



IRIS Incorporated Research
Institutions for Seismology

AT A GLANCE 2020

WHO WE ARE

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' work.

IRIS VISION

IRIS is a world leader in advancing discovery, research, and education in seismology to understand our planet and to benefit society.

FRONT COVER. Bangladeshi locals look on as PASSCAL field engineer Alissa Scire and BIMA project member Celine Grall install a seismic station as part of the Tripartite-BIMA (Bangladesh-India-Myanmar Array) deployment. *Photo credit: Leonardo Seeber, LDEO*

IRIS 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.



Alumni mentor Neala Creasy (with hand lens) leads six undergraduates in examining rocks at Magdalena Mountain during orientation for the summer 2019 IRIS Internship Program. *Photo credit: Paige Given*

WHAT WE DO

FACILITATE

The IRIS Consortium, with funding from the National Science Foundation (NSF), provides a suite of community-governed, multi-user facilities for instrumentation and data management to support research and education in seismology and the Earth sciences. A high-performance network of more than 150 permanent stations provides data for global studies of earthquakes and deep Earth structure. An array of seismometers and atmospheric sensors is deployed in Alaska. More than 4,000 portable

instruments, including magnetotelluric systems, are available for short- and long-term loan to university-based researchers for detailed studies as part of NSF-funded field programs. Future observing needs are addressed through systematic engineering efforts. Data from all of these observational systems, along with extensive collections of seismic data contributed by other organizations, are freely and openly available through the SAGE Data Management Center.

COLLABORATE

Over its 30-year history of operations, IRIS has collaborated with numerous federal agencies, foreign governments, and academic researchers in the United States and around the world to promote best practices of open data availability, full retention of maximum bandwidth, continuous data recording, and direct community access to state-of-the-art seismological instrumentation and software. For example, since its inception, IRIS has collaborated closely with the

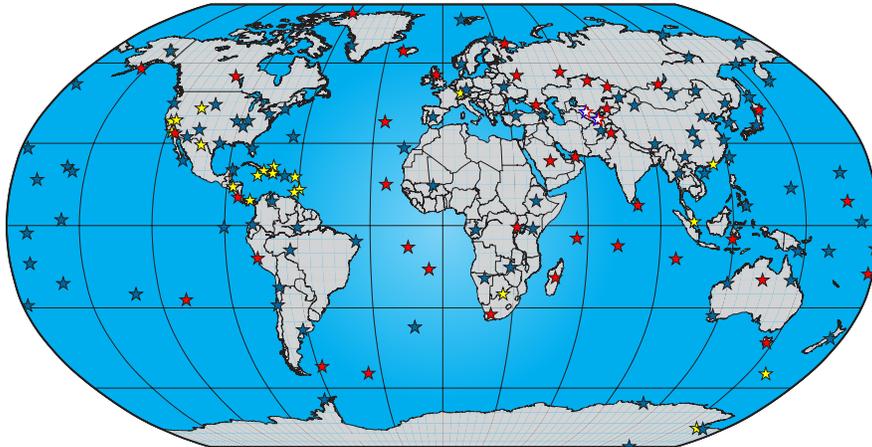
International Federation of Digital Seismograph Networks in global site selection of high-quality permanent seismograph stations and in encouraging policies for free and open data exchange. IRIS shares knowledge gained and lessons learned from more than 30 years of operating seismological infrastructure by conducting training courses that encourage the creation and/or operation of high-quality, sustainable networks worldwide.

The IRIS Education and Public Outreach program, funded by NSF, is committed to advancing awareness and understanding of seismology and geophysics, while inspiring careers in the Earth sciences. Creating a more Earth science literate public is also an important mission at Consortium member and affiliated institutions, as only a small minority of the people who participate in our programs are expected to become professionals who use Earth science in their work.

IRIS Education and Public Outreach directly links the public, schools, and undergraduate institutions with the activities of the academic research community by demonstrating how basic seismological observations are made and used in Earth science investigations. Through a wide variety of activities, IRIS encourages students to engage in scientific inquiry and appreciate the importance of the Earth sciences in their lives.

EDUCATE

GLOBAL SEISMOGRAPHIC NETWORK



★ IRIS/IDA Stations ★ IRIS/USGS Stations ★ Affiliate Stations ★ Planned Stations

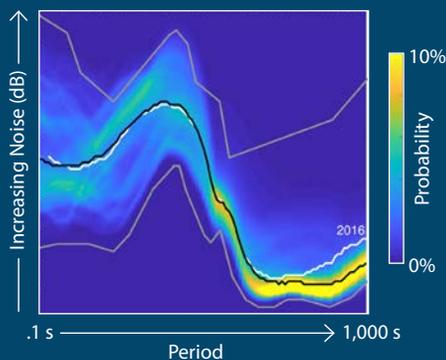
The multi-use, long-term, high-quality, state-of-the-art, telemetered Global Seismographic Network (GSN) is a collaboration between IRIS, NSF, and the U.S. Geological Survey (USGS). This 150+ station network, including 13 affiliate stations, provides global coverage and is a key source for free and open data that are used for seismological research, earthquake and explosion monitoring, tsunami warning, and education and outreach. The University of California San Diego IDA group, funded by NSF through IRIS, and the USGS Albuquerque Seismological Laboratory share network operations and maintenance.

