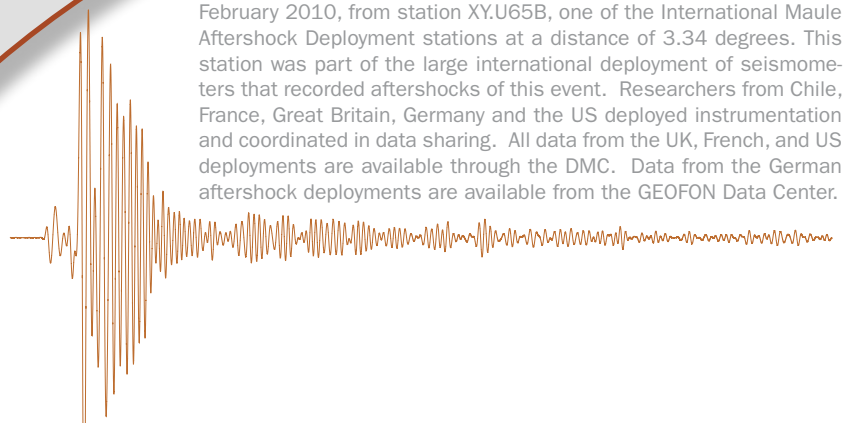
# DATA SERVICES



Recording of an aftershock of the great Maule, Chile, earthquake of February 2010, from station XY.U65B, one of the International Maule Aftershock Deployment stations at a distance of 3.34 degrees. This station was part of the large international deployment of seismometers that recorded aftershocks of this event. Researchers from Chile, France, Great Britain, Germany and the US deployed instrumentation and coordinated in data sharing. All data from the UK, French, and US deployments are available through the DMC. Data from the German aftershock deployments are available from the GEOFON Data Center.



# DATA Management System

## OVERVIEW

The IRIS Data Management System (DMS) continued to make progress in many areas during the past year. The two DMS Data Collection Centers at the US Geological Survey (USGS) Albuquerque Seismic Laboratory and the University of California, San Diego International Deployment of Accelerometers (IDA) group are actively working on enhanced quality control of Global Seismographic Network data in collaboration with the IRIS Data Management Center (DMC). The DMS continues to support the Kazakh National Data Center in Almaty, Kazakhstan, providing regional support services to ensure continuing data flow from networks in Central Asia. Significant help also was provided through the Regional Exchange of Earthquake Data (REED) project to regional centers in Central Asia, SW Pacific, and Africa. The University of Washington has undertaken an ambitious project to process all data using a tremor envelope algorithm that will ultimately aid in global tremor detection.

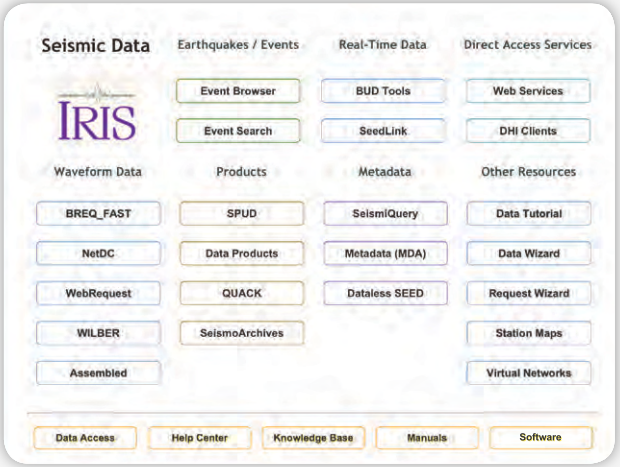
## DATA MANAGEMENT CENTER ACTIVITIES

The DMC is moving from dedicated SUN servers to virtualized servers running RedHat Enterprise Virtualization software with the RedHat Enterprise Linux operating system. This will improve cost effectiveness by reducing the number of servers, resulting in significant power savings and lower hardware and software maintenance costs. At the present time about one-third of our processes have been moved into the virtualized environment and we anticipate this will be completed during the next year. We are also moving data into a large condominium compute environment at the University of Washington as a first step in determining how realistic it is to run in a cloud computing environment. The DMC is working with its data providers to ensure all of the waveform data are brought up to the current version of SEED. This will enable the newer web services to deliver all data from the archive.

The DMC developed the specifications for the next generation quality assurance system that will be brought into routine operations. As QUACK (Quality Analysis Control Kit) is phased out of operations, the new MUSTANG (Modular Utility for Statistical Knowledge Gathering) system will significantly enhance quality assurance capabilities. The new system will be developed using a service-oriented architecture built upon web services. It will allow improved quality assurance for all SEED formatted data in the archive, not just data received in real time.

## IMPROVING USER SUPPORT SERVICES

The DMC has introduced three new tools to improve the user experience. These include a new Data Access Navigator (http://www.iris.edu/data/access), a new "mouse pad" (see below) (http://www.iris.edu/data/mousepad), and a Knowledge Base system (http://www.iris.edu/KB). These tools make it easier for users to find the information they need of at the DMC and to receive answers to questions they might have.




A new "mouse pad," providing rapid interactive access to most DMC data request methods, is now available at http://www.iris.edu/data/mousepad. This page also provides rapid access to the new IRIS Knowledge Base, Help Center, manuals, and software pages.

### WEB SERVICES

In December 2010, an initial collection of web services was released as a new method to programmatically access the information maintained at the DMC. These services were developed with support from the National Science Foundation (NSF) and augmented with funds from the USGS. A complete listing of the web services can be found at http://www.iris.edu/ws. The key services provide access to 1) single and multiple waveforms; 2) determination of data availability for a given geographic region, time period, and sensor type; 3) information from earthquake catalogs; and 4) metadata describing seismic stations. Progress has been made enabling use of IRIS web services within workflows using the Microsoft Trident Scientific Workflow Engine.

### PRODUCTION OF HIGHER LEVEL PRODUCTS

The core service of the DMC continues to be traditional waveform distribution; however, the generation, management, and distribution of higher level products continues to grow in importance. Initial products that are now available include: Ground Motion Visualizations, Event Plot Suites, gCMTs (Global Centroid Moment Tensors) from Lamont-Doherty Earth Observatory, Electromagnetic Transfer Functions from Oregon State University, and the EarthScope Automated Receiver Survey (EARS) from the University of South Carolina. During FY2012, Princeton-generated 3D synthetic seismograms, tomographic models from the Earth Model Collaboration, and Source Characterization products will become available. Lists of existing products or those in development can be found at http://www.iris.edu/dms/products.

### UNPRECEDENTED DATA DISTRIBUTION

Calendar year 2011 is promising to be an incredible year for data distribution. As of August 31, 2011, it is projected that a total of 147 terabytes of time series data will be distributed to the research and monitoring communities. While traditional requests from the DMC (Breqfast, NetDC, autoDRM, Wiggles, and WILBER) remain the dominant data distribution methods (42.1% of total data volume), real-time data feeds (31.4%), web services (20.5%), and DHI (6.0%) continue to grow in importance.

As evidence of the high use and re-use of IRIS data and services, this is the first year in which the amount of data shipped by the DMC (~147 terabytes) was nearly the same as the total amount of data in the archive (149 terabytes), and five times the amount of data added to the archive this year.

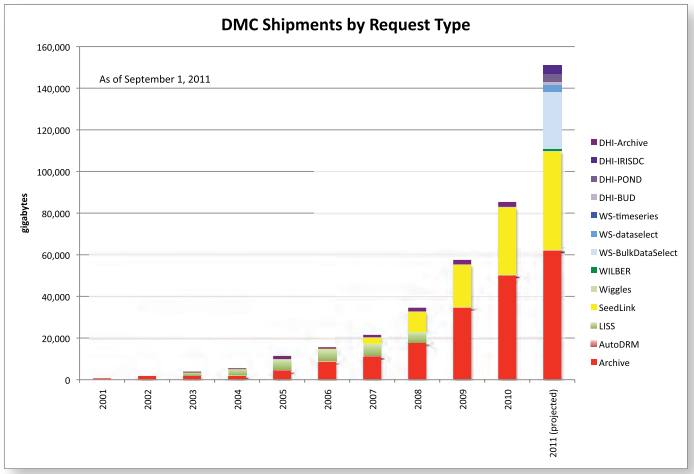



FIGURE 1. The amount of data distributed by the DMC (~147 terabytes) continues to increase exponentially. While distribution from the archive (62 terabytes) continues to be the dominant distribution mechanism, real-time methods (~46 terabytes), web services (~30 terabytes), and DHI (~9 terabytes) contribute heavily to data distribution. The active use of the new web services is impressive.

