Lamont-Doherty Earth Observatory

Columbia University | Earth Institute

2012 Annual Report

contents

Lamont-Doherty Earth Observatory is one of the largest and most distinguished Earth science research institutions in the world. Our vibrant research and education community is made up of more than 600 people, including scientists, postdoctoral researchers, graduate students and administrative staff.

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EACH DAY, OUR RESEARCHERS PURSUE NEW KNOWLEDGE ABOUT THE COMPLEX DYNAMICS OF OUR PLANET AND APPLY THAT KNOWLEDGE TO BENEFIT HUMANITY.

Dear Friend,

For more than 60 years, Lamont-Doherty Earth Observatory has been a center for innovative Earth science research and a training ground for the next generation of Earth scientists, a place where scientific creativity, novel observations and fresh theories fuel discovery. Each day, our researchers pursue new knowledge about the complex dynamics of our planet and apply that knowledge to benefit humanity.

You've invested in Lamont-Doherty through your annual support, and many of you have made additional special gifts to our recent campaigns. For that, we are deeply grateful. It's now our turn to tell you about the return on your investment.

Through our fundamental research on Earth systems, in fields as diverse as oceanography, seismology, and climate physics, we have made substantial progress toward understanding and addressing the challenging issues facing our planet.

Our broad expertise in Earth science has led to early recognition of decadal trends in climate, new insight into the causes of explosive volcanic eruptions and a growing understanding of extreme weather events such as Hurricane Sandy.

Atmospheric scientist Adam Sobel, who specializes in the dynamics of climate and weather, was the first to describe the rare confluence of events that produced Sandy. Now, he and his colleagues are designing new experiments that investigate the science behind the storm, examining how Sandy evolved and whether powerful hurricanes and megastorms will become more frequent.

Geochemist Terry Plank is making exciting discoveries about the most explosive volcanic eruptions and the roles of water and carbon dioxide recycled into Earth's deep interior at subduction zones. Last year, The John D. and Catherine T. MacArthur Foundation named Plank one of 23 MacArthur Fellows, an award given to the world's brightest creative individuals. Plank's research may ultimately lead to better predictions of volcanic activity, giving vulnerable communities more time to prepare for an eruption.

Ongoing studies by climate scientist Richard Seager have revealed that the devastating drought in the American southwest is not an isolated event. Seager's predictions of future water availability provide vital information to government agencies and resource managers, who must determine how water issues will impact agricultural productivity, forest fires and variable river flows in the region.

These are just three of the hundreds of Lamont-Doherty researchers examining Earth's complex physical, chemical, and biological systems.

Earth is not a static planet and neither is the field of Earth science. Through our dynamic, forward-looking investigations, we remain at the forefront of research that addresses our planet's most pressing problems.

We've recently made a major investment in a suite of laboratories that will accelerate advances in marine biology, biological oceanography and biogeochemistry, and we have been recruiting top scientists with the research expertise to exploit these new capabilities. Regular investment in new research directions has been a hallmark of Lamont-Doherty since its inception and will continue to quicken the pace of discovery.

Every accomplishment described in this annual report was made possible by your generosity. Your continued support enhances the Observatory's capacity for the research, scholarship and creative activity that generates new knowledge and translates our research into practical applications for societal gain.

Thank you for making an investment with returns beyond what we could have imagined.

With gratitude,

Sean C. Solomon
Director

Lamont Scientists Respond to Hurricane Sandy

Sandy was a wake-up call for New York City, with its record storm surge that flooded city streets, subways and other critical infrastructure. As the waters receded, scientists at Lamont-Doherty went to work to understand its significance, under both modern climate conditions and those projected for the future.

Adam Sobel, an expert on extreme weather, found himself repeatedly fielding the same questions from journalists calling to understand Sandy's bizarre storm track. How rare was this event? Did global warming play a role? An inability to come up with satisfying answers led Sobel and colleagues to design two experiments that could get closer to the truth.

In a forthcoming study, Sobel and Timothy Hall, a scientist at NASA's Goddard Institute for Space Studies, looked at the odds of a hurricane over the Atlantic Ocean veering sharply left like Sandy, hitting the coastline at a perpendicular angle. Since record-keeping began in 1851, a storm has never made such a sharply angled landfall on the New Jersey coast. Using statistical methods and computer modeling to simulate millions of Atlantic hurricanes, they placed the chance of a Sandy-like event in any given year at 1 in 700.

But what about climate change? Would Sandy still be rare in a world heated up by carbon emissions? To find out, postdoctoral researcher Elisabeth Barnes, with Sobel and Lorenzo Polvani, is running a similar experiment that uses the latest climate change models. One question they hope to address is what role shrinking Arctic sea ice may have on Atlantic hurricanes. Under one controversial explanation for Sandy's unusual track, the jet stream, altered by declining Arctic sea ice, helped to create a blocking weather pattern that deflected Sandy onto land. The Lamont team hopes to learn more about the influence of climate change on the jet stream and if the East Coast may see more blocking scenarios in the future.

The coastal flooding that Sandy produced surprised many New Yorkers, but not Klaus Jacob. For years, the geophysicist had been warning of New York City's vulnerability to a 100-year storm surge, particularly its multibillion dollar transit system. In a 2011 study funded by New York State, Jacob predicted that such a surge would swamp subway tunnels and stations and take weeks to months to fix. Before Sandy, *New York Magazine* dubbed Jacob the "Cassandra" of subway flooding. After Sandy, the world was suddenly all ears. Jacob was one of 50 people picked for *Time* magazine's "People Who Mattered in 2012," and featured prominently in a *New Yorker* story on urban climate adaptation.

