Polar Support Services

Polar Support Services provides polar-specific engineering support for experiments in Antarctica and the Arctic, maintains and updates a specialized pool of cold-rated equipment, and supports field operations in Earth's high-latitude regions. This engineering support, along with advances in technology, has greatly improved data quality and return from these extremely remote and logistically expensive polar regions, optimizing experiment costs and greatly improving the scientific return for seismologists and glaciologists alike. The National Science Foundation's Division of Polar Programs supports base-level engineering efforts through additions to the polar equipment pool, cold-chamber and testing facilities, and engineering personnel support. In addition, IRIS also installed and now operates stations as part of the Greenland Ice Sheet Monitoring Network, an international effort to enhance the scientific community's capability in seismic and geodetic observation of the dynamic behavior of the Greenland Ice Sheet as it interacts with the atmosphere, ocean, and solid Earth.

GEOICE. The stability of ice sheets and the geologic history of ice-covered regions are poorly understood. Extreme weather and complex logistics can severely hamper scientific investigations. To significantly increase the observational capabilities and logistical efficiencies in places like Alaska, Greenland, and Antarctica, the National Science Foundation is providing funds to IRIS to develop a set of seismic sensors in support of the Geophysical Earth Observatory for Ice-Covered Environments (GEOICE). This mobile observatory will consist of 125 seismometers that will be sensitive enough to measure even the smallest Earth and ice motions, providing information on matters such as ice sheet stability and deep Earth structure. The instruments will be about 50 pounds lighter and will use much less energy than conventional designs, and they will be able to withstand icy and/or wet environments. These design elements will permit rapid deployment in these harsh environments and significantly reduce the amount of instrument servicing related to battery replacement and leaks.

EARLY CAREER MENTORING. IRIS is committed to supporting and encouraging early career scientists (defined as senior graduate students through pre-tenure faculty) and integrating these young investigators into the geoscience research and education communities. One example of the positive impact of this support is a pilot mentoring program where IRIS supported an early career scientist from Oregon State University to work with a senior scientist from Northwestern University. The scientists use different but complementary techniques to study Earth structure, and combining the approaches has resulted in a very successful collaboration that has the potential to yield new insights into Earth processes. In addition to being introduced to new scientific areas and techniques, the early career scientist received valuable career-related advice from her mentor, including input on shaping her CV and job application materials.

Through extended visits to each other's institutions, the scientists developed and shaped initial ideas for joint scientific proposals that will be submitted to funding agencies. The proposals will help build the younger scientist's research career at this critical juncture. The IRIS Education and Public Outreach program also supported the young investigator's travel to the IRIS Workshop, allowing her to continue to learn new seismic methods that will help in her research. Meeting participation also provided dozens of opportunities for her to network with other scientists from around the country.

Education and Public Outreach

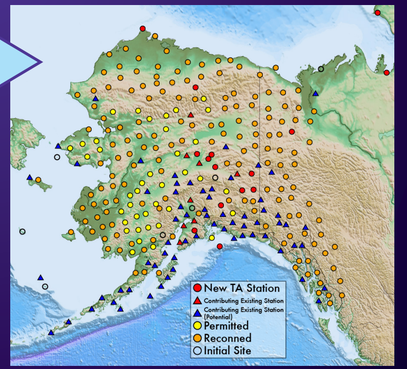
The Education and Public Outreach program combines the seismological expertise of Consortium members with that of IRIS staff to create products and activities that advance awareness and understanding of seismology and geophysics while inspiring careers in Earth science. These products and activities are designed for use in diverse settings: self-directed exploration over the Web, interactive museum exhibits, major public lectures, and in-depth exploration of Earth's interior in formal middle school through undergraduate classrooms. Each year, a select group of undergraduates spends the summer conducting research under the expert guidance of scientists at Consortium member institutions and affiliates. IRIS staff also widely distribute "Teachable Moment" slide sets for use in college and school classrooms within a day of major earthquakes, animations and videos of earthquake and related processes, new content for the IRIS Active Earth Monitor that is on display in numerous museums, and data visualization tools.