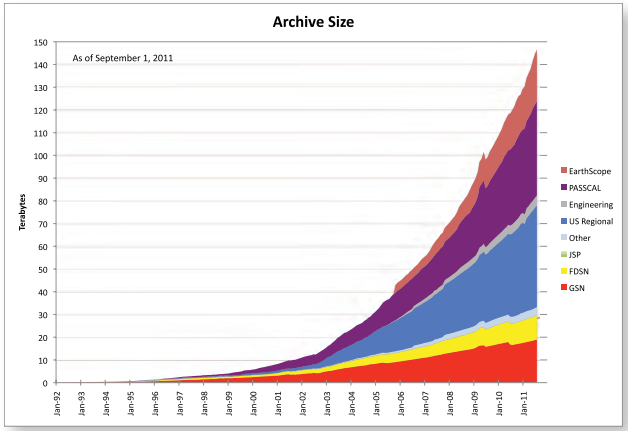
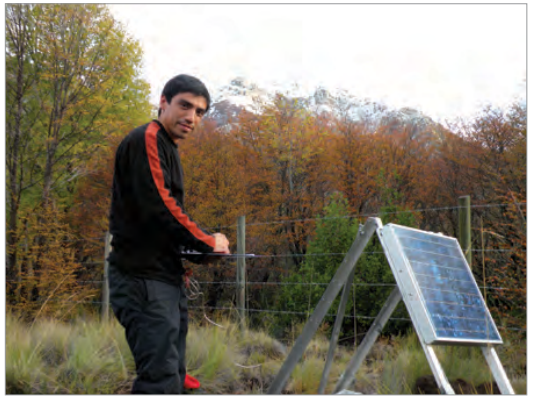



FIGURE 2. The data archive at the IRIS DMC is growing at a rate of 27 terabytes per year and now has a total size of 149 terabytes.



Ismael Ortega of the University of Chile assisted staff from the PASSCAL Instrument Center with installation of seismic stations for the aftershock study.

Carl Ebeling (right), a PhD student at Northwestern University, and a team member from Chile (left) install one of the 58 IRIS Chile RAMP broadband stations contributed to IMAD.

# International Maule Aftershock Deployment

Susan Beck
University of Arizona
Anne Meltzer
Lehigh University
Ray Russo
University of Florida
Steve Roecker
Rensselaer Polytechnic Institute
Harley Benz
US Geological Survey

On February 27, 2010, the Mw 8.8 Maule earthquake struck off the coast of south-central Chile rupturing nearly 600 km of the Nazca-South American plate boundary. Over 11 million people in Santiago, Valparaiso, Concepcion, and the surrounding towns and countryside experienced moderate to strong ground shaking. The earthquake generated a tsunami that was locally damaging and contributed to many of the fatalities. Through planning, preparation, and local/national emergency response, the loss of life and damage was minimized, although still tragic and significant: 521 lives were lost, ~800,000 people were displaced, and the economic impact exceeded $30 billion, 17% of the country's GDP. Large-to-great subduction zone megathrust earthquakes are not new to Chile. There have been seven megathrust earthquakes with magnitudes greater than 7.9 since 1906 along the Chile coast. The mainshock was well recorded by the Global Seismographic Network (GSN) and by regional networks around the globe. However, only two of the GSN stations that recorded the event are actually located in Chile, making clear the need for temporary seismic network deployments for adequate recording of aftershocks.

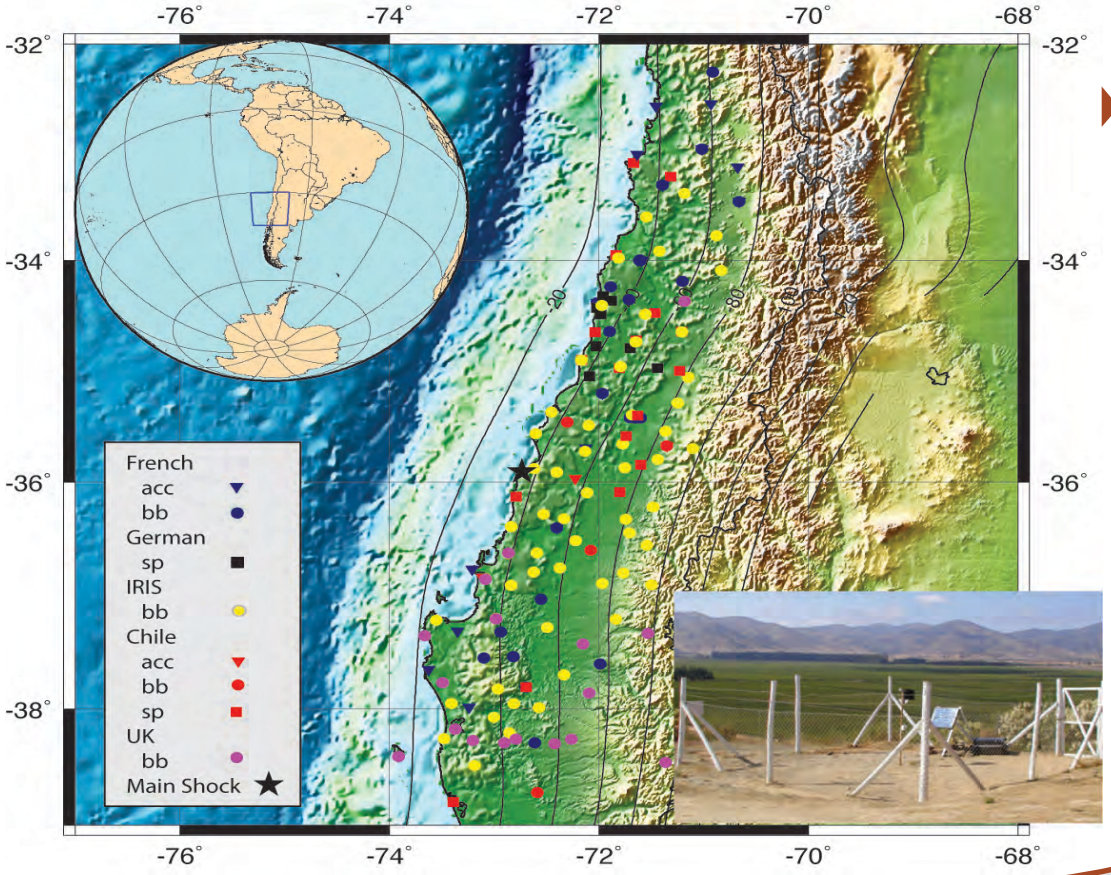
Immediately following the Maule earthquake, teams of seismologists from Chile, France, Germany, Great Britain, and the US mobilized, coordinating resources to capture aftershocks and other seismic signals associated with this great earthquake. In total, 164 instruments (91 broadband, 48 short period, and 25 accelerometers) were deployed above the rupture zone of the mainshock from 33°-38.5°S and from the coast to the Andean front (see figure). The global seismological community response to the Chile earthquake established a new standard for international cooperation to produce high-quality, open-access data in the wake of significant earthquakes. Coordination and data sharing resulted in a relatively uniform network covering virtually the entire onland rupture region, some 90,000 km$^2$, at a nominal station spacing of 30 km. The resulting International Maule Aftershock Deployment (IMAD) captures one of the best ever recorded aftershock sequences in the wake of a great megathrust, second only to the 2011 Tohoku aftershock sequence.

To integrate these data into a unified catalog, the US Geological Survey's (USGS) National Earthquake Information Center (NEIC) developed procedures to use their real-time seismic monitoring system (Bulletin Hydra) to detect, associate, locate, and compute earthquake source parameters from these stations. As a first step in the process, the USGS built a seismic catalog of more than 17,000 earthquakes (M1.5 or larger) for the time period of the main aftershock deployment of IRIS-supported stations, March-July 2010. The catalog includes earthquake locations, magnitudes, associated phase picks, and regional moment tensors solutions for most M4 or larger events. From that catalog, NEIC will review all M3.5 or larger events, which will than be integrated with the teleseismic phases, amplitude measures, and body-wave moment tensor (MT) and centroid moment tensor (CMT) solutions for larger events (typically M4.5 and larger).