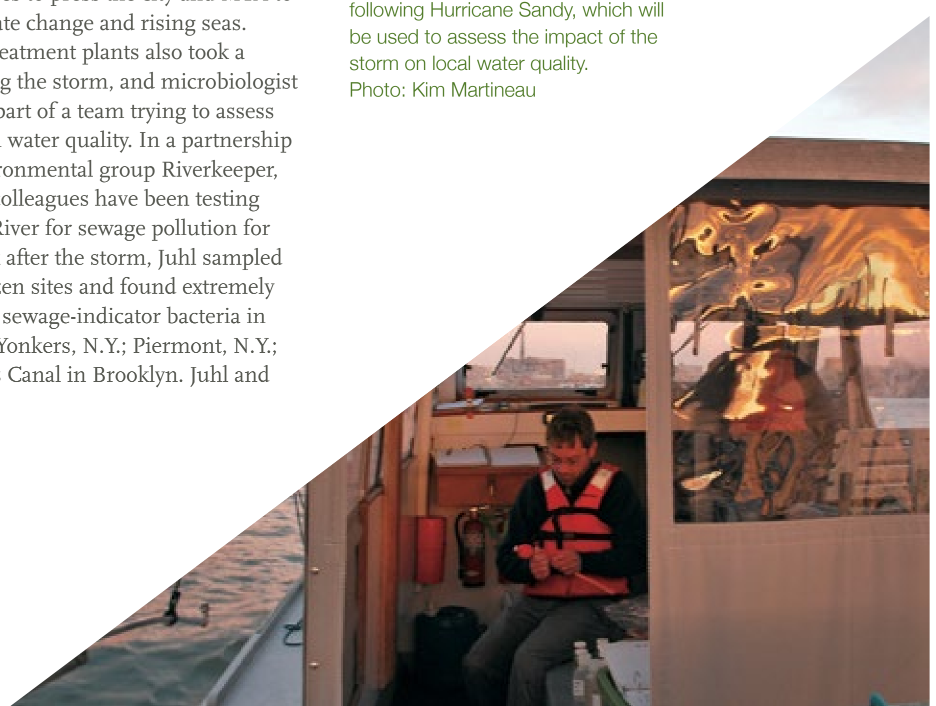
BUT WHAT ABOUT CLIMATE CHANGE? WOULD SANDY STILL BE RARE IN A WORLD HEATED UP BY CARBON EMISSIONS?

Sandy caused about $5 billion in damage to NYC's transit system, but it could have been worse. Thanks in part to Jacob's warnings, the subways were shut down more than a day before the storm hit land, averting bigger losses. In an ongoing lineup of public-speaking engagements and media interviews, Jacob continues to press the city and MTA to plan for climate change and rising seas.

Sewage treatment plants also took a beating during the storm, and microbiologist Andy Juhl is part of a team trying to assess the impact on water quality. In a partnership with the environmental group Riverkeeper, Juhl and his colleagues have been testing the Hudson River for sewage pollution for years. A week after the storm, Juhl sampled some two dozen sites and found extremely high levels of sewage-indicator bacteria in three places: Yonkers, N.Y.; Piermont, N.Y.; and Gowanus Canal in Brooklyn. Juhl and Riverkeeper Capt. John Lipscomb speculated that flooded pump stations in Gowanus and Piermont had forced raw sewage into the river while Yonkers, normally one of the cleanest plants on the Hudson, had probably also suffered flood damage.

In a second post-Sandy project, Juhl and his Lamont colleagues Greg O'Mullan and Eli Dueker are analyzing driftwood and other debris washed up by the storm for sewage contamination. DNA extracted from the samples will help identify any potential pathogens.

In the future, towns and cities may need to move sewage treatment infrastructure to higher ground to protect water quality. But in the short term, said Lipscomb, the more pervasive problem continues to be combined sewer overflows, or CSOs. Antiquated sewers that combine waste coming from homes and running off streets are often overwhelmed during even moderate rain storms, forcing plant operators to divert raw sewage into streams and rivers. The problem may only get worse as New York City faces sea level rise and more severe weather. In the news, climate change has become a "new reality" for politicians. But in a recent profile in *Columbia Magazine*, Jacob called the problem old news. "They should have woken up after Irene," he was quoted as saying. "How many wake-up calls do we need?"



› Microbiologist Andy Juhl collects water samples on the Hudson River following Hurricane Sandy, which will be used to assess the impact of the storm on local water quality.
Photo: Kim Martineau

Searching for Clues to Sea Level Rise in and Below Polar Ice

In September 2012, scientists from the National Snow and Ice Data Center announced that Arctic sea ice cover was at its lowest point ever, setting off warnings about the rate of change in the polar regions. Both Arctic and Antarctic landscapes consist primarily of enormous ice sheets, vast glaciers and thick sea ice. And, as with the rest of our planet, these polar regions are warming, causing ice to rapidly weaken, melt and shrink—actions that will impact future sea level rise. To better understand the decline in ice, scientists have taken to the skies in airborne laboratories to measure, monitor and assess change in the polar regions.

For the past three years, Operation IceBridge, funded by NASA, has utilized a fleet of specially equipped research aircraft to observe and characterize annual changes in the thickness of sea ice, glaciers and ice sheets. The project relies on the expertise of scientists in the Polar Geophysics Group; each year, the Lamont IceBridge team, led by geophysicist Jim Cochran, spends three months flying over Greenland and six weeks flying over Western Antarctica. During as many as 16 science flights per month, scientists use sophisticated laser, radar and mapping equipment to gather data on the internal structure of ice sheets and the shape of the land beneath them.

Lamont scientists are responsible for Icebridge's mapping instruments: the gravimeter and magnetometer, whose data provide a window into the geology below the ice. The gravimeter measures the strength of gravitational fields, information scientists use to determine the shape of seawater-filled cavities under floating ice shelves. The magnetometer gathers data about the magnetic properties of bedrock beneath ice sheets and glaciers to help identify what type of rock lies below the ice. Used together, these instruments provide important images and knowledge of ice beds—measurements previously unattainable due to the limitations of radar.

The valuable data produced by the Lamont scientists has improved understanding of the structure of the rock under the ice and enabled researchers to predict how ice mass loss may change in the future. This information helps answer questions of how and why polar ice is changing and is used in predictions of future glacial movements and rates and extent of change.

"This extensive set of data, all coregistered in time and space and made available to the entire scientific community as soon as it is processed, is an exceptional resource for studying the structure and behavior of the ice sheets," Jim Cochran said.

Postdoctoral researcher Kirsty Tinto has participated in many of the Greenland and Antarctic flights. "Ultimately this work will help us predict the influence of the ice loss on sea level rise and make models that can really understand what the ice is doing," Tinto explained. "How it moves, how it responds to different changes in the ocean and the atmosphere, and where sea level is going to be in 50 or 100 years time."