IDA technician Jim Conley works with Mamma of the Indonesian Geophysics Agency to upgrade the primary sensor at GSN station II.KAPI. *Photo credit: Don Elliott, UCSD*



GSN Modernization

Background noise at upgraded GSN stations, showing that the new sensors achieve the most difficult feat in seismology—recording with very low noise at long periods (shown by the bright yellow-low region in the lower right corner).





LA BASIN Seismic Experiment

Beginning in 2017, the LA Basin Amplification Seismic INvestigation (BASIN) has been conducting seismic surveys with a goal of mapping the structure of the San Gabriel and San Bernardino sedimentary basins beneath greater Los Angeles. These basins are known to amplify seismic waves, and mapping their structure is crucial for estimating seismic hazards in the region. This multiyear project involves scientists and students from several institutions across the country and is supported by sensors provided by the PASSCAL Instrument Center. A deployment in late 2019 utilized more than 250 PASSCAL compact nodal sensors along a 78 km line in a variety of urban environments, including private residences.

Louisiana State University PhD student Ritu Ghose installs a nodal seismometer during the LA BASIN project in Southern California. *Photo credit: Patricia Persaud, LSU*

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 and other geophysical instrumentation, and advanced field and database management tools. Over its history, the IRIS portable seismology program (PASSCAL) has supported deployment of over 1,300 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. In recent years, IRIS has enabled larger field deployments via a new pool of over 1,000 nodal-style seismometers and has also broadened PASSCAL capabilities by adding near-surface and magnetotelluric instrumentation. By integrating planning, logistical, instrumentation, and engineering services, and supporting the efforts with professional staff, IRIS has enabled seismologists to mount large-scale experiments throughout the United States and around the globe.

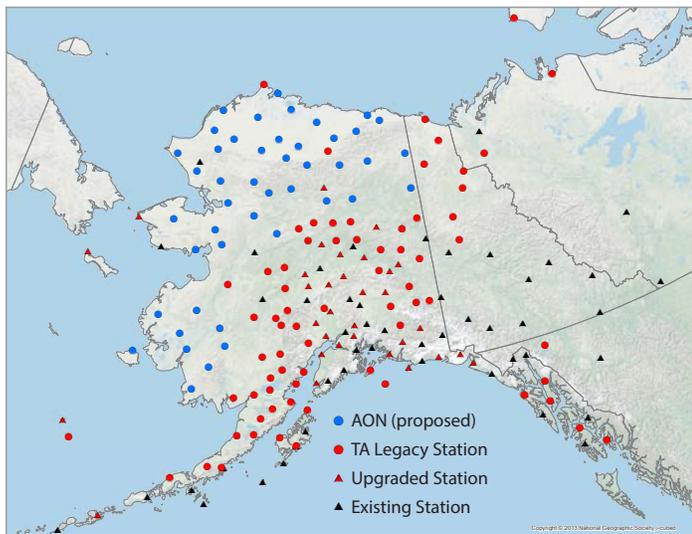


Locations of active experiments using IRIS portable seismic instrumentation from January 2015 through December 2019. Blue dots (49) denote experiments started prior to January 2015 but that were still active during the timeframe. Red dots (271) are experiments initiated after January 2015.

TRANSPORTABLE ARRAY-ALASKA

Alaska Transportable Array Station Specialist Jeremy Miner (right) and Alaska Earthquake Center Field Engineer Evan McArthur (left) install a new seismometer at station O20K on Slope Mountain, Alaska. Photo credit: Tim Dittmann, UNAVCO

The 280-station Alaska Transportable Array, consisting of 195 new stations and 85 cooperating stations across Alaska and western Canada, was installed during the summers of 2015, 2016, and 2017 and will be operated through the spring of 2021. While the primary mission was to record earthquakes to image the structure of the North American Plate, the stations contributed important information to the Alaska Earthquake Center for improved seismic hazard monitoring, including for the November 30, 2018, magnitude 7.1 Anchorage earthquake and the August 12, 2018, magnitude 6.4 Kaktovik earthquake and ensuing swarm in Alaska's North Slope region. Additional geophysical and environmental data recorded by these stations have been used by diverse organizations to enhance regional weather forecasts, strengthen wild-fire preparedness, detect landslides, and monitor volcanoes. As the Transportable Array concludes, nearly half the stations were transitioned to Alaskan operators for continued operations, leaving a legacy of NSF's investment in Arctic science