IMAD provides unprecedented opportunities to gain insight into rupture processes associated with megathrusts and the dynamics of ocean-continent collision along the Andean margin. In addition, data from ground truth events can be used to calibrate the velocity structure of central Chile to improve future real-time monitoring. Initial analysis of IMAD indicates complex spatial and temporal patterns of seismicity and earthquake focal mechanisms, earthquake clustering, non-volcanic tremor, and low frequency events. The dataset also offers opportunities to generate higher resolution images of the seismogenic zone, forearc wedge, and subducting slab, to reveal the role that spatial changes in material properties play in seismogenesis and slab dynamics. Data from collocated stations before the Maule earthquake can be used to investigate secular changes in material properties before and after the rupture.

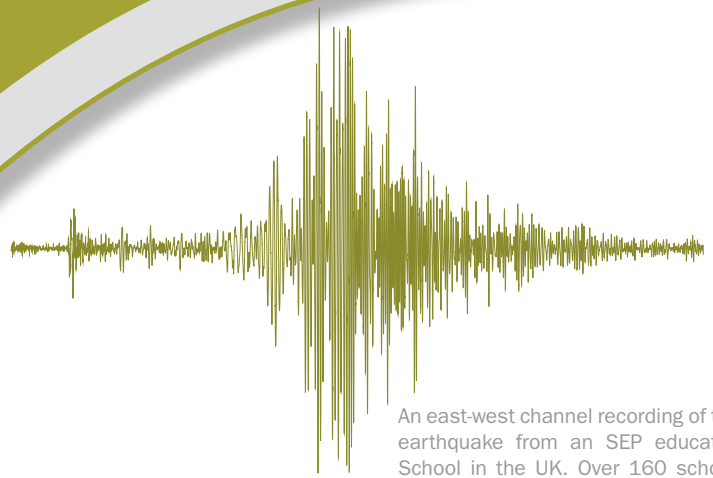
The US IRIS, French and British data are available for download at the IRIS Data Management Center (DMC) using the virtual network code _IMAD or individual network codes: British 3A 2010, French XS 2010, and United States XY 2010. The German data are available at the Geofon Data Centre, operated by GFZ under the network code ZE at http://geofon.gfz-potsdam.de/geofon//new/netabs/ze.html.

Acknowledgements: The US IRIS Community response was made possible by National Science Foundation Rapid Response Research (RAPID) grants EAR-1036349 and EAR-1036352 and by the availability of EarthScope Flexible Array instruments. Partners, collaborators, and volunteers include: Sergio Barrientos, Diana Comte, Mario Pardo, Javier Ruiz, and Carlos Aranda (Universidad de Chile); Klaus Bataille (Universidad de Concepcion, Chile); Jean-Pierre Vilotte (IPG, France); Frederic Tilmann, Ben Heit, and Bernd Schurr (GFZ, Germany); Dietrich Lange (University of Potsdam, Germany); Andreas Rietbrock (University of Liverpool, United Kingdom); Noel Barstow, Brian Bonnet, Angela Marie Reusch, George Slad, and Bob Greschke (IRIS PASSCAL); Olga Cabello and David Simpson (IRIS Consortium); Aaron Velasco (University of Texas,at El Paso); Carl Ebeling (Northwestern University); and Harley Benz (US Geological Survey). We are grateful to the individuals, families, and local communities in Chile who were welcoming and generous in providing assistance with this project.




Map of all the IMAD stations with insert photo of an IRIS CHAMP seismic station. Academic volunteers and PASSCAL personnel deployed the IRIS CHAMP (Chile RAMP) stations in record time, 58 stations in 10 days. Stand-alone stations were installed with Guralp 3T sensors using the direct burial method and powered by solar panels and batteries. Data were recorded on-site and retrieved at approximately six-eight week intervals during the six-month deployment. In August of 2010, four of the IRIS stations were upgraded to transmit data by cell phone modem to the University of Chile and back to the IRIS DMC as a proof of concept for real-time data collection during an international RAMP deployment.

# EPO



An east-west channel recording of the March 9, 2011, M7.2 foreshock to the Tohoku earthquake from an SEP educational sensor stationed at Bishop Wordsworth School in the UK. Over 160 schools that are part of the UK school seismology network are registered on the IRIS Seismographs in Schools web site and can use the web site to share data with other schools. The seismogram is unfiltered and spans 1 hour and 20 minutes.



# Education and Public Outreach

### OVERVIEW

The Education and Public Outreach (EPO) program is committed to advancing awareness and understanding of seismology and Earth science while inspiring careers in geophysics. The EPO program develops and disseminates a suite of educational activities designed to impact 5th grade students to adults in a variety of settings, ranging from self-exploration in front of one's own computer, to the excitement of an interactive museum exhibit, a major public lecture, or in-depth exploration of the Earth's interior in a formal classroom.

In the past year, the impact of the IRIS EPO program has increased through the development of new materials and by responding to public interest after major earthquakes such as the magnitude 9 Japan earthquake in March 2011. For example, our Teachable Moment presentations, prepared following major earthquakes and produced in collaboration with the University of Portland, are generally posted to the IRIS web site within 24 hours of the event. In the case of the Japan earthquake, the slides were available before educators headed into class the next morning and provided a starting point to discuss the earthquake (see pages 28-29).

### UNDERGRADUATE INTERNSHIPS

Our summer internship program (15 students in 2011) continues to thrive via a Research Experiences for Undergraduates grant from the National Science Foundation and through positions funded by IRIS community research programs. IRIS is also a partner with UNAVCO's Research Experiences in Solid Earth Sciences for Students (RESESS) program that is designed to provide multi-year research experiences for students from underrepresented groups. Some RESESS students were able to join the IRIS student cohort in their final year. IRIS interns began the summer with a one-week orientation hosted by New Mexico Institute of Mining and Technology and then spent the rest of the summer engaged in research at 13 different IRIS institutions. They kept in touch with each other via Internet blogs, webinars, and a private Facebook group. Of the 114 students who have participated in the program since 1998, 90% of those who have completed their undergraduate degree have gone on to graduate school in the geosciences, often at the school where they did their internship.

## OUTREACH ACTIVITIES

The EPO web and social media pages are the primary means of dissemination of information and resources and we continue to add new material, including a total of over 80 animations and short instructional videos. A significant increase in the number of visitors to the site has been achieved by the ongoing examination of all the delivery venues for educational content, followed by revisions and reorganizations across the web site, increased use of social networking sites, and encouraging other groups to link to and translate our materials. For example, our animations and videos posted to YouTube generate more hits than the same animations on our web site, and we provide frequent posts on a range of topics on our Facebook page. Our newest poster, featuring wave propagation across the Transportable Array, is also linked to a student-centered web entry point where students are guided through a series of explorations. The Seismographs in Schools web site helps teachers make use of seismic data and communicate with the growing global community of educational seismograph users.

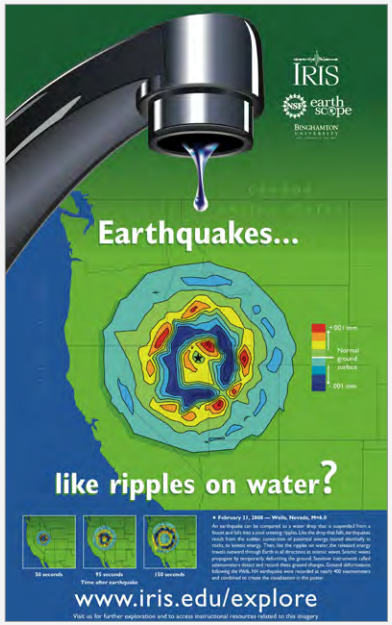
## MUSEUM DISPLAYS

Millions of people have interacted with IRIS/US Geological Survey museum displays, many of them at the American Museum of Natural History in New York and the Smithsonian Institution National Museum of Natural History in Washington, DC. A growing number of people also explore seismological concepts through the Active Earth Monitor (AEM). The AEM is a smaller, more flexible version of the museum display and is in use at universities, schools, and visitor centers throughout the US. Served via a web browser, the display is customizable and the software is available to anyone who applies via the IRIS EPO web pages. Touch screens provide an interactive experience and new content continues to be developed. The AEM formed a central part of the new EarthScope exhibit designed and installed in the past year at a new welcome center on Interstate 55 in Missouri with a New Madrid earthquake theme. Another program aimed at general audiences is the IRIS/Seismological Society of America Distinguished Lecture Series, where two speakers are selected each year from a pool of nominees generated from the IRIS community. These lectures reach a broad sector of the public through venues that often have a well-established lecture series.