The Polar Geophysics Group is currently expanding on their IceBridge success with a new, one of a kind, instrument named IcePod. Funded by the National Science Foundation and developed by Robin Bell, Nick Frearson, Chris Zappa and colleagues, IcePod will measure, in great detail, both the ice surface and the ice bed. IcePod will be installed on a New York Air National Guard LC-130 aircraft, which carries out routine servicing flights to Greenland and Antarctica. The IcePod data sets will support the development of accurate ice sheet models to predict sea level rise and make more accurate forecasts of ice mass loss.

› A glacier in East Greenland, seen from an IceBridge mission in the Arctic
Photo: Margie Turin

Assessing Water Availability in the American West

The Colorado River system is the primary water resource for the American West, supplying water to more than 40 million people in Colorado, California, Nevada, Arizona and Mexico. Climate change is already affecting water availability in the region. Now, the results of a recent study by climatologist Richard Seager have prompted people to take an even closer look at how to manage this precious resource.

Seager's work focuses on climate variability and the impact of climate change on the global hydroclimate. To better understand future water availability in the Western United States, Seager and colleagues in the Division of Ocean and Climate Physics and the NASA Goddard Institute for Space Studies analyzed historical records and numerous climate model projections to project what might happen to surface water availability in three water resource regions of the West: the headwaters of the Colorado River, the California-Nevada region and Texas. "We looked at how precipitation, evaporation, river run-off and soil moisture are projected to change in those three areas over the course of the 21st century, with a focus on the next three decades," Seager said.

The model simulations project that in 2021–40 the Colorado River flow will most likely be about 10 percent less than its late 20th-century average. While that doesn't sound like a large amount, "The river flow is already over-allocated amongst its users, while the population of the West is going up and irrigation needs are also increasing," Seager said, explaining that demand for water will very likely outstrip supply in coming decades.

It's a similar story in California and Nevada, which get most of their water from the Sierra Nevada mountains range but also a significant amount from the Colorado River system. And, though the models predict winter precipitation in Northern California will increase, the warming climate causes more of what falls to evaporate back into the atmosphere, leaving less to sustain rivers and soil moisture. Further, climate models also predict a drop in spring precipitation of up to 20 percent in California. "So, again, it adds up to a big reduction in runoff in that region as well, and it's a similar story for Texas," Seager said. "It doesn't matter where you are in that region, it looks like there's going to be less water available in the near-term future."

For his next study, Seager will investigate near-term changes in U.S. Western weather and climate in the next few decades. He and his colleagues will examine water resources and the wider range of ecosystem and land management issues in the region. These include forest fires, wildlife management and how vulnerable ecosystems might be affected by drought, changing temperatures and extreme weather events. Project collaborators at the NOAA Earth System Research Laboratory and the University of Colorado in Boulder, Colo., will look at the practical applications of these studies to sectors such as land and water management.

Seager's research is critical to understanding how climate will affect water resources in the West. Government agencies and water resource managers can use this work to determine how to adapt to life with less water to allocate to users. Scientists working in federal agencies, such as the Bureau of Reclamation and the United States Geological Survey, have already requested Seager's recent study of the Colorado River system. "This isn't a case where people have their heads in the sand," Seager said. "Water seems to be too important to the Southwest to ignore this research and deny that there's a problem."

DEMAND FOR WATER WILL VERY LIKELY OUTSTRIP SUPPLY IN COMING DECADES.

› In the Southwest U.S., thirsty cities and irrigated agriculture are straining water supplies and damaging ecosystems.

Climate Lessons From Mongolian Tree Rings, Ecology and Culture

Mongolia conjures images of grasslands, mountains, Genghis Khan; a country populated primarily by nomadic herders, largely dependent on natural resources. And harsh winters, hot summers: one of the most extreme continental climates in the world. Yet Mongolia's weather and climate history are just beginning to be understood.

Over the last 18 years, investigations by Lamont-Doherty Tree-Ring Laboratory scientists have added tremendously to knowledge of Mongolian climate history. Our dendrochronologists were among the first to collect tree-ring data in Mongolia, and they continue to pioneer studies of the country's climate. Rosanne D'Arrigo and Gordon Jacoby began this effort in 1995 when they established the Mongolian American Tree-Ring Project (MATRIP), a partnership with the Mongolian Academy of Sciences. MATRIP's goal is to engage in collaborative tree-ring research in Mongolia, using instrumental and observed records of climate, temperature and precipitation to reconstruct the region's past climate.

Dendrochronologist Neil Pederson first worked in Mongolia with the MATRIP project in 1998 and has returned seven times, most recently as part of a National Science Foundation and National Geographic Society funded project examining climate, fire and forest history in Mongolia. In 2010, while roaming a lava field in the central mountains of Mongolia in search of old trees, Pederson collected a few pieces of deadwood and ancient-looking Siberian pine. Months later, at Lamont-Doherty, analysis of these cross sections revealed that the rings in the wood dated back 1,200 years, to the time before Genghis Khan and the 13th century rise of his Mongol Empire, making the samples the oldest ever found in Mongolia. Pederson also discovered that the rings from the years 1208 to 1231, the time when Genghis Khan was in power, were among the widest rings on the sample, suggesting that more rain than usual may have fallen on the region in this time period.

With the data from these cross sections and the history of the Mongol Empire in mind, Pederson recently began a new study that seeks to understand the environmental conditions before, during and after the rise of the Mongol Empire.

"Our hypothesis, which builds on ecosystem ecology, human ecology and our preliminary studies, is that warmer conditions, and possibly wetter conditions, might have fueled the Mongol Empire," Pederson said. "It's very basic ecology: if you have more water and warmer temperatures, you have more grass. And if you have more grass you have more sheep and horses and yak, and maybe you can even sustain a slightly larger human population."

Pederson and his collaborators propose that environmental conditions may have enabled Genghis Khan to develop a complex social, economic, and political system and create the largest land empire in world history. The project integrates climate history and ecological models to investigate how Mongolia's past climate influenced grassland productivity, animal populations and energy flow through the 13th-century Mongol ecosystem. It will compare tree-ring data to historical records on the Mongol empire and sediment records from lakes in the region to estimate animal density at the time.

The results of their study may reveal more about how Genghis Khan was able to build his vast empire, but Pederson stresses that their findings have greater importance.

