications including gravity, GPS, InSAR, LiDAR, and radar altimetry, to understand earthquakes, volcanoes, tsunamis, tectonics, mantle flow, glacier dynamics, sea level, and/or Earth's rotational dynamics.

of these activities will depend on the qualifications and interests of the incumbent.

Drs. Y. Tony Song and Zhen Liu, Research Scientist, in JPL's Earth Science Section will serve as JPL postdoctoral advisors to the selected candidate. The appointee will be guided by the JPL advisor to ensure that the research work will result in publications in the open literature.

Applicants should have a recent Ph.D. in geophysics, geodesy, applied mathematics, computational fluid dynamics, or a related field. Skills in Unix/Linux, Matlab and parallel computing are essential. Prior experience with earthquake inversion models is a plus. Demonstrated proficiency in written and spoken English is also required.

Interdisciplinary/Other

ASSISTANT PROFESSOR OF EARTH AND ATMOSPHERIC SCIENCES (Hydrogeology/Groundwater Modeling)

Applications are invited for a tenure track position as Assistant Professor in the Department of Earth and Atmospheric Sciences at the University of Nebraska-Lincoln. The successful candidate will be expected to participate in teaching and curricular development of undergraduate and graduate courses, to advise and direct

graduate students, and to develop a rigorous research program that is supported by external funding. It is expected that the research program will focus on the responses of groundwater systems to climate change. Ability to contribute to multidisciplinary water and climate research efforts within Department of Earth & Atmospheric Sciences and across the university will be considered as an advantage. The candidate should demonstrate strong potential for research and teaching and must hold a Ph.D. in Geology, Hydrogeology, or a related field at the time of appointment.

The Department of Earth and Atmospheric Sciences offers B.S. degrees in Geology and Meteorology-Climatology, as well as M.S. and Ph.D. degrees in Earth and Atmospheric Sciences. Primary research areas within the geological sciences include hydrogeological sciences, sedimentary geology, paleontology and paleobiology, petroleum geosciences, and geobiology. Research in atmospheric sciences is focused on meteorological hazards, climate change, and remote sensing. Additional information about our department can be found on our web site: <http://eas.unl.edu>.

To apply, go to <http://employment.unl.edu>, requisition # F_150187 and complete the "faculty/administrative

form". Applicants must attach a cover letter, curriculum vitae, statements of research and teaching interests, and contact information for at least three references via the above website. We will begin to review applications on October 31, 2015, but the position will remain open until it is filled.

The University of Nebraska is committed to a pluralistic campus community through affirmative action, equal opportunity, work-life balance, and dual careers. See <http://www.unl.edu/equity/notice-nondiscrimination>.

For further information, contact Dr. Richard Kettler, Search Committee Chair by email, phone, or mail at: rkettler1@unl.edu, 1-402-472-0882; Department of Earth & Atmospheric Sciences, University of Nebraska-Lincoln, 214 Bessey Hall, Lincoln NE 68588-0340.

Assistant Professor, Sedimentary Geology/Paleoclimatology

The Department of Geology at Occidental College invites applications for an Assistant Professor in sedimentary geology with a research focus in paleoclimate, paleoenvironmental change, and/or fluvial-coastal processes. Occidental is a nationally ranked liberal arts college recognized for its diverse student body and outstanding undergraduate research program. We seek a colleague who values undergraduate teaching and can sustain an active research program involving undergraduates. In addition to courses related to specialty, the successful candidate will contribute to teaching introductory geology, support the Environmental Science concentration, engage undergraduates in research, and mentor students through completion of senior theses.

Applications should include a statement of teaching and research interests in the context of a liberal arts college. Candidates should specifically address their ability to 1) teach in a socioeconomically, ethnically and culturally diverse environment, and 2) engage students in an ongoing research program. Submit statement, curriculum vitae, 1-3 significant publications, and contact information for three referees to Dr. Margi Rusmore, Search Committee Chair, at geosearch1@oxy.edu. Members of underrepresented groups are especially encouraged to apply. Review of applications will begin October 15, 2015, and will continue until the search closes on December 22, 2015. Search committee members will meet interested candidates at the GSA and AGU meetings; email the committee to make arrangements.