## PROFESSIONAL DEVELOPMENT

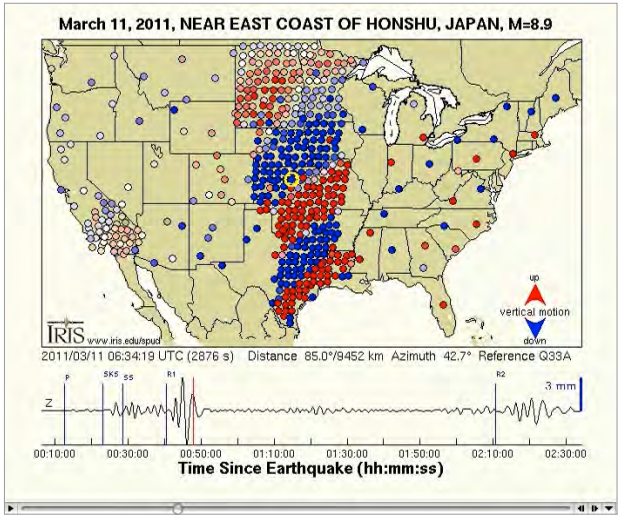
The EPO Program provides professional development experiences designed to support the needs of formal educators. For example, a 2.5-day workshop is held in collaboration with Penn State and North Carolina A&T as part of the AfricaArray project. In addition, a series of short workshops are held each year as part of the National Science Teachers Association annual meeting and we regularly collaborate on workshops organized by other groups. To reach a broader audience, a special seismology issue of the National Earth Science Teachers Association quarterly journal "*The Earth Scientist*" was sponsored and edited by IRIS EPO. The issue contains science articles by IRIS community members as well as classroom-ready activities.

IRIS summer research interns Ado Mucek and Dwight Williams set up a PASSCAL instrument during the intern orientation at New Mexico Tech.




The newest IRIS EPO poster highlights ground motions from the Transportable Array and ties to a set of web pages where students can explore the concepts of the poster in greater detail using animations and visualizations.


Children learn about and explore seismic activity on an interactive display designed by IRIS with content developed in collaboration with UNAVCO and other groups.




Snapshot of Ground Motion Visualization (GMV) from the March 2011 Honshu earthquake. The GMVs are created automatically by the IRIS Data Management Center and are included in the Teachable Moments created after major events.

# IRIS Teachable Moments: Combining the Resources and Expertise of the Consortium to Foster Wide Impact

Michael Wysession
Washington University

There are no sciences like Earth & Space Sciences when it comes to the "Teachable Moment." Look at the front page of any major newspaper and you will see the evidence of it. From earthquakes in Virginia to flooding in Vermont, the Earth is always busy, often with significant impacts to humans. These geologic events have a positive side, however: they present opportunities to teach students about the Earth in a current and relevant context that provides a unique opportunity for learning. Not only are these Earth-science Teachable Moments exciting (ask children what they want to be when they grow up, and they are more likely to say "astronaut" or "paleontologist" than banker or lawyer), but they are perfect opportunities to directly connect course content to a larger world beyond the classroom.

Over the past two years, IRIS's Education and Public Outreach program, in collaboration with Bob Butler at the University of Portland, have invested significant effort into developing rapid-response resources following large newsworthy earthquakes. This suite of products, the IRIS Teachable Moments, provides the framework and elements necessary for educators to explore the unique storyline of a newsworthy earthquake within 24 hours of the event. Each IRIS Teachable Moment features photos from the Associated Press, descriptions and graphics of regional tectonic relationships, US Geological Survey (USGS) graphics and summaries, customized concept animations developed by IRIS EPO, seismic data, and USArray Ground Motion Visualizations produced by the IRIS Data Management Center. For very large events, the scope of the resource is further enhanced as researchers within our community share additional resources such as visualizations of aftershock sequences, rupture propagation, maps and other data products.

The IRIS Teachable Moment resource is unique, not only because of its timeliness but also because products are combined into the easily editable format of an annotated PowerPoint presentation. As a result, IRIS community members are empowered to impact students across a spectrum of levels, including learners beyond the classroom. For example, following the 2011 Tohoku, Japan earthquake, the IRIS Teachable Moment was extremely valuable for my own education and outreach efforts, and I used versions of it for many different venues.

The earthquake occurred during the night while I was in San Francisco, and by 6 am the phone started ringing from multiple radio and TV stations that wanted to interview a seismologist concerning the disaster in Japan. While I was on the phone, I downloaded the IRIS Teachable Moment, read through it, and used its well-summarized information as the foundation of my interviews. As more information became available about the earthquake, the Teachable Moment was revised to reflect these latest interpretations. Thus, I went back several times to get the most up-to-date version.

Once back in St. Louis, I was able to make use of the IRIS Teachable Moment on several more occasions. First, I was invited to be part of a presentation on the earthquake and damage to the Fukushima nuclear reactor that was open to all of the Washington University community, with several hundred in attendance. I used an abridged version of the Teachable Moment for this venue. Second, I was also teaching an undergraduate geophysics course that semester. In class, I expanded on the Teachable Moment's foundation by adding slides produced by members of the IRIS research community (by C. Ammon and M. Ishii). This expanded talk also supported a presentation to an organization of undergraduate students interested in learning more about the earthquake-induced disaster.

Next, I gave a videotaped interview for the St. Louis Science Center that was developed into a web-based presentation for public consumption that included images from the Teachable Moment. Finally, I used the IRIS Teachable Moment on the 2011 Tohoku earthquake as the model example of a teachable moment class presentation in an online workshop on Visualizing Seismic Waves that I co-conducted in the spring of 2011 with Dave Mogk of Montana State University through the *On The Cutting Edge* program (http://serc.carleton.edu/NAGTWorkshops/geophysics/seismic11/).

By capitalizing on the strengths and resources of the IRIS Consortium, the Teachable Moments have become powerful educational tools that make newsworthy earthquakes understandable to individuals around the world in a timely and rapid manner. It is now possible for any instructor, anywhere in the world with Internet access, to provide an interesting, engaging, balanced, and accurate presentation to his or her class within hours of a major earthquake.

IRIS Teachable Moments

## Magnitude 9.0 NEAR THE EAST COAST OF HONSHU, JAPAN
**Friday, March 11, 2011 at 05:46:23 UTC**

Shaking intensity scales were developed to standardize the measurements and ease comparison of different earthquakes. The Modified-Mercalli Intensity scale is a twelve-stage scale, numbered from I to XII. The lower numbers represent imperceptible shaking levels, XII represents total destruction. A value of IV indicates a level of shaking that is felt by most people.

| Modified Mercalli Intensity | Perceived Shaking |
|---|---|
| X | Extreme |
| IX | Violent |
| VIII | Severe |
| VII | Very Strong |
| VI | Strong |
| V | Moderate |
| IV | Light |
| II-III | Weak |
| I | Not Felt |