Knowledge of past and present climate and how people have reacted to past climate-related events can help us plan and prepare for future changes in our climate. "If Hurricane Sandy taught us anything, it's that we have to adapt," Pederson said. "We can't stop climate change. That's a huge lesson."

OVER THE LAST 18 YEARS, INVESTIGATIONS BY LAMONT-DOHERTY TREE-RING LABORATORY SCIENTISTS HAVE ADDED TREMENDOUSLY TO KNOWLEDGE OF MONGOLIAN CLIMATE HISTORY.

› Neil Pederson's tree-ring investigations seek to understand the environmental conditions before, during and after the rise of the Mongol Empire. Photos: Neil Pederson

Clocking Volcanic Processes

Volcanoes are dramatic and powerful natural phenomena, evidence that below the surface Earth is a living planet. In the Comer Geochemistry Building and in explosive deposits around the world, geochemists Terry Plank and Philipp Ruprecht are collecting and examining evidence left by past volcanic eruptions to determine how magma ascends through Earth's crust. The results of their research will add to our understanding of volcanic processes and may help determine why some volcanoes are more explosive and erupt more frequently than others.

Plank and Ruprecht want to know more about the complex system of magma transport in the crust and how magma already on the rise interacts with and mobilizes stored magmas beneath volcanoes. "When people try to predict or forecast what a volcano will do, they usually look at the top five miles beneath the volcano, interpreting volcanic gases released at the surface or detecting small earthquakes indicating magma movement in the upper crust," Ruprecht explained. "But the action that drives a volcano is actually coming from much greater depths, at least 20 miles down, beneath the crust and into the Earth's mantle. It's very important to see how fast the magmas are rising, as this rate may set the course for how the magma finally erupts."

As magma moves through Earth's crust in the run-up to a volcanic eruption it often carries olivine, a green mineral, which has crystallized as the magma cooled. During its rise, magma typically pools in chambers within the crust, mixing with resident magma and obscuring the information about deep processes prior to the mixing. Eventually this magma rises all the way through the crust, and the volcano erupts with the crystals being the lone recorders of that deeper history. Ruprecht is specifically interested in information contained in these crystals, which act as a sort of clock that records changes in the surrounding environment over time. Analysis of the crystals can reveal the process by which magma is moved through Earth's crust, from the mantle to the surface.

"Magmas in the crust represent barriers for new magmas to move through, so any magma that comes up is probably encountering another magma," Ruprecht said. "Nonetheless, we see the new magmas transiting through the barriers quickly. So in these environments, how these types of magmas can make it up so quickly and undisturbed is the bigger question that we need to answer, as it reveals how the crust is actually built beneath large volcanoes."

Ruprecht has been studying lava samples from Irazú, an active volcano in Costa Rica that had two large, recent historic eruptions in 1723 and 1963–65. Initial findings from Irazú indicate that magmas may have moved over a much shorter timescale of just a few months, rather than decades to years. "The big picture is that we may learn something about volcanic hazard assessment and mitigation when the magmas that are potentially driving this eruption are still in the mantle," says Ruprecht. This knowledge would give vulnerable communities more time to prepare for an impending volcanic eruption. Plank and Ruprecht are now looking at data from volcanic eruptions in Alaska's Aleutian Islands, Chile and Tonga to see if the same crystal signal exists in other regions as well.

"OUR DATA ARE THE HISTORY."

"Our data are the history," Plank said. "We can look at past deposits and the past 20 eruptions that a volcano has dished out and we can use this clock and say how rapidly a volcano woke up. If we also know how big the eruption was, then we get a history of what the volcano has done and that might be the best predictor of future activity."

› Terry Plank displays olivine crystals, such as those found in magma from Costa Rica's Irazú volcano. Photo: A.J. Wilhelm

› Rachel Sheppard, a Columbia undergraduate, discusses a rock sample collected from an exposed fault with Pratigya Polissar. Sheppard has been involved in Polissar and Heather Savage's research since her summer 2011 internship at the Observatory. Photo: Eileen Barroso

Seismic Shifts: Innovation Advances Understanding of Earthquakes

On the afternoon of March 11, 2011, Japan began to shake. In a catastrophic earthquake and resulting tsunami, nearly 16,000 lives were lost, with devastating impacts to the region's infrastructure and more than $200 billion in damage. The magnitude 9.1 Tohoku earthquake is among the five largest earthquakes ever recorded, and it brought to the fore the destructive potential of such natural hazards.

As news of the Tohoku earthquake reached New York, local media crews flocked to the Lamont-Doherty campus. Each wanted to know: *What caused this earthquake and what made it so strong?*

FROM VERMONT TO THE SAN ANDREAS AND THE ALASKAN SUBDUCTION ZONE, SAVAGE AND POLISSAR HAVE APPLIED GEOCHEMICAL ANALYSES TO A DIVERSE RANGE OF FAULT ZONES.

Seismologist Heather Savage is trying to answer these questions. Savage studies the structure and motion of the solid earth. Her research focuses on faults, or cracks in Earth's brittle outer crust, along which slabs of rock move relative to one another during events such as the Tohoku earthquake. While Savage can measure how much pressure miniature faults in her laboratory can take before they slip, the same is not true for faults in nature, which often begin rupturing deep within the Earth. The Tohoku earthquake, for example, originated 30 km below the seafloor off the east coast of Japan.

For decades, seismologists have searched for a method to determine the stresses that cause a fault to fail in an earthquake. A recent collaboration between Heather Savage and Pratigya Polissar, an organic geochemist in the Biology and Paleo Environment division, takes a bold new approach.

Rock mechanics and organic geochemistry are at opposite ends of the Earth science spectrum. The range of natural processes each discipline is traditionally concerned with and the analytical techniques they employ are very different. Savage uses heavy machinery to test the physical limits of faults; Polissar extracts molecular fossils from rock powders using a highly sensitive gas chromatograph to analyze the molecular remains left behind by ancient plants and animals.

As slabs of rock slide past one another during an earthquake, intense pressure and friction generate heat, much like the heat produced by rubbing your hands together on a chilly day. When frictional heating occurs along fault zones that contain organic material—plants or algae deposited in sedimentary rock layers over geologic time—the temperature rise alters the molecular geochemistry of the organic material.