Transportable Array

The Transportable Array is an array of 400 high-quality seismographs placed in temporary sites for two years of observations and then moved to the next set of grid points. The project began operations on the West Coast in 2005, and after 10 years, it has crossed the entire United States to the Atlantic seaboard. It will finish there in 2015 and move to Alaska. With a nearly uniform spacing of about 70 km, the instruments record global and local earthquakes, and even ground shaking from storms at sea. These data are used to model Earth structure as shallow as a few kilometers to as deep as the core-mantle boundary at nearly 3000 km depth, enabling a better understanding of the structure and evolution of the North American continent. The Transportable Array's extensive geographic footprint and dense station locations allow scientist to generate movies of large event ruptures, providing insight into how great earthquakes occur and differ. In addition to the seismometer, each site includes infrasound and meteorological sensors. Data from all stations are continuously transmitted to the IRIS Data Management Center and made promptly and freely available worldwide for research and outreach activities.

CENTRAL AND EASTERN U.S. NETWORK. Recent earthquakes in the central and eastern United States, such as the 2011 Virginia earthquake, have raised awareness of gaps in knowledge about seismicity, site response to ground shaking, and the basic geologic underpinnings in this densely populated region. The National Science Foundation, the U.S. Geological Survey, the Nuclear Regulatory Commission, and the Department of Energy together recognize the unique opportunity to collect data that address these gaps by leveraging investment in the Transportable Array. After the two-year period originally funded by the National Science Foundation, about 160 Transportable Array stations will continue operation as the Central and Eastern U.S. Network (CEUSN) supported by the U.S. Geological Survey. The stations significantly improve ground motion monitoring in the region, some adding specialized sensors to address earthquake engineering issues. A multi-agency group selected stations to achieve a nearly uniform distribution and avoid duplication while focusing on known regions of seismic hazard, nuclear power plants, and other critical facilities, as well as scientific targets.

TRANSPORTABLE ARRAY IN ALASKA. Beginning in 2014, and over the next three years, IRIS will deploy 300 Transportable Array (TA) seismograph stations in Alaska. Despite the lack of roads or infrastructure in most regions of interest, the stations are nevertheless arranged in a grid with a spacing of about 85 km, covering all of interior Alaska and parts of Canada's Yukon, Northwest Territories, and British Columbia. IRIS anticipates completing observations in 2019. The TA stations join more permanent stations of the Alaska Earthquake Center, Alaska Volcano Observatory, and the Alaska Tsunami Warning Center in monitoring earthquakes in the region. The additional instruments provided by the TA will permit far better imaging of the tectonic structure of America's most extensive subduction zone where many great earthquakes have occurred, such as the one in 1964 on Good Friday—the largest earthquake ever recorded in North America. IRIS is also collaborating with the Arctic science community during the development and implementation of the TA in Alaska to include a standard barometric pressure sensor package with each station. Additional instruments may include a meteorological sensor suite, a strong motion sensor, and a soil temperature profiler. As with all other TA operations, data will be transmitted back to the IRIS Data Management Center in near real time and made publicly available.



WWW.IRIS.EDU
Incorporated Research Institutions for Seismology • 1200 New York Avenue NW, Suite 400, Washington, DC 20005 • Printed December 2014

2014 IRIS AT A GLANCE

Incorporated Research Institutions for Seismology programs contribute to scholarly research, education, earthquake hazard mitigation, tsunami warning, and to the monitoring of underground nuclear tests.

IRIS is a consortium that includes virtually every U.S. university with a commitment to research in seismology or a closely related field, as well as Educational Affiliates, U.S. Affiliates, and Foreign Affiliates. A Board of Directors composed of faculty members from the Consortium membership and expert committees nominated by the community and appointed by the Board guide every aspect of IRIS's work.

THE IRIS CONSORTIUM MISSION.

- Facilitate and conduct investigations of seismic sources and Earth properties using seismic and other geophysical methods.
- Promote exchange of geophysical data and knowledge through the use of standards for network operations, data formats, and exchange protocols, and by 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.

COOPERATION WITH THE NATIONAL SCIENCE FOUNDATION. IRIS carries out activities under the terms of cooperative agreements with the National Science Foundation. Based on broad input from researchers, educators, and other professionals, these activities include management of the Global Seismographic Network, Transportable Array, Portable Instrumentation Pools, Data Services, Polar Services, Education and Public Outreach, and the Ocean Bottom Seismograph Instrument Pool.