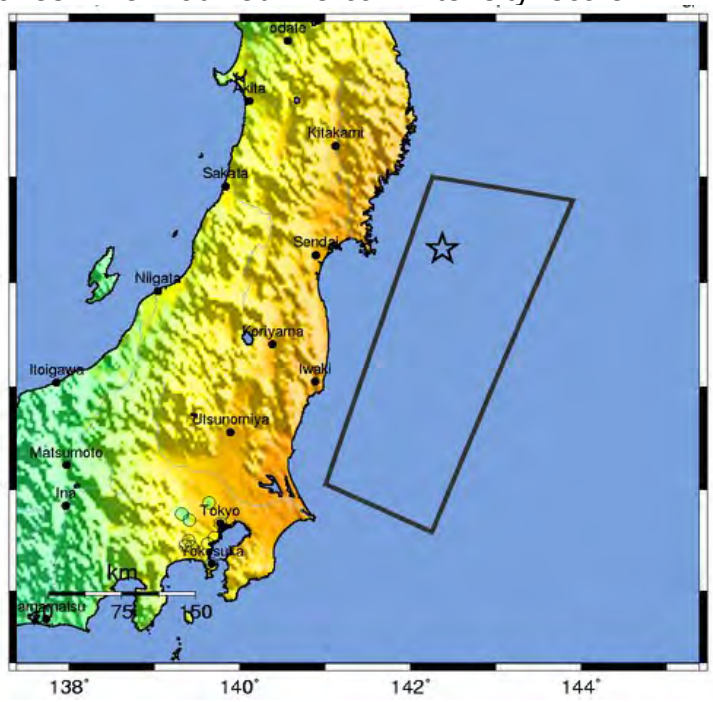
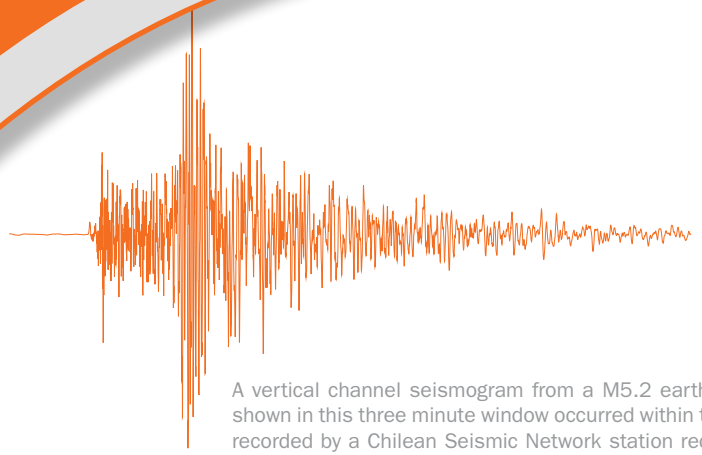



*Image courtesy of the US Geological Survey*

*USGS Estimated shaking Intensity from M 9.0 Earthquake*

Sample Teachable Moment slide showing the USGS estimated intensity from the Honshu earthquake. USGS and other information is pulled together into a story that teachers and college faculty can use in the classroom.

# IDS



A vertical channel seismogram from a M5.2 earthquake near Concepción, Chile on July 28, 2011. The event shown in this three minute window occurred within the rupture area of the 2010 M8.8 Maule earthquake and was recorded by a Chilean Seismic Network station recently upgraded as part of the a collaborative agreement between IRIS and the University of Chile. Ultimately ten comprehensive geophysical observatories will be installed along the length of Chile, including telemetered broadband and strong motion seismometers, as part of an effort to encourage multidisciplinary science and improve hazard mitigation.

## IDS committee

| | |
|---|---|
| Anne MELTZER (Chair) | Leigh University |
| Sergio BARRIENTOS | Universidad de Chile |
| Noel BARSTOW | PIC, New Mexico Tech |
| Susan BECK | University of Arizona |
| Karen FISCHER | Brown University |
| Art LERNER-LAM | Lamont-Doherty Earth Obs of Columbia University |
| Andy NYBLADE | Pennsylvania State University |
| Eric SANDVOL | University of Missouri, Columbia |
| Niyazi TÜRKELLI | Bosphorus University, Kandilli-Turkey |

## IDS management

| | |
|---|---|
| Olga CABELLO | IRIS |
| Ray WILLEMANN | IRIS |

# International Development Seismology

International Development Seismology (IDS) is the vibrant newest IRIS program that facilitates the global practice of seismology with emphasis in the developing world, and supports actions that extend the social impact of seismology.

The IDS mission is to merge IRIS focus on scientific progress with the community's interest on broadening social impact. While highly interdependent, these two perspectives require orchestrating diverse operational modalities, populations of participants, funding sources, and partner communities. IDS serves the seismology community by identifying and supporting the pursuit of scientific opportunities in developing countries, and by leveraging the emerging interest and commitment of the community in ensuring that discovery positively impacts society.

Over the past year, IRIS IDS has initiated a systematic set of activities focused on developing international partnerships between the seismological communities in the US and Middle America, and within the region. The launching event for these efforts was the workshop "Geophysical Hazards and Plate boundary Processes in Central America, Mexico and the Caribbean". The workshop was jointly funded by the National Science Foundation and the US Agency for International Development and was attended by over eighty participants representing 20 countries. Through a highly interactive agenda, the outcome of this event was the creation of a coalition of stakeholders committed to the development of seismological capacity in the region, ALMAS. Workshop participants identified five areas of interest to be pursued by international interest groups, and coordinated by IRIS IDS. These are Research, Hazards and Risk, Education and Public Outreach, Monitoring and Data Management, and Preparedness and Response. Leaders of these groups had the opportunity to reconvene in February 2011, to outline follow-up actions focused on promoting international collaboration for hazard assessment and monitoring in the region.

During FY2011, IDS has expanded efforts to other global regions, including South America and Southeast Asia, with planned capacity building activities in Ecuador and Thailand, in coordination with IRIS core programs. IDS continues to serve the IRIS community by promoting the establishment of trans-sector, multidisciplinary, international partnerships that enable partners around the world and serve the transcendence of scientific discovery to global social impact.

# Geophysical Hazards and Plate Boundary Processes in Central America, Mexico and the Caribbean: A Workshop to Build Seismological Collaboration and Capacity

Karen Fischer, Brown University

Panel discussion on capabilities and opportunities in the Caribbean. From left to right: **Michael Schmitz**, Director, Departamento de Geofisica, Fundacion Venezolana de Investigaciones Sismologicas; **Richie Robertson**, Director, Seismic Research Centre, Trinidad and Tobago; **Victor Huerfano Moreno**, Interim Director, Puerto Rico Seismic Network; **Lyndon Brown**, Head Research Fellow, Earthquake Unit, University of the West Indies; **Jean Robert Altidor**, Technical Director, Bureau of Mines and Energy, Haiti; **MariePaule Bouin**, Seismologist in Charge, Guadeloupe observatory IPGP, Monica Arcila, Geologist, INGEOMINAS; **Eugenio Polanco**, Director, Instituto Sismologico, Universidad Autonoma de Santo Domingo, Dominican Republic; **Garymar Rivera**, Technical Planning Officer, Department of Disaster Management, British Virgin Islands.

On October 24-28, 2010, over 100 scientists, hazard mitigation and development planners, and students gathered in Heredia, Costa Rica for "Geophysical Hazards and Plate Boundary Processes in Central America, Mexico and the Caribbean: A Workshop to Build Seismological Collaboration and Capacity". The workshop goals were to share knowledge and lay the foundation of a collaborative structure whose mission is to enhance seismological and geodetic research and monitoring and to reduce vulnerability to natural hazards within the region. Workshop participants represented 20 countries.

The workshop was initiated and developed by the IRIS International Development Seismology Committee and Jay Pulliam (Baylor University), and its program was planned by an outstanding international organizing committee (listed at http://www.iris.edu/hq/middle_america along with the workshop program, presentations, ratified statements, and ongoing working groups). The workshop was funded by the National Science Foundation (NSF) Office of International Science and Engineering and the US Agency for International Development, with additional support from the American Geophysical Union.

Talks and discussion during the meeting highlighted the needs and potential for seismological and geodetic research and monitoring, both for mitigation of earthquake, tsunami and volcano hazards, and for addressing key science questions regarding plate boundary processes and evolution. The education of the next generation of seismologists in the region was a priority topic, as were strategies for translating research into effective hazard reduction practices, and models for funding future collaborative efforts.

Key outcomes of the workshop were ratification of a statement of recommended actions to reduce exposure to earthquake hazards for nations in the region and a resolution of support for Haiti as it recovers from the January 12, 2010 earthquake. The sense of the meeting was that working together on specific projects is the best means of fostering regional collaboration and carrying forward workshop goals.

Five working groups were formed to organize future projects. A microzonation study in the Dominican Republic was identified as a particularly high priority. The chairs of the working groups and other interested scientists reconvened at the February 2011 UNAVCO COCONET Workshop (with NSF support), adopted the acronym ALMAS, and have been developing a proposal for the Dominican Republic microzonation study.

Eighty seven participants representing twenty countries convened for three days days in Heredia, Costa Rica to outline priorities and opportunities for seismological capacity development in the Middle America region.