What brings these two fields together in this case, is heat.

From Vermont to the San Andreas and the Alaskan subduction zone, Savage and Polissar have applied geochemical analyses to a diverse range of fault zones, measuring the frictional heating signature that corresponds to the stress sustained during past earthquakes. Next, they will apply this method to sediments taken from the Japan Trench following the Tohoku earthquake.

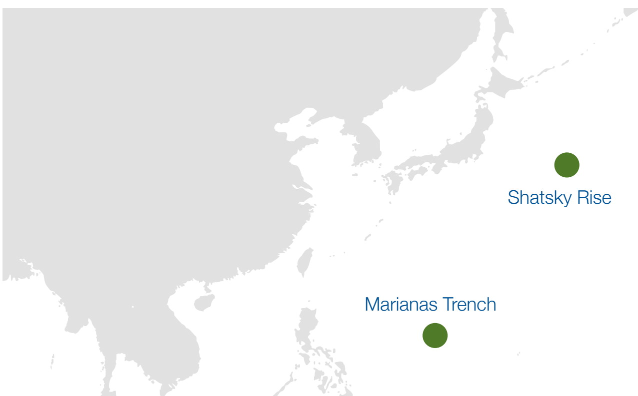
Using their complementary expertise to constrain the relationship between frictional heating and the stress on faults, Savage and Polissar have provided the scientific community with a new tool for understanding the basic nature of faults and the causes of earthquakes. This advance would not be possible without the vision and determination to collaborate across fields in unprecedented ways.

Their work exemplifies the collaborative scientific spirit championed by the Observatory for more than 60 years. "Lamont is a place that encourages pushing forward something completely new," Savage said.

Ocean Explorer: R/V *Marcus G. Langseth*

Lamont-Doherty's research vessel, the *Marcus G. Langseth*, unique in its capabilities to image the sub-seafloor, enables scientists to conduct studies that produce groundbreaking discoveries in the fields of marine geophysics, seismology and general oceanography. The ship is a critical part of the academic research vessel fleet, providing the academic community with the resources to acquire state-of-the-art, two-dimensional (2-D) and three-dimensional (3-D) marine seismic-reflection data. Particularly unique are the *Langseth's* extensive geophysical capabilities that include a seismic recording system with four 6 km solid-state hydrophone streamer cables and a 2,000 psi, pneumatic sound source array towed in four "strings" that can be configured either as a single, 2-D source or dual, alternating 3-D source arrays. No other ship in the academic research fleet approaches the seismic acquisition capabilities of the *Langseth*; consequently research conducted aboard the ship continues to make invaluable contributions to humankind's knowledge of Earth's oceans and sub-seafloor.

2012 R/V LANGSETH RESEARCH EXPEDITIONS In 2012, the *Langseth* completed seven research cruises, spending 208 days at sea and collecting more than 7,200 km of seismic data.



Feb. 1–March 1, March 3–22
Marianas Trench, Western Pacific
Doug Wiens, Washington University in St. Louis
Dan Lizarralde, WHOI
To image the distribution of upper mantle serpentinization

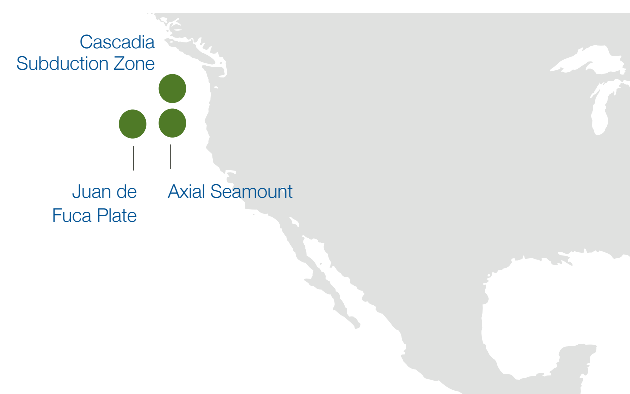
March 24–April 16
Shatsky Rise, Northwest Pacific
Jun Korenaga, Yale University
Will Sager, Texas A&M University
A combined 2-D multi-channel seismic (MCS) and ocean bottom seismometer (OBS) survey

May 1–25
Shatsky Rise, Northwest Pacific
Pratigya Polissar, LDEO
Jean Lynch-Stieglitz, Georgia Tech
To collect sediment material and water samples to study the past changes in the marine Intertropical Convergence Zone (ITCZ) as well as the behavior of El-Nino Southern Oscillation (ENSO)

June 13–July 8
Juan de Fuca Plate; Cascadia Ship to Shore, Oregon/Washington Coast
Suzanne Carbotte, Geoff Abers, Helene, Carton, LDEO
Ann Trehu, Oregon State University
Acquisition of active source seismic data (MCS and OBS) along three transects of the Juan de Fuca plate, offshore Washington state to the Endeavour Ridge, offshore Oregon to Axial Volcano, and along the Cascadia trench. An additional shelf-shore component was done to extend imaging of subducting plates.

July 12–24
Cascadia Subduction Zone, Washington Coast
Jun Korenaga, Yale University
Will Sager, Texas A&M University
To collect 2-D seismic reflection data, with the goal of improving knowledge of subduction processes and the location of the downgoing plate boundary

August 16–26
Axial Seamount, Juan de Fuca Ridge, Washington Coast and Southwest British Columbia
David Butterfield, University of Washington; Maurice Tivey, WHOI
To collect data to understand how hydrothermal ecosystems on undersea volcanoes evolve with volcanic eruption cycles



EDUCATION HIGHLIGHTS

Lamont-Doherty envisions a future with a high degree of scientific literacy, where the public is excited about the potential for fundamental Earth science research to improve the world and young learners are inspired to pursue STEM careers. From our long-running Summer Intern Program for undergraduates, to the individual efforts of our scientists to engage students and teachers in hands-on field and laboratory work, our education initiatives continue to grow dramatically, deepening our impact and inspiring future science leaders.

Postdoctoral Education

Lamont-Doherty continues to be an attractive and competitive place for postdoctoral researchers to complete their training and investigate problems at the forefront of Earth science. The Observatory is experiencing the largest growth ever in our cohort of postdoctoral fellows, with numbers increasing significantly over the last two years. From 32 in Fall 2010 to more than 40 two years later, we expect these numbers to increase in coming years as well.

As part of a new initiative, in 2012 Columbia University committed $30 million to enhancing the diversity of its faculty and postdoctoral fellows. With the leadership of Kuheli Dutt, assistant director of academic affairs and diversity, Lamont was one of four research institutions across Columbia's campus selected by the Provost's Office to offer a Provost's Postdoctoral Research Scientist/Scholar Award. Through an application process, the award will be offered to promising scholars from historically underrepresented groups; the first award will be announced in 2013.

Department of Earth and Environmental Sciences

Our Department of Earth and Environmental Sciences (DEES) is distinguished as having the best Earth science Ph.D. program in the nation, reflecting our exceptional faculty and students, resources and affiliated programs. We offer graduate students an incredible breadth of experience, providing hands-on laboratory, field and sea-going experiences. Our program trains broadly educated Earth scientists for careers in academia, research, government and industry; along the way, our students move swiftly from receiving knowledge to creating it.

In early 2012, our first Graduate Student Research Awards were presented to Rafael Almeida, Steven Brusatte and Shannon Sweet. This new program encourages DEES Ph.D. students to develop projects that will expand the scope and impact of their dissertation research. Carrying on the Lamont tradition of innovative thinking, the awards are designed to encourage students to explore new ideas and applications of their research. The second round of Graduate Student Research Awards were presented in the fall to Angelica Patterson, John Templeton and Marc VanKueren.

The 29th annual Sara Fitzgerald Langer Book Prize was awarded to Jesse Farmer by the Graduate Student Committee. This award is an acknowledgement, by his peers, of Jesse's outstanding contributions to academic and graduate student life in the department and at Lamont.

OUR EDUCATION INITIATIVES CONTINUE TO GROW DRAMATICALLY, DEEPENING OUR IMPACT AND INSPIRING FUTURE SCIENCE LEADERS.

“THIS IS THE SORT OF CAREER THAT YOU CAN’T JUST READ ABOUT—YOU HAVE TO JUST GO OUT THERE AND LIVE IT FOR A BIT.”

Team Diebold Goes to Sea

For select Columbia University students, spending a summer on a cruise is no vacation. Undergraduates interested in seagoing and marine geophysical research now have the opportunity to experience these firsthand. In 2011, marine geophysicist Maya Tolstoy and seismologist Donna Shillington inaugurated “Sea-going Experience in Earth Sciences,” a course that enables students to spend time in the classroom and on a research vessel learning about the complexities of doing research at sea. Known among students and faculty as Team Diebold, in honor of the late marine geophysicist John B. Diebold, the course provides students land-based training and coursework, followed by a multiweek research cruise.

With support from the National Science Foundation and Columbia’s Department of Earth and Environmental Sciences, in 2011 five students went to sea on Lamont’s ship, the R/V *Marcus G. Langseth*. Led by Chief Scientist Donna Shillington, students participated in an expedition to map the ocean floor off of Alaska’s Aleutian Islands. In 2012, another group of five students spent two weeks aboard the R/V *Thomas G. Thompson* with Co-Chief Scientist Maya Tolstoy, recovering and deploying ocean bottom seismometers, which gather data to be used in characterizing earthquakes.

In the *Columbia Record*, Andrew Wessbecher, who was inspired by his participation in the 2011 research cruise to pursue a master’s degree in geophysics, commented, “This is the sort of career that you can’t just read about—you have to just go out there and live it for a bit.”

Hands Wet, Waders On

“Moisture saturated the early morning air, covering the air in a ghostly film. Two large herons stood motionless where the Sparkill Creek widens into the Hudson, and at the pier’s end a kingfisher perched on a tall piling, surveying the area. The silence was soon broken by three buses of high schoolers arriving to sample, measure, and assess the river and its inhabitants.”—Margie Turrin

A Day in the Life of the Hudson River, an education and outreach program designed and led by Education Coordinator Margie Turrin and partners at the Hudson River Estuary Program, marked its 10th anniversary in 2012. The program engages students and teachers in hands-on research, in partnership with Lamont scientists, to collect and create a rich data set for use in classroom activities. Over the years the program has expanded its learning model to offer teacher workshops and train undergraduate science and pre-service teacher classes to serve as field support for elementary and high-school student participants. The event began in 2003 with 300 participants and continues to grow in size and focus, with more than 3,000 participants from 75 schools in 2012.

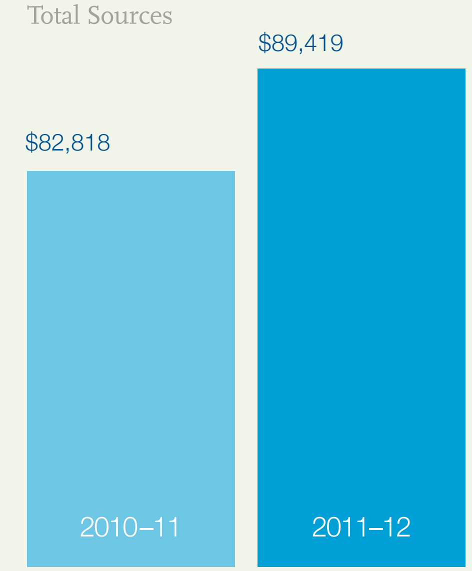
Participant and high-school senior Jenna Delgrosso, 17, gave the day high marks. “We’re actually doing fieldwork,” she said. “It’s good to get a firsthand look at the river.”

› In Piermont, N.Y., participants in A Day in the Life of the Hudson catch fish using a seine net for an activity to see how species vary along the river.

FINANCIALS

Statement of Activities

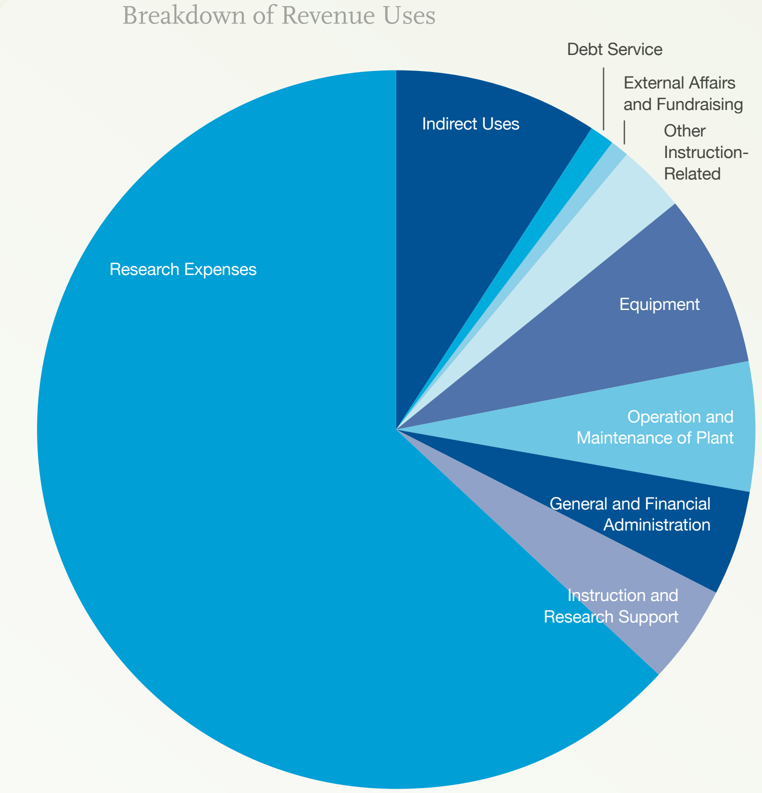
Total Sources



SOURCES OF REVENUE	’10–’11	’11–’12
National Science Foundation	34,396	39,924
National Oceanic and Atmospheric Administration	13,453	6,422
National Aeronautics and Space Administration	7,164	6,229
National Institute of Environmental Health and Safety	2,025	1,913
U.S. Geological Survey	893	3,877
Office of Naval Research	1,112	1,337
USDA	43	7
Department of the Air Force	61	-
New York State	52	16
Department of Energy	541	862
Government Funds via Subcontracts with Other Institutions	8,988	10,300
Miscellaneous Federal Funds	937	2,364
Total Government Grants	69,541	73,253
Private Grants	3,412	3,160
Gifts	871	1,421
Endowment Income	5,640	5,931
Miscellaneous	57	47
Indirect Sources	3,296	5,608
Total Sources	82,818	89,419

USES OF REVENUE	’10–’11	’11–’12
Research Expenses	53,738	57,911
Instruction and Research Support	3,343	4,079
General and Financial Administration	4,227	4,427
Operation and Maintenance of Plant	4,837	5,285
Equipment	3,607	7,153
Other Instruction-Related	1,860	2,757
External Affairs and Fundraising	737	666
Debt Service	1,130	1,130
Indirect Uses	8,507	8,207
Total Uses of Revenue	81,985	91,615
Net Operating Gain/(Loss)	834	(2,196)
Capital Expenses	187	515
Transfers From Endowment	33	–
Subtotal Nonoperating Expenses	219	515
Beginning Fund Balance	13,765	14,379
Ending Fund Balance	14,379	11,669

Breakdown of Revenue Uses



Each year, inspired by the promise of groundbreaking advances in Earth and environmental science, hundreds of private individuals, foundations and corporations ensure the continued success of our remarkable institution. With their generosity, we have made significant advancements in several critical areas.

The transformative Gary C. Comer Geochemistry Building was one of our top fundraising objectives, which included the completion of the Ultra Clean Laboratory and an ongoing challenge to match a $250,000 pledge made by Columbia Trustee H.F. (Gerry) Lenfest to name a portion of the Comer Building in Wallace Broecker's honor.

A campaign for the Ultra Clean Laboratory was launched early in 2010, when the National Institute for Standards and Technology (NIST) awarded the Observatory $1.36 million toward the construction of the lab, academia's largest and most sophisticated facility for geochemistry. In response to this extraordinary opportunity, more than 230 friends, alumni and staff made gifts to help Lamont meet NIST's contribution, raising $1.3 million by the close of the campaign.

Among these, we extend special appreciation to the 19 donors who contributed gifts of $5,000 or more. These individuals will be acknowledged on a plaque outside the Ultra Clean Lab, in recognition of their commitment to scientific discovery. Of this group, the following donors gave $100,000 or more and will have a workstation in the lab named in their honor. They are: The Quentin J. Kenendy Family; the Botwinick-Wolfessohn Foundation, Inc.; George Lawrence Becker Jr. and family, M.D.; and Frank and Joanne Gumper.

We are deeply honored by the continued generosity of the G. Unger Vetlesen Foundation, whose dedication to supporting the Earth sciences has sponsored decades of scientific achievement at Lamont-Doherty and made possible the Vetlesen Prize—the most distinguished honor an Earth scientist may receive.

HUNDREDS OF PRIVATE INDIVIDUALS, FOUNDATIONS AND CORPORATIONS ENSURE THE CONTINUED SUCCESS OF OUR REMARKABLE INSTITUTION.

A generous gift from Sarah E. Johnson Redlich of $500,000 for our Climate and Life Initiative will cement and expand the Observatory's eminence in interdisciplinary studies of the intersection between living and nonliving systems. The Charles and Ann Johnson Foundation also made a leadership gift of $100,000 for this project, for which we extend deep gratitude.

In addition to their success securing institutional grants from federal sources, several of our scientists raised significant private funding for their research, including generous and steadfast support from the Comer Science and Education Foundation and the Global Climate Change Foundation.

We would like to thank Riverkeeper, Inc., for their considerable financial and scientific partnership in support of research on Hudson River water quality. Since 2004, the Brinson Foundation has provided generous and steadfast support for promising research at the Observatory, contributing $110,000 during this recent two-year period to support the work of Postdoctoral Research Fellow Einat Lev and early career scientists in the Earth Microbiology Initiative. We also acknowledge the Tides Foundation, which provided $100,000 to support the synthesis of global seafloor bathymetry by our marine geologists.

Advisory Board

Members of our Advisory Board provide specialized technical expertise and knowledge to the Observatory, serving as strategic thought leaders, collaborators and catalysts for action. For more than five years, Quentin J. Kennedy led the Board through a multitude of achievements and unprecedented growth before retiring as Board chair at the end of 2011. In recognition of Mr. Kennedy's service, the conference room in the Gary C. Comer Geochemistry Building was named in his honor.

The chairmanship transitioned to Frank Gumper, former vice-chair and student at Lamont in the 1970s. Under the leadership of Mr. Kennedy and Mr. Gumper, the Advisory Board has focused on identifying effective strategies to sustain current momentum and attract new interest in the Observatory.

A major initiative in 2011 and 2012 was the establishment and expansion of the Director's Circle, a group of donors who make an annual gift of $2,000 or more to the Observatory and have a keen interest in our mission, research accomplishments and broader impacts. The Director's Circle was established in October 2010, when the Advisory Board hosted the first *Afternoon of Science Master Classes* for members of the Circle. Since its establishment, the Director's Circle has grown from 20 members in 2011 to more than 30 in 2012.

Alumni Board

The Lamont-Doherty Alumni Board provides opportunities for the hundreds of Lamonters who have worked or studied on our campus to maintain their connections with each other and with the Observatory. Under the leadership of Steven Cande (Ph.D. '77), the Alumni Board has expanded its membership and engaged alumni of all ages and from all parts of the world.

New Alumni Board members include: Debra Tillinger (Ph.D. '10), professor at Touro College in New York City; Philip Orton (Ph.D. '10), postdoctoral research associate in the Department of Environmental and Ocean Engineering at Stevens Institute of Technology; and Dee Breger (staff at Lamont from 1982–2004), founder and owner of Micrographic Arts.

The Observatory's primary alumni events take place during the fall Open House on our campus and at our annual Alumni Reception, held in San Francisco in December. Thanks to the participation of our Alumni Board members, each Open House since 2010 has included a panel discussion with Lamont alumni on career paths within and outside of academia—drawing alumni back to campus and providing valuable insights for current students.

July 1, 2010 THROUGH June 30, 2012

$500K +

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We wish to acknowledge and thank the many friends, alumni and staff who gave so generously to help us complete the Gary C. Comer Geochemistry Building's Ultra Clean Laboratory.

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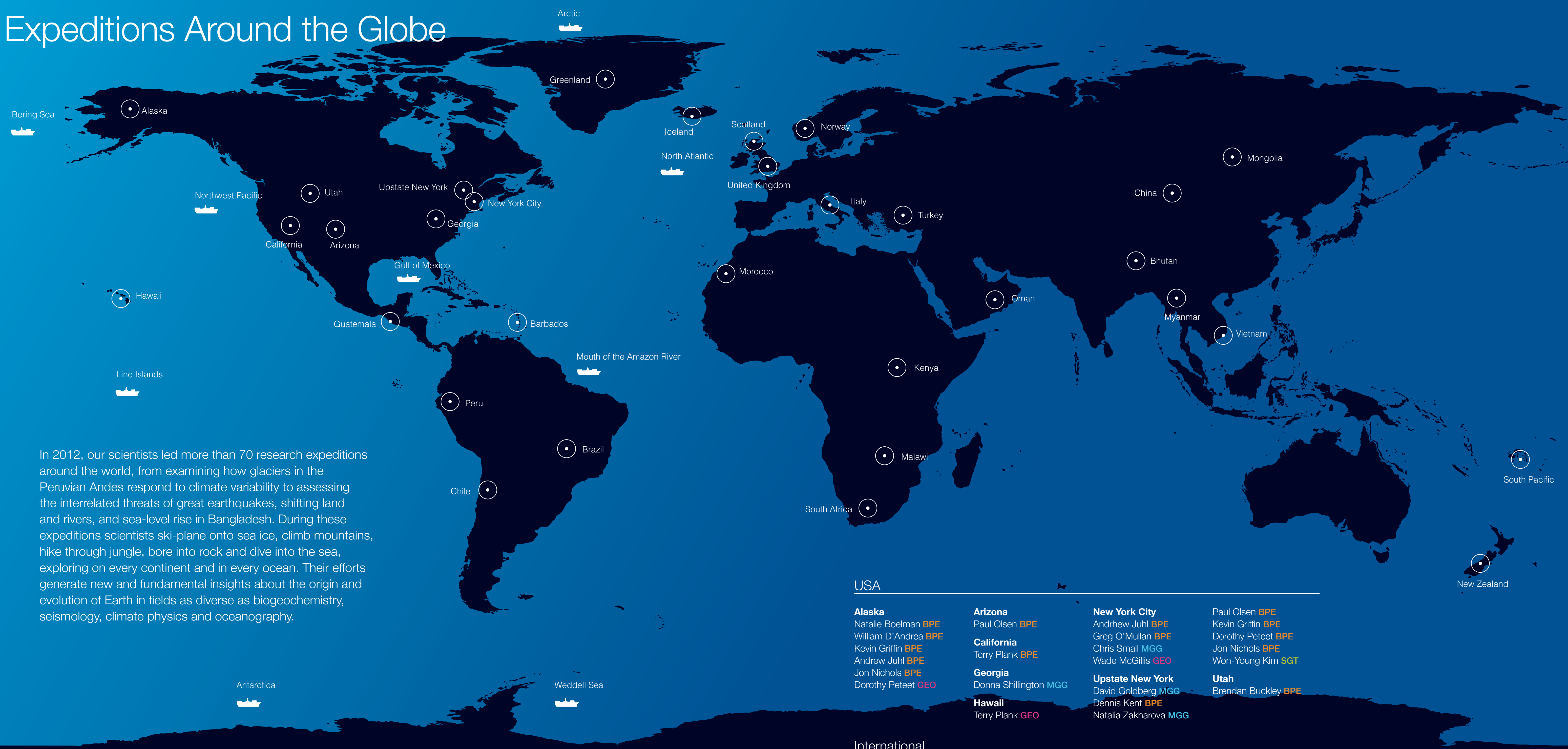

In 2012, our scientists led more than 70 research expeditions around the world, from examining how glaciers in the Peruvian Andes respond to climate variability to assessing the interrelated threats of great earthquakes, shifting land and rivers, and sea-level rise in Bangladesh. During these expeditions scientists ski-plane onto sea ice, climb mountains, hike through jungle, bore into rock and dive into the sea, exploring on every continent and in every ocean. Their efforts generate new and fundamental insights about the origin and evolution of Earth in fields as diverse as biogeochemistry, seismology, climate physics and oceanography.

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