PARTNERSHIP WITH THE U.S. GEOLOGICAL SURVEY. All IRIS services—including instrumentation, Data Services, and Education and Public Outreach—are coordinated with the USGS to ensure that we offer complementary facility capabilities to researchers, educators, policymakers, and the general public.

COMMUNITY-WIDE WORKSHOP. During 2014, seismologists, other Earth scientists, educators, and related professionals gathered during the biennial IRIS Workshop to develop strategic priorities for facilitating progressively more interdisciplinary research in Earth system dynamics. The themes that emerged from the workshop included the need to develop and use new observational systems, the importance of diverse forms of cyberinfrastructure, the increasing importance of seismology in the ocean, and the expanding use of seismic data in areas other than deep Earth processes.

LARGE-SCALE EXPERIMENTS. Technological advances continue to facilitate sensor deployments in progressively greater numbers and density across ever larger areas. Together with new processing and interpretation techniques, some of them adapted from the exploration industry, these data collection efforts are yielding higher resolution, more definitive models of Earth dynamics and structure at all scales and depths. The results include rapid advances in our understanding of geophysical hazards, natural resources, and the complementary, interactive 4.5 billion year evolution of solid Earth structure, the ocean, the atmosphere, the cryosphere, and life.

INTERNATIONAL DEVELOPMENT. Advances in seismology research rely on the global participation of scientists to offer potential benefits to broader society everywhere. For each aspect of its mission—from facilitating geophysical investigations to conveying benefits of geophysical research—IRIS leverages the knowledge and skills of its Members and Affiliates to disseminate best practices among Earth scientists around the world through training, free and open data exchange, and instrumentation program activities that facilitate collaborative research.

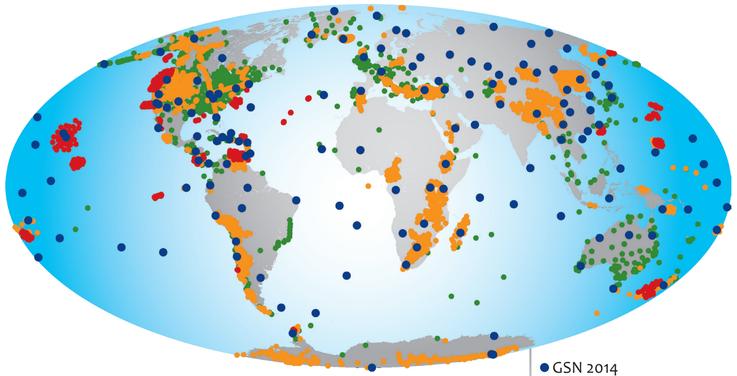
Portable Seismology

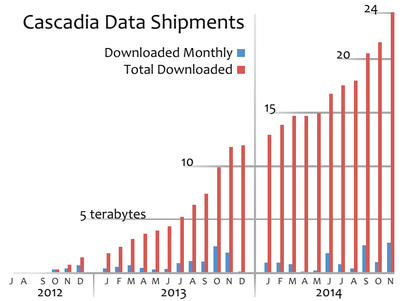
IRIS facilitates portable array seismology worldwide for diverse scientific and educational communities with end-to-end experiment support services, state-of-the-art portable seismic instrumentation, and advanced field and database management tools. Over its history, PASSCAL has supported deployment of over 1000 experiments to image Earth beneath tectonic plate boundaries, the stable parts of continents, mountain belts, and volcanoes. These data further understanding of natural hazards, groundwater resources, and deep Earth structure. By integrating planning, logistical, instrumentation, and engineering services, and supporting the efforts with full-time professional staff, IRIS has enabled seismologists to mount large-scale experiments throughout the United States and around the globe. The access to professionally supported state-of-the-art equipment and archived, standardized, open data has revolutionized the way that geophysical research is conducted.