Cartography and Geovisual Analytics, Assistant Professor

The College of Earth, Ocean, and Atmospheric Sciences at Oregon State University located in Corvallis, Oregon invites applications for a 9-month (1.0 FTE) or 12-month (0.75 FTE) ten-

ure-track position as Assistant Professor with a focus on cartography and geovisual analytics. We seek a colleague in Geography who will conduct research, teach graduate and undergraduate courses, advise graduate students in cartography and geovisual analytics to improve understanding of coupled human and natural systems or a combination of geographic processes. Position will establish/maintain an externally funded research program; teach undergraduate and graduate courses in geovisual analytics including cartography, spatial thinking, geovisualization, web mapping, geospatial databases, visualization algorithm development, and others. Requires: PhD in Geography or related discipline by start of employment; record of scholarship in cartography and geovisual analytics; ability in fundamental methods and/or theory of cartography and geovisual analytics; record of collaborations involving geovisual analytics applications to coupled human and natural systems and/or geographic processes; ability or potential to teach spatial thinking, maps and imagery, cartography, algorithms in geovisual analytics, web mapping; commitment to teaching and advising excellence; strong communication/interpersonal skills; proficiency in oral/written English; commitment to educational equity in a multicultural setting. Preferred qualifications: knowledge of cartographic theory; ability to develop geovisual analytics curricula; ability to develop novel and creative algorithms for visualizing processes in space and time; ability to teach programming in R; ability to secure extramural grants/contracts. See announcement at: <http://ceos.oregonstate.edu/employment/10/27/2015>. Closing date: 11/27/2015. Posting 0015729 <https://jobs.oregonstate.edu/>

Earth & Environmental Sciences Lehigh University

Tenure Track Assistant Professor Lehigh University invites applications for a tenure track position in earth and environmental sciences at the assistant professor level. Successful candidates will have a PhD, research expertise that contributes to department strengths through establishment of an internationally recognized externally funded research program, a commitment to teaching at both undergraduate and graduate levels, and a documented commitment to diversity and inclusion.

Applications should submit a cover letter, curriculum vitae, names and contact information of three references, statements of research and teaching interests, and a description of experience and vision for enhancing participation of traditionally underrepresented groups to <https://academicjobsonline.org/ajo/jobs/5945>.

ETH

Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zürich

Research Associate and Lecturer in Hydrogeomechanics – Physical Hydrogeology

The Chair of Engineering Geology at the ETH Zurich is looking for a senior research associate and lecturer in Hydrogeomechanics or Physical Hydrogeology. An appointment at the junior (Postdoc) research associate level could be considered as an alternative. The successful candidate must have a Ph.D. or equivalent degree in earth sciences, petroleum engineering or related field. Knowledge and demonstrated experience of flow and transport processes in fractured rocks are of prime importance. Demonstrated interest in novel in-situ experiments, hydro-mechanical coupling and numerical modeling of flow in fracture networks are desired.

The candidate will be expected (1) to teach one to two classes in the field of quantitative physical hydrogeology, (2) to develop funded research programs addressing hydromechanical problems of fractured rocks, (3) to supervise graduate students and their thesis work, and (4) support students in the use of our lab or field testing equipment.

This ETH staff position with an attractive salary according to ETH standards and sophisticated field sites and testing equipment can be filled by the successful candidate at the beginning of 2016 for a period of about 6 years. The Chair of Engineering Geology is a multidisciplinary research and teaching unit devoted primarily to the study of fundamental hydro-(thermo-)mechanical processes in fractured rocks in the uppermost kilometers of the earth's crust and the corresponding applications – such as deep underground constructions, deep geothermal energy and nuclear waste disposal. Further information about the Chair of Engineering Geology is available at our Web Site www.engineering-geology.ethz.ch. Questions related to the open position can be addressed to Dr. Maria Klepikova, Engineering Geology, ETH Zurich (e-mail: maria.klepikova@erdw.ethz.ch).

Please send your application per regular mail (not e-mail) incl. cover letter, curriculum vitae with full personal and career details, and a detailed statement of research interests to ETH Zurich, Prof. Dr. Simon Loew, Engineering Geology, Sonneggstrasse 5, CH-8092 Zurich, Switzerland (ref. AD_OA4_15). Applications should be submitted until end of October 2015, but are accepted until the position is filled.

To ensure full consideration the application should be received by November 1, 2015.

For additional Information contact Anne Meltzer, Search Committee Chair, EES Dept., 1 West Packer Avenue, Bethlehem PA 18015-3001, ameltzer@lehigh.edu and see the EES department web pages, <http://www.ees.lehigh.edu/>.