Acting Science and Technology Adviser to the U.S. Secretary of State, Andrew W. Reynolds, delivered the Inaugural Keynote Address to the Workshop.

IRIS is a university consortium sponsored by the National Science Foundation that is dedicated to the operation of scientific facilities for the acquisition, management and distribution of freely available seismic data. The IRIS Consortium serves as a forum for exchanging ideas, setting community priorities, and fostering cooperation. There are seven key IRIS program areas (GSN, PASSCAL, DMS, EPO, USArray, Polar and IDS) that are each addressed earlier in this report. This section addresses activities and initiatives undertaken by IRIS that complement these key IRIS program areas in the form of meetings, publications and proposals.

# Special Activities and Initiatives

## IRIS Community Collaborates with Chilean Scientists

Following the M8.8 earthquake that occurred off the coast of Chile on February 27, 2010, the IRIS Consortium, on behalf of its Member Institutions and with support from the National Science Foundation, worked with scientists from US universities and the University of Chile to deploy 58 broadband seismic instruments to record aftershocks. This earthquake provided an unprecedented opportunity to advance our understanding of megathrust earthquakes and associated phenomenon. This segment of the Chile subduction zone has similarities with Cascadia and Alaska, including shallow dip, sediments in the trench, and a history of great earthquakes, and could provide important information for comparative studies. Data collected during the six-month deployment that ended in September 2010, are freely open and available through the IRIS Data Management Center.

IRIS President David Simpson and Chile Ambassador to the United States Arturo Fermandois.

In March 2011, IRIS and the University of Chile signed a Memorandum of Understanding to support enhancements to Chile's national seismic monitoring network. Funded by the National Science Foundation, the Global Reporting Geophysical Observatories project installed ten permanent stations in Chile in early summer 2011. These data are used by Chilean authorities and the US Geological Survey to locate and report on national and global earthquake activity. This collaboration was highlighted in March by the US Department of State in conjunction with President Barack Obama's meeting with Chilean President Sebastian Piñera in Santiago.

George Slad, PASSCAL Instrument Center, and Anne Meltzer, Lehigh University, installing one of the 58 portable seismic stations in Chile for the aftershock study.

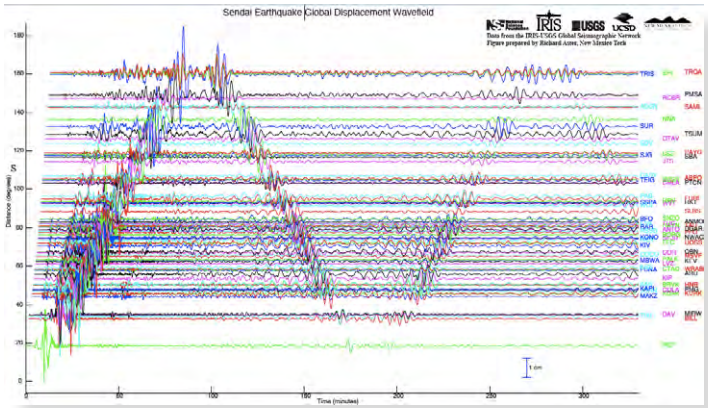
## Short Course Focuses on Processing Techniques for USArray Data

A USArray Data Processing Short Course was held August 25-29, 2010, at Northwestern University.

Participants in the 2010 USArray Data Processing Short Course.

Twenty-three graduate students, post-docs and early career faculty were selected from the group of applicants to participate in the five-day course. Initially developed and conducted in 2009, this very productive and highly successful short course addresses opportunities and challenges in USArray data processing, presents a current practices forum for relative newcomers, and inspires new leaders to advance EarthScope data analysis. As part of the course, student teams worked on projects that were presented to the entire group on the last day. Graduate students Januka Attanayake, Abhijit Ghosh, and Adewale Amosu ("Team Mighty Mouse") developed strategies for visualizing seismic wave propagation across the Transportable Array. After the short course concluded, the team subsequently built on their project and presented their results as a poster at the American Geophysical Union 2010 Fall Meeting in San Francisco.

## Special Web Page Provides General Information and Preliminary Research Results for the M9.0 Tohoku Earthquake




This record section displays vertical displacements of the Earth's surface recorded by the Global Seismographic Network. The traces are arranged by distance (in degrees) from the epicenter. Time since earthquake initiation is plotted on the horizontal axis and vertical displacements of the Earth are shown on the vertical axis. Note the 1-cm scale bar at the bottom of the plot.

Following the M9.0 Tohoku, Japan earthquake, IRIS developed a special web page (http://www.iris.edu/news/events/japan2011/) that focused on seismological data, products and early research results from the event. In addition to direct links to data and materials available from IRIS programs, this page included general information on earthquakes and tsunamis, educational resources, photos and videos, and a compilation of preliminary results from the seismological community. Traffic to the site was high and the number of hits greatly exceeded that following any previous events. For example, the USArray Ground Motion Visualization product received 24,925 hits from 8,783 unique IP addresses between March 11 and March 21, 2011.

## IRIS Earthquake Exhibit Attracts Thousands During the USA Science and Engineering Festival Expo

IRIS participated in the first-ever USA Science & Engineering Festival Expo held on the National Mall in Washington, DC, October 23-24, 2010. The IRIS exhibit was extremely well attended and featured the ever-popular family-friendly "Make an Earthquake" activity where visitors jump up and down to create an "earthquake" and then watch the seismic waves they produced. Visitors also had an opportunity to explore the Active Earth Display, watch USArray wave visualizations, and try a number of other hands-on seismology-related activities. More than 500,000 visitors attended the two-day event that had more than 550 exhibits with 1500 hands-on activities and over 50 stage shows and performances. IRIS plans to participate in the next Expo event scheduled in April 2012.

## National Geographic Channel Highlights EarthScope's Transportable Array

The Transportable Array was prominently featured in "X-Ray Earth," a two-hour special produced for the National Geographic Channel. The segment included footage filmed in July 2010, during the installation of Transportable Array station J32A near Parkston, South Dakota.

The program, which premiered on Sunday, May 15, 2011, shows how scientists are using technology and sophisticated tools, such tomography, gravitational mapping, and spectroscopy, to provide insights into Earth's systems.

Filming of Transportable Array segment of "X-Ray Earth".

## IRIS Presents 40-year Seismogram to Albuquerque Seismological Laboratory in Celebration of 50 Years of Service

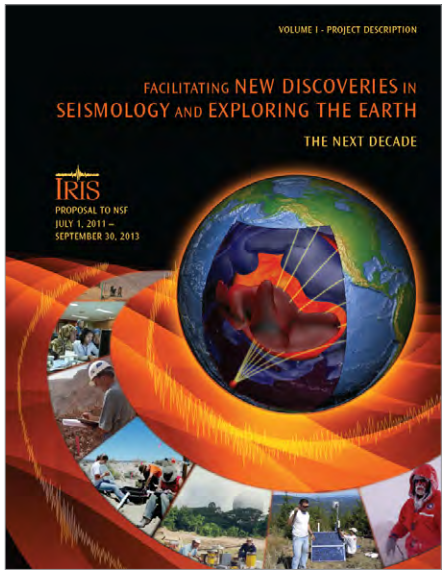

IRIS's Bob Woodward (center) and David Simpson (second from right) present the 40-year seismogram to Bob Hutt (left), past Scientist-in-charge of ASL, Jon Peterson (second from left), past Scientist-in-charge (ret.) of ASL, and Lind Gee (right), Scientist-in-charge of ASL.

The US Geological Survey's (USGS) Albuquerque Seismological Laboratory (ASL) celebrated 50 years of service to the nation and the international seismological community. The ASL was originally established as the central facility for the deployment of the World-Wide Standardized Seismograph Network (WWSSN). Over the years, ASL has deployed seismograph stations all over the world as part of multiple seismographic networks, including the Global Seismographic Network, a cooperative partnership between IRIS and the USGS and coordinated with the international community.

As a symbol of the appreciation from IRIS and the academic community, IRIS created a four-decade "seismogram" showing the complete record of digital data recorded at the ASL (under the station names ALQ and ANMO) from 1972 to 2011. The seismogram, plotted "helicorder style", provides a unique view of the last 40 years of global seismicity. The record is a compelling demonstration of both the high-quality seismic recordings made at ASL and the comparative sizes of earthquakes, including several recent great earthquakes, that have occurred in the last 40 years.