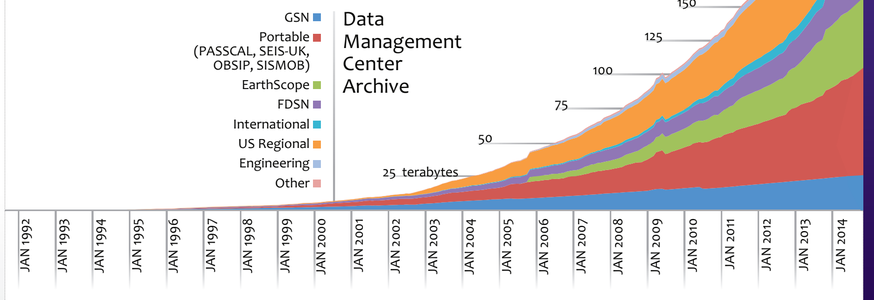
IMAGING MAGMA UNDER ST. HELENS. Imaging Magma Under St. Helens (iMUSH) is a four-year collaborative study that is being conducted by several IRIS Consortium members. The National Science Foundation funded project is using multiple geophysical and geological techniques to investigate the volcano's plumbing system and how major regional faults control volcanism along the Cascadia range. Seventy long-term seismographs that passively record regional and global earthquakes, and 2500 short-term seismographs that record signals from man-made seismic sources, are allowing scientists to construct detailed three-dimensional maps of the subsurface to tens of kilometers depth. All of the seismographs were borrowed from the IRIS PASSCAL and USArray Flexible Array instrument pools, and the data collected from these instruments are openly available from the IRIS Data Management Center.

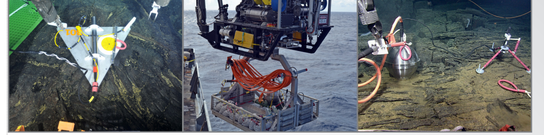
In order to better image the complex structure of the volcano, an additional 1000 autonomous recording seismic sensors were added to the experiment to more densely sample the seismic waves produced by shots set off during the experiment and the noise recorded by sensors between shots.

(middle photo) Seismometer (yellow in foreground) with Mount St. Helens in the background. *Photo credit: Steve Hansen, University of New Mexico.*









REAL-TIME SEISMIC DATA FROM THE SEAFLOOR. In collaboration with the National Science Foundation-funded Ocean Observatories Initiative (OOI), IRIS Data Services will be archiving and initially distributing pre-commissioned data from 13 OOI cabled seafloor seismometers (eight short period and five broadband) located on the Juan de Fuca plate in the Northeast Pacific Ocean. Installation of OOI's Cabled Array, of which these seismometers are a part, was completed in late summer 2014, and will be commissioned by late May 2015, with open data access via the OOI website at that time. The array has sensors on the seafloor as well as in the water column at mooring sites offshore of Washington and Oregon. The Cabled Array provides power, timing, and a telemetry capacity of 10 gigabits per second from each primary science site. The OOI seafloor seismometers are located at the summit and base of Axial Seamount, an active seafloor volcano on the Juan de Fuca Ridge; at the base of the continental slope; and at Southern Hydrate Ridge offshore Oregon where abundant frozen methane is buried beneath the seafloor. The near-real-time data from these cabled seafloor seismometers will allow investigators to study volcanic and tectonic processes at both mid-ocean ridge and subduction zone settings, as well as the response of methane hydrate systems to seismic events.

The photos above show aspects of Axial Seamount operations. (left) Installation of a short-period seismometer. (middle) The ROV ROPOS with a broadband seismometer in the tray. (right) The ROV ROPOS installing a broadband seismometer and low-frequency hydrophone. *Photo credits: NSF-OOI/UW/CSSF*

Data Services

The core mission of Data Services is to collect, curate, and distribute data from IRIS programs—including the Global Seismographic Network, Portable Instrumentation Pools, Transportable Array, and the Ocean Bottom Seismograph Instrument Pool. Data Services also manages seismic data from other components of EarthScope, backbone stations from networks that are members of the international Federation of Digital Seismograph Networks, regional networks supported by the U.S. Geological Survey, and stations operated by partner organizations worldwide. Collectively, these data are one of the largest scientific archives of globally distributed observational data in the world. IRIS offers a wide and growing variety of services that Earth scientists rely on in over 150 countries worldwide, increasingly through Web services. Data distribution is nearing one petabyte in volume annually. Data Services creates a wide range of data products, such as visualizations of wave propagation for researchers and specialized products for public outreach, and plays a key role in facilitating quality control of time series data managed at the IRIS Data Management Center.

GLACIAL EARTHQUAKES IN GREENLAND. Rapid changes in the Greenland and Antarctic ice sheets are a global concern. Ice sheet melting contributes to sea level rise and also exposes the underlying bedrock, which can feed additional climate warming through a decrease in albedo. In particular, the loss of mass of Greenland's outlet glaciers has accelerated, demonstrated by large-scale calving into the ocean. Increases in surface ocean temperature appear to be linked to faster ice mass loss, but the nature of the interaction remains poorly understood. Using data from the Global Seismographic Network, researchers are building on the work of previous investigators to compile an 18-year record of the rate, size, and locations of glacial calving events around Greenland. They found that when a newly calved iceberg capsizes, it can generate a recognizable seismic event. They also documented the northward progression of glacial earthquakes on Greenland's west coast over that period and concluded that important changes in ice dynamics are taking place. From 1993 to 1999, glacial earthquake production was relatively steady and concentrated in Southeast Greenland. From 2000 to 2005, many previously inactive glaciers in Northwest Greenland began to produce glacial earthquakes regularly. From 2006 to 2010, production declined in East Greenland as glaciers retreated so far that they transitioned from floating to grounded termini, but continued to rise in West and Northwest Greenland.

Global Seismographic Network

The Global Seismographic Network is a permanent telemetered network of seismological and geophysical sensors. A key source of free and open data for seismological research and Earth science education, the network is also a principal global source of data for earthquake locations, earthquake hazard mitigation, earthquake emergency response, and tsunami warning. Work continues on updating this 153-station, nearly 30-year-old network to the next generation of acquisition, sensor, and infrastructure systems, as well as on implementing an upgraded data quality assurance system to improve data quality and data return. Updated stations show remarkable improvement in data quality. The Global Seismographic Network is primarily operated and maintained through the U.S. Geological Survey Albuquerque Seismological Laboratory and the University of California at San Diego IRIS/IDA group, and managed by IRIS. Twenty-two affiliate stations and arrays around the globe contribute to the network, including the nine-station USGS Caribbean Network

OBSIP

The Ocean Bottom Seismograph Instrument Pool (OBSIP) supports research to increase understanding of natural hazards (e.g., earthquakes and volcanic eruptions), active Earth processes (e.g., seafloor spreading and mountain building), and deep Earth structure by making available seismometers that are deployed on the ocean floor. Some of the instruments remain for months to years, passively recording local and distant earthquakes. Others are used for short-term experiments that employ man-made sound sources. IRIS works closely with the academic research fleet schedulers for experiment support. Scientists at research institutions can request the use of instruments as part of the National Science Foundation standard proposal process. Other private and public organizations and industry can also use the instruments, depending upon availability. The program is funded by the National Science Foundation and is composed of a management office and three Institutional Instrument Contributors that provide both instruments and technical support—Lamont-Doherty Earth Observatory, Scripps Institution of Oceanography, and Woods Hole Oceanographic Institution.

CASCADIA INITIATIVE. This onshore/offshore seismic and geodetic experiment in the Pacific Northwest addresses topics ranging from regional earthquake occurrence, to the plumbing systems of volcanoes, to the formation and aging of the seafloor out to hundreds of kilometers off the coast.

The offshore part of the experiment is supported by the National Science Foundation with funds from the 2009 American Recovery and Reinvestment Act. The ocean bottom seismometers purchased with these funds permit the extension of the Transportable Array offshore. In addition to increasing accuracy of earthquake locations in the region, these instruments allow scientists to image properties of the interface where the largest earthquakes are generated. This four-year offshore experiment will complete fieldwork in fall 2015. The data are publicly available from the IRIS Data Management Center.

In October 2014, IRIS hosted a workshop to discuss future scientific studies that can make optimal use of these ocean bottom seismometer assets. The research community made several key recommendations on the type, size, and scope of critical scientific targets.

The photos below show deployment of ocean bottom seismometers at Cascadia, Northeast Pacific Ocean.