The College of Arts and Sciences at Lehigh University is especially interested in qualified candidates who can contribute, through their research, teaching, and/or service, to the diversity and excellence of the academic community. Lehigh University is an Equal Opportunity Affirmative Action Employer. Lehigh University provides comprehensive benefits including partner benefits. Lehigh University is a recipient of a NSF ADVANCE Institutional Transformation award for promoting the careers of women in academic sciences and engineering.

GDL Foundation Fellowships in Structure and Diagenesis

The GDL Foundation supports study and research of chemical and mechanical interactions, structural diagenesis, in sedimentary basins. Practical applications are of particular interest.

We are currently seeking applications from M.S. and Ph.D. candidates, post-doctoral researchers, and scientists for fellowships, up to \$10,000, based on specific proposals for research and participation in meetings and conferences to share results.

Submit applications (available at: www.gdlfoundation.org) by November 2, 2015.

Natural Hazards, Assistant Professor

The College of Earth, Ocean, and Atmospheric Sciences at Oregon State University located in Corvallis, Oregon invites applications for a 12-month (1.0 FTE) tenure-track position as Assistant Professor with a focus on Natural Hazards. We seek a colleague to conduct externally funded research on natural hazards and their spatial interactions with human lives, livelihoods, and infrastructure, with a focus on the fundamental relationships among exposure, sensitivity and the resilience of coupled human-environmental systems subject to natural disasters. This position will: teach undergraduate and graduate courses in geography of natural hazards; teach/advise on topics such as the geography of disaster, emergency management, and spatial planning for natural hazards; establish and maintain a funded research program; and perform service. Requires: PhD in Geography or related discipline by start of employment; record of scholarship in natural hazards; ability to secure external research funding; ability to teach and commitment to teaching/

advising excellence; strong communication/interpersonal skills; proficiency in oral and written English; commitment to educational equity in a multicultural setting. Preferred requirements: record of research collaborations involving natural hazards examined from one or more of the following perspectives: environmental security; political ecology; emergency management; risk perception; spatial risk prediction and mitigation; or geospatial analysis and planning. <http://ceos.oregonstate.edu/employment> For full consideration apply by 10/27/2015. Closing date: 11/27/2015. Posting 0015729 <https://jobs.oregonstate.edu/>

SCIENCE OF ENVIRONMENTAL CHANGE, SUSTAINABILITY AND RESILIENCE

The Department of Geography, Planning and Environment is seeking a tenure-track appointment in the Science of Environmental Change, Sustainability and Resilience, with particular attention to the scientific assessment of human impacts on the environment and human adaptation to climate change. The candidate should hold a PhD in physical geography or a related field, and be engaged in research on how humans interact with and are shaping the environment. The successful candidate will teach courses in our B.Sc. in Environmental Science, as well teach and supervise students in our Master's and PhD programs. We are looking for demonstrated research excellence in a relevant field of study within the natural sciences such as, but not limited to, terrestrial biogeochemistry, land-use dynamics, geomorphology, and climate science. A research program with a field component would be an asset.

All applications should reach departments no later than November 15th 2015. See application information at: <http://www.concordia.ca/artsci/about/jobs/tenure-track-appointments/jobs-of-environmental-change-sustainability-resilience.html>

TENURE-TRACK FACULTY POSITION - ASSISTANT PROFESSOR, DEPARTMENT OF EARTH AND ATMOSPHERIC SCIENCES, SAINT LOUIS UNIVERSITY

Saint Louis University, a Catholic, Jesuit institution dedicated to student learning, research, health care, and service invites applications for a tenure-track faculty position in Geoscience at the Assistant Professor level in the Department of Earth and Atmospheric Sciences (EAS), to begin in August, 2016.

We seek applicants with expertise in geomorphology in any of the following areas: rivers and streams, floodplains, or hillslopes. Faculty responsibilities include a balance of research, teaching, service, and the mentoring of undergraduate and grad-

uate students. Teaching responsibilities include undergraduate courses in surface processes and field methods, and graduate courses in the candidate's area of expertise. We seek an individual who values collaboration, field-based research, teaching, and collegiality. A PhD in earth science or a related field is required at the time of appointment. Post doctoral experience is highly desirable.

Department programs include undergraduate degrees in environmental science, environmental studies, geology, geophysics, and meteorology. The department grants MS and PhD degrees in geoscience (with concentrations in geology, geophysics, and environmental geoscience) as well as in meteorology. Faculty may also participate in the interdepartmental Integrated and Applied Sciences PhD program. For more details, visit the EAS website (www.slu.edu/x35834.xml). Outside of the department, there is opportunity for collaboration with other university departments and units including the Center for Sustainability (<http://www.slu.edu/sustainability>) and the Parks College of Engineering, Aviation and Technology (<http://parks.slu.edu/>). Additional information can be found at www.slu.edu.