## Funding of IRIS Facilities Approved by the National Science Board

On May 11, 2011, the National Science Board, the governing body for the National Science Foundation, issued a resolution (NSB-11-28) authorizing development of an award for renewed support of the seismological facilities and programs operated by IRIS to cover the period July 1, 2011 to September 30, 2013. This resolution was based on NSF's review of the proposal, "Facilitating New Discoveries In Seismology and Exploring The Earth: The Next Decade," submitted by IRIS on behalf of the Consortium in Fall 2010. The two-volume proposal includes a project description of the infrastructure and operation of the IRIS core facilities and several related programs, and a review of accomplishments comprised of nearly 250 one-page vignettes contributed by the research community. The complete volumes as well as individual sections are available online through the IRIS web site.



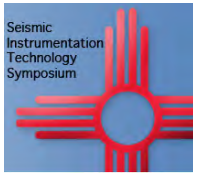

## National Science Foundation Provides Support for Topical Workshops

During FY2011, IRIS assisted in organizing several important community-based scientific workshops including:

- 

"Experiments with Portable Ocean Bottom Seismographs" (September 2010) to examine the future of ocean bottom seismology using portable instrumentation for studying problems in Earth structure and dynamics.

- The 2nd biennial "Seismic Instrumentation Technology Symposium" (June 2011) to explore emerging instrumentation technologies that provide solutions for key technical challenges in observational seismology.




- 

"Autonomous Polar Observing Systems" (September 2010) to discuss measurement requirements for instrument deployment and data collection in high-latitude remote regions devoid of infrastructure.

Each of these meetings brought together interested stakeholders from academia, government, and industry to identify issues and develop strategies needed to advance seismological science and technology and enable new discoveries about our dynamic Earth.

OBSIP

## IRIS Facility Management Broadens to Ocean Bottom Seismometry

In March 2011, IRIS was selected by the National Science Foundation to manage the Ocean Bottom Seismic Instrument Pools (OBSIP) program through the formation of an OBSIP Management Office (OMO). The OMO will be established in FY2012 to manage OBSIP operations at Lamont-Doherty Earth Observatory, Woods Hole Oceanographic Institution, and Scrippts Institution of Oceanography/University of California, San Diego, and to serve as an interface between NSF, the institutionalinstrument contributors, research principal investigators, the broader OBS research community, and the University-National Oceanographic Laboratory System (UNOLS fleet).

The OMO will also work with the NSF Marine Geology & Geophysics Program and the OBSIP community to facilitate and expand interactions between marine- and land-based observations and advance geophysical research.

# FINANCIAL Services

## BUDGET & FINANCE subcommittee

| | |
|---|---|
| Stephen P. GRAND (Chair) | University of Texas at Austin |
| Jeroen TROMP | Princeton University |
| Douglas WIENS | Washington University, St. Louis |

## FINANCIAL management

| | |
|---|---|
| Candy SHIN | IRIS |
| Ray WILLEMANN | IRIS |
| Robert WOOLLEY | IRIS |

# Overview

### FINANCIAL OVERVIEW

The Incorporated Research Institutions for Seismology (IRIS) is a 501(c)(3) non-profit consortium of research institutions founded in 1984 to develop scientific facilities, distribute data, and promote research. IRIS is incorporated in the state of Delaware.

### GLOBAL SEISMOGRAPHIC NETWORK

The GSN is operated in partnership with the US Geological Survey (USGS). Funding from the National Science Foundation for the GSN supports the installation and upgrade of new stations, and the operation and maintenance of stations of the International Deployment of Accelerometers (IDA) network at University of California, San Diego and other stations not funded directly within the budget of the USGS. Operation and maintenance of USGS/GSN stations is funded directly through the USGS budget. Subawards include the University of California, San Diego; the University of California, Berkeley; the California Institute of Technology, and Columbia University.

### PROGRAM FOR ARRAY SEISMIC STUDIES OF THE CONTINENTAL LITHOSPHERE

Funding for PASSCAL is used to purchase new instruments, support the Instrument Center at the New Mexico Institute of Mining and Technology, train scientists to use the instruments, and provide technical support for instruments in the field. Subawards include the New Mexico Institute of Mining and Technology, and University of Texas at El Paso.

### IRIS budgets 2011

Core program budgets *
(July 1, 2010 - June 30, 2011)

| | FY2011 |
|---|---|
| **GSN** | 3,182,501 |
| **PASSCAL** | 3,193,225 |
| **DMS** | 3,261,436 |
| **EPO** | 739,339 |
| **Community Activities** | 261,709 |
| **Indirect Costs** | 1,721,789 |
| **Total** | 12,360,000 |

### DATA MANAGEMENT SYSTEM

Funding for the DMS supports data collection, data archiving, data distribution, communication links, software development, data evaluation, and web interface systems. Major subawards include the University of Washington; the University of California, San Diego; and the Institute of Geophysical Research, Kazakhstan.

### EDUCATION AND PUBLIC OUTREACH

Funding for EPO is used to support teacher and faculty workshops; undergraduate internships; the production of hardcopy, video and web-based educational materials; a distinguished lecturer series; educational seismographs; and the development of museum displays. Subawards are issued to IRIS institutions for software and classroom material development, summer internship support and support of educational seismology networks.

*Budgets are for core IRIS programs from the NSF Earth Sciences Division Instrumentation & Facilities Program, and does not include additional funding from other sources, such as NSF Polar Programs, DOE, CTBTO, UNAVCO, State Department, etc.

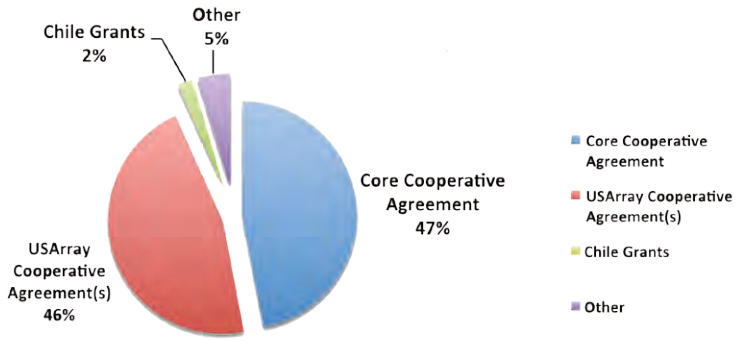
## EARTHSCOPE awards

(October 1, 2010 - September 30, 2011)

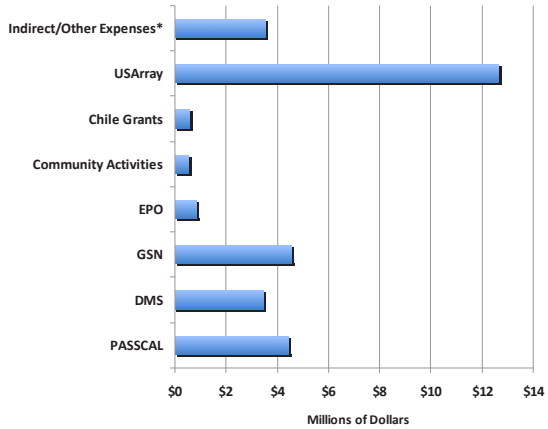
| | |
|---|---|
| **USArray (O&M Year 8)** | 12,811,475 |
| **EarthScope National Meeting** | 146,518 |
| **Cascadia (Year 2)** | 169,609 |
| **Workshop on EU-US Cooperation** | 2,661 |
| **Indirect Costs** | 1,635,410 |
| **Total** | 14,765,673 |

## FY2011 Federal Award Revenues

(preliminary)




## FY2011 Expenses (preliminary)




Indirect/Other Expenses includes DC office overhead, DMC office overhead, G&A, and unallowable expenses.

### EARTHSCOPE

EarthScope awards include funding for USArray activities. Subawards include the University of California, San Diego; New Mexico Institute of Mining and Technology; Oregon State University; UNAVCO, and other siting and partnership subawards. Contracts for USArray Transportable Array station construction and installation are issued to Honeywell and Coastal Technical Services.

### INDIRECT EXPENSES

Costs in this category include corporate administration and business staff salaries; audit, human resources and legal services; general headquarters and Seattle office expenses; insurance; and corporate travel costs.