All applications must be made online at <https://jobs.slu.edu> and must include a cover letter, curriculum

vite, a two-page statement of teaching, research, and professional goals, and the names and complete contact information of at least four references. Review of applications will begin 1 November and will continue until the position is filled. Inquiries may be sent to geosearch@eas.slu.edu.

Saint Louis University is an Affirmative Action, Equal Opportunity Employer (AA/EOE), and encourages nomination and application of women and minorities

Tenure-Track Position in Sedimentology or Geophysics at Texas Tech University

The Department of Geosciences at Texas Tech University seeks applicants for a tenure-track, assistant professor position in either sedimentology or geophysics to start Fall 2016. A PhD in an Earth Science or closely related discipline at time of appointment is required.

We seek a dynamic researcher and teacher who uses innovative field, laboratory and/or modeling approaches in either targeted area. For sedimentology, we seek candidates with expertise in sandstone, mudstone or carbonate sedimentary systems. For geophysics, we seek candidates with a specialty in seismology or CSEM/MT methods. The geophysics candidate's main area of

Faculty position - Environmental Engineering Northwestern University

The Department of Civil and Environmental Engineering at Northwestern University invites applicants for a tenure track faculty position at the Assistant or Associate professor level in environmental engineering. The Department is seeking candidates within the broad field of ecological engineering to join in new initiatives focused on reinventing cities with particular emphasis on water, energy, and resource cycles. Applications from individuals with excellent research records in ecological modeling, microbial ecology, hydrology, protection/restoration of ecosystem goods & services, or any other fundamental, quantitative research on interactions between humans and the natural and built environments are expected. Candidates should have a Ph.D. in Environmental Engineering or related fields, the ability to establish a well-funded program of independent and collaborative research, and strong teaching skills.

Applications should be submitted electronically via the link below. Applications must include a cover letter, curriculum vitae, statements of research and teaching interests, and a list of at least three referees with contact information from whom letters of recommendation can be requested. Application materials should be submitted to the search committee via the website. Review of applications will begin November 15, 2015, and will continue until the position is filled.

<https://facultysearch.mccormick.northwestern.edu/apply/index/Nzk=>

Northwestern University is an Equal Opportunity, Affirmative Action Employer of all protected classes including veterans and individuals with disabilities. Hiring is contingent upon eligibility to work in the United States.



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research should be in imaging and interpreting crust and lithospheric features and whose interests include the basin scale. A letter of application including contact information for three references, vita, and short statements of research and teaching philosophies can be uploaded at <http://www.texas-tech.edu/careers/requisition#5155BR>.

We seek candidates with strong records of scholarship who have the proven capacity or the clear potential to bring externally sponsored research to Texas Tech University. The department (www.geosciences.ttu.edu) has active research specialties in geology, geophysics, geochemistry, geography, and atmospheric science. We have ~400 undergraduate majors and ~85 graduate students. Texas Tech is located in Lubbock on the edge of the Permian Basin. The region appreciates the social and economic importance of geoscience research due to the importance of petroleum and groundwater resources to the national economy. Teaching duties include graduate and undergraduate courses in the candidate's specialty. Service to the department, university, and discipline is expected.

As an Equal Employment Opportunity/Affirmative Action employer, Texas Tech University is dedicated to the goal of building a culturally diverse

faculty committed to teaching and working in a multicultural environment. We encourage applications from qualified candidates who can contribute, through research, teaching, and service, to the diversity and excellence of the academic community at Texas Tech University. The university welcomes applications from minorities, women, veterans, persons with disabilities, and dual-career couples. Evaluation of candidates will begin November 11, 2015 and continue until the position is filled. Department representatives will be available to discuss the position at the GSA Annual Meeting (1-4 November) in Baltimore, Maryland. Questions should be sent to Dr. Jeff Lee, Search Committee Chair: jeff.lee@ttu.edu.

The Roy M. Huffington Department of Earth Sciences at SMU announces a search to fill a named tenure-track or tenured professorship (the rank is open) honoring WB Hamilton.

We solicit nominations and applications from earth scientists who maintain vigorous and sustainable research programs and who have a commitment to full participation in the educational mission of the department to provide professional training in a liberal arts environment. As the fourth holder of the chair established in 1921, the successful candidate will extend existing departmental

strengths in earth science. The department's focus is on pure research to understand Earth history and geologic processes with applied research on problems in the national interest such as climate and environmental change, earthquake seismology including induced seismicity, natural hazards, nuclear test ban monitoring and resources including geothermal energy. The expected start date is August 1, 2016.

Applications can be submitted electronically to sschwob@smu.edu or in writing to:

Professor John Walther
Search Committee Chair, Department of Earth Sciences,
Southern Methodist University,
P.O. Box 0395
Dallas TX 75275

Applicants should include curriculum vitae, statements of research and teaching interests, and contact information for three references. To insure full consideration applications must be received by December 5, 2015, but the committee will continue to accept applications until the position is filled. The committee will notify applicants of its employment decisions after the position is filled.

Southern Methodist University will not discriminate in any program or activity on the basis of race, color, religion, national origin, sex, age, disability, genetic information, veteran status, sexual orientation, or gender identity and expression. The Executive Director for Access and Equity/Title IX Coordinator is designated to handle inquiries regarding nondiscrimination policies and may be reached at the Perkins Administration Building, Room 204, 6425 Boaz Lane, Dallas, TX 75205, 214-768-3601, access-equity@smu.edu.

Hiring is contingent upon the satisfactory completion of a background check.

Student Opportunities

Funded PhD opportunities in water resources at the Univ. of Idaho through the NSF's IGERT program. Seeking applicants with backgrounds in hydrology, environmental science, ecohydraulics, fisheries science, water resources engineering, climate science, ecology, sociology, rural and community economics, or public policy interested in integrating team-based science and applications. Contact Mary Schierman, marys@uidaho.edu for more info. or www.uidaho.edu/igert. Applications due Nov. 15, 2015.

Funding is available to support M. Sc or Ph.D. students at Washington State University, Vancouver. Students will focus on internal wave dynamics and turbulent mixing, using unique field observations and theoretical modeling (<http://research.vancouver.wsu.edu/stephen-henderson>). Further infor-

mation at <http://careers.agu.org/jobs/7539763/msc-phd-assistantships-in-hydrodynamics>

PhD Student Opportunity in Hydrology, Washington State University

Four year RA available for student to work with an interdisciplinary team to understand the interactions between drought, forest management, and wildfire on forest ecosystem resilience. Students experienced with Linux/programming and/or ecohydrology will be competitive. The student will be co-advised by Jennifer Adam (WSU) and Christina Tague (UCSB). Interested students should contact jcadam@wsu.edu for more information. Fall semester applications to WSU are due on 10 January for priority consideration.

Postdoctoral Research Associate in the Department of Earth and Environmental Science at the University of Pennsylvania.

We seek an individual with experience in studying impact-induced melting and deformation in rocks to investigate rock fulgurites, which result from lightning strikes. The successful candidate will apply modeling, theoretical and/or experimental approaches to understanding the formation of fulgurites and associated shock microstructures, and will work closely with mineralogists and geochemists in our department to inform models and theory with microstructural observations. A key goal will be to understand similarities and differences between shock-induced planar deformation features in fulgurites and similar features in rocks deformed by meteoric impacts or experimental shock loads.

The position is available for one year and may be renewable based on performance and the further availability of research funds.

Please send a letter of interest, CV, and the names and contact information of 3 references to Prof. David Goldsby (dgoldsby@sas.upenn.edu) or Prof. Reto Gieré (giere@sas.upenn.edu). Evaluation of applications will begin immediately and continue until the position is filled. Penn is an affirmative action, equal opportunity employer.

The University of Maryland Center for Environmental Science (UMCES) is pleased to announce up to 3 competitive graduate fellowships to support incoming Ph.D. students starting fall 2016. Up to 3 years stipend, health benefits, and tuition will be covered. UMCES students specialize in fields including: Fisheries Science, Oceanography, Environmental Science, Ecology, Chemistry, Molecular Biology/Biotechnology, and Toxicology. For more information, please contact UMCESfellowship@umces.edu.

**Lamont Doherty Earth Observatory
COLUMBIA UNIVERSITY | EARTH INSTITUTE**

Postdoctoral Fellowships: Earth, Environmental, and Ocean Sciences

Lamont-Doherty Earth Observatory (LDEO) invites applications for Postdoctoral Fellowships in the fields of the Earth, environmental, and ocean sciences. Our researchers work to understand the dynamics of the Earth's chemical, physical, and biological systems, from the core to the upper atmosphere. Our scientists lead research in the fields of solid Earth dynamics; ocean, atmospheric, and climate systems; cryospheric dynamics; paleoclimate; and biogeoscience.

The principal selection criteria for Fellows are scientific excellence and a clearly expressed plan to investigate problems at the forefront of Earth science. Candidates should have recently completed their Ph.D. or should expect to complete their degree requirements by September 2016. Applications from all related fields are welcomed. Fellowships are supported institutionally for 24 months, include a \$5,000 research allowance, and carry an annual salary of \$62,000. LDEO is especially interested in qualified candidates whose record of achievement will contribute to the diversity of the Observatory's scientific personnel.

The deadline for applications is November 16, 2015.

For more information and to apply for the fellowship please visit:
<http://www.ldeo.columbia.edu/postdoc>

LDEO is committed to diversity. Columbia University is an Equal Opportunity/Affirmative Action – Race/Gender/Disability/Veterans Employer.

Faculty Positions in UPSTREAM PETROLEUM ENGINEERING RESEARCH CENTER



Faculty at all levels are sought with experience in physics, chemistry, thermodynamics, interfacial science, geomechanics, reservoir engineering, and petroleum engineering. Ideal candidates will have experimental background and experience in a subset of the following topics:

1. Reservoir engineering, multiphase flow through porous media at different scales, physics of fluid-fluid and fluid-solid interfaces, fluid displacement mechanisms, and rock wettability and its alteration.
2. Enhanced Oil Recovery (EOR) research focusing on, but not limited to, the injection of low salinity water with other additives, surfactant injection, novel polymer-based fluids with functional group, and miscible CO₂ injection.
3. Creation of massive hydrofractures in mudstones (shales) by any means, development of space-filling fractures and microfractures, improvements of gas (and oil) well performance.

KAUST is an international, graduate-level research University dedicated to advancing science and technology through interdisciplinary research, education, and innovation. Located on the shores of the Red Sea in Saudi Arabia, KAUST offers superb research facilities, generous assured research funding, and internationally competitive salaries.

The compensation package includes: competitive tax-free salary, health care (medical and dental) for you and your eligible dependents, and six weeks of annual vacation. You may also be eligible for additional benefits.

To learn more about KAUST, the Upstream Petroleum Engineering Research Center and to complete the online application form visit <http://apptrkr.com/662506>

Application requirements include the following:

- Updated Curriculum Vitae with a full list of publications
- Statement of Research
- Statement of Teaching interests
- Details of at least three potential referees

Positions remain open until filled.

uperc.kaust.edu.sa

An aerial photograph showing a river meandering through a landscape. The river flows from the top left towards the bottom right, forming a large loop. The surrounding area includes golden-brown agricultural fields, a dense green forest, and a small pond with a tree island in the lower left. The text is overlaid on a semi-transparent white box in the upper left quadrant.

Postcards from the Field

Hello, everyone.

Here in Oxfordshire, we've been carrying out a drone survey of the River Glyme, as part of a collaborative project with a local charity to restore some of the natural features of the channel. By capturing high-definition video at different altitudes, we've been characterising various aspects of the river, from the general shape of its meanders to the distribution of Himalayan balsam (an invasive plant with pink flowers) along its banks. Our data will help to monitor the evolution of the channel during and after the restoration work.

We're very excited to be using novel scientific techniques in this way, because it offers different perspectives of the Oxfordshire countryside to visitors and restoration professionals alike!

—**Jerome Mayaud**

Ph.D. student, University of Oxford (UK)

@JeromeMayaud

View more postcards at:

<http://americangeophysicalunion.tumblr.com/tagged/postcards-from-the-field>.

Apply for Amazon Web Services Research Grants Online During the AGU Fall Meeting

Visit AWS at Booth #516



Amazon Web Services and AGU are excited to announce a special **Live Granting of Amazon Web Services research grants at the 2015 Fall Meeting.**

Applications will be accepted and evaluated 20 October–31 December 2015 with the opportunity for live applications and granting at the AWS booth (#516) during the Fall Meeting. Grants will be awarded during and following the Fall Meeting.

Visit **FallMeeting.agu.org/2015/AWSLiveGranting** for more information and to apply.

AGU FALL MEETING

San Francisco | 14 – 18 December 2015

Save Money the Right Way



Act now to save on registration and housing.

**Housing and Early Registration Deadline:
12 November 11:59 P.M. EST**

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