### OTHER ACTIVITIES

Other activities include IRIS workshops, publications and International Development Seismology.

A complete copy of IRIS' financial statements and auditor's reports are available from the IRIS business office by contacting admin@iris.edu.

## proposal FUNDING

### NEW PROPOSALS funded

| | | |
|---|---|---|
| AGU Support: Geophysical Hazards and Plate Boundary Processes; San Jose, Costa Rica, October 2010 | AGU | 15,000 |
| Modernization of Instrumentation at Nine Global Seismographic Network Stations | DOE/NNSA | 250,000 |
| Monitoring the Stability of Large Dams in Tajikistan | NATO | 10,000 |
| Pan-American Advanced Studies Institute on New Frontiers in Seismological Research: Sustainable Networks, Earthquake Source Parmeters, and Earth Structure; Quito, Ecuador | NSF | 101,000 |
| MRI: Acquisition for Integrating Global Reporting Geophysical Observatories within the Chilean National Seismic Network (GRO-Chile) | NSF | 1,000,000 |
| US Latin America Workshop: Geophysical Hazards and Plate Boundary Processes; San Jose, Costa Rica, October 2010 (Incl. USAID funding of $80,000) | NSF | 152,399 |
| Collection of Open Data for Broadband Seismological Observations of Aftershocks of the February 27, 2010 Chilean Earthquake | NSF | 192,000 |
| Development of Innovative Data Access Techniques and Processing Methods to Support Seismological Research | USGS | 249,956 |
| | TOTAL NEW PROPOSALS FUNDED | 1,970,355 |

### PROPOSALS pending

| | | |
|---|---|---|
| Facilitating New Discoveries in Seismology and Exploring the Earth – The Next Decade (27 months) | NSF | 29,512,001 |
| A Community-Based OBSIP Management Office (5 years) | NSF | 20,523,811 |
| | TOTAL PROPOSALS PENDING | 50,035,812 |

Seismometers at the PASSCAL Instrument Center prior to deployment.

# Staff

## IRIS headquarters

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| Arlene BLOOM | Sr. Human Resources Specialist |
| Tammy BRAVO | Seismology Education and Outreach Specialist |
| Olga CABELLO | Director of International Development Seismology |
| Rick CALLENDER | Media and Graphics Specialist |
| Perle DORR | Public Outreach Manger |
| Michael HUBENTHAL | Sr. Education Specialist |
| Shanna HUDDLESTON | Sr. Accounting Specialist |
| April JONES | Human Resources/Administrative Generalist |
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| Patrick MCQUILLAN | Education and Outreach Specialist |
| Robin MORRIS | Sr. Project Accountant |
| Aubrey PATSIKA | Web Developer/Administrator |
| Teresa SAAVEDRA | Office Manager/Receptionist |
| Candy SHIN | Chief Financial Officer |
| David SIMPSON | President |
| Ruth SOBEL | Award and Procurement Administrator |
| John TABER | Director of Education and Public Outreach |
| Nicole TATRO | Accounting Manager |
| Russ WELTI | Software Engineer |
| Raymond WILLEMANN | Director of Planning |
| Tenisha WILLIAMS | Administrative Assistant |
| Robert WOODWARD | Director of Instrumentation Services |
| Robert WOOLLEY | Director of Program Support and Special Projects |
| Robert BUSBY | Transportable Array Manager |
| Anthony GONZALES | USArray Lead Construction Engineer |
| Katrin HAFNER | Transportable Array Chief of Operations |
| Howard PEAVEY | Station Speclaist |
| Graylan VINCENT | Transportable Array Recon Specialist |
| Kent ANDERSON | Acting GSN Program Manager |

## DATA management center

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| | |
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| Manochehr BAHAVAR | Product Specialist |
| Richard BENSON | Director of Data Management |
| Richard BRAMAN | Unix Systems Administrator |
| Thani BUSH | Data Control Technician |
| Robert CASEY | Director of Information Technology |
| Gale COX | Office Manager |
| Mary EDMUNDS | Data Contrrol Technician |
| Alexander HUTKO | Product Specialist |
| Un JOE | Data Control Technician |
| Peggy JOHNSON | USArray Data Control Analyst |
| Lonny JONES | USArray Systems Administrator |
| Richard KARSTENS | Sr. Software Engineer |
| Timothy KNIGHT | Information Services Coordinator/ Webmaster |
| Christopher LAUGHBON | Sr. Software Engineer |
| Anh NGO | Operations Programner |
| Juan RODRIGUEZ | Software Engineer |
| Sue SCHOCH | Sr. Software Engineer-Database Specailization |
| Gillian SHARER | USArray Lead Data Control Analyst |
| Ashley SPENCER | Data Control Technician |
| Sandra STROMME | Software Engineer |
| Yazan SULEIMAN | Software Engineer |
| Mary TEMPLETON | USArray Data Control Analyst |
| Chad TRABANT | Director of Projects and Services |
| Ingie WATSON | Sr. Systems Administrator |
| Bruce WEERTMAN | Software Engineer |
| Maryann WOOD | Data Control Technician |

## PASSCAL

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100 East Road, Socorro, NM 87801
Telephone (575) 835-5070 • Fax (575) 835-5079

| | |
|---|---|
| James FOWLER | Sr. Advisor for Engineering and Instrumentation |
| James GRIDLEY | PASSCAL Program Manger |

IRIS partners operating major facilities with separately employed staffs include:

- Project IDA (http://ida.ucsd.edu)
- New Mexico Institute of Mining and Technology (http://www.passcal.nmt.edu)
- USGS Albuquerque Seismological Laboratory (http://earthquake.usgs.gov/regional/asl)
- USArray Network Facility (http://anf.ucsd.edu)



The 2011 Annual Report was assembled by Kelly Holcomb and Perle Dorr with bannergrams and other major contributions from Andy Frassetto.

# The IRIS mission, actively supported by each Member and Affiliate Institution, is to:

- Facilitate and conduct geophysical investigation of seismic sources and Earth properties using seismic and other geophysical methods.
- Promote exchange of geophysical data and knowledge, both through use of standards for network operations, data formats and exchange protocols, and through pursuing policies of free and unrestricted data access.
- Foster cooperation among IRIS Members, Affiliates, and other organizations in order to advance geophysical research and convey benefits from geophysical progress to all of humanity.

## PLANNING committee

| | |
|---|---|
| Greg BEROZA (Chair) | Stanford University |
| Geoffrey ABERS | Columbia University |
| Susan BECK | University of Arizona |
| Larry BRAILE | Purdue University |
| Emily BRODSKY | University of California, Santa Cruz |
| David OKAYA | University of Southern California |
| Jeffrey PARK | Yale University |
| Barbara ROMANOWICZ | University of California, Berkeley |
| Brian STUMP | Southern Methodist University |
| David SIMPSON | IRIS |
| Ray WILLEMANN | IRIS |

## PROGRAM COORDINATING committee (CoCOM)

| | | | |
|---|---|---|---|
| James GAHERTY (Chair) | Columbia University | Timothy Ahern | IRIS |
| John HOLE (Vice-Chair) | Virginia Polytechnic Institute | Kent ANDERSON | IRIS |
| Richard ALLEN (PASSCAL) | University of California, Berkeley | Robert BUSBY | IRIS |
| Chuck AMMON (GSN) | Penn State University | Olga CABELLO | IRIS |
| Matthew FOUCH (USArray) | Carnegie Institution of Washington | James GRIDLEY | IRIS |
| Keith KOPER (DMS) | Saint Louis University | Candy SHIN | IRIS |
| Glenn KROEGER (EPO) | Trinity University | David SIMPSON | IRIS |
| Anne MELTZER (IDS) | Lehigh University | John TABER | IRIS |
| | | Ray WILLEMANN | IRIS |
| | | Robert WOOLLEY | IRIS |
| | | Robert WOODWARD | IRIS |

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Founded in 1984 with support from the National Science Foundation, IRIS is a consortium of over 100 US universities dedicated to the operation of science facilities for the acquisition, management, and distribution of seismological data. IRIS programs contribute to scholarly research, education, earthquake hazard mitigation, and the verification of a Comprehensive Test Ban Treaty.

IRIS is a 501(c)(3) nonprofit organization incorporated in the state of Delaware with its primary headquarters office located in Washington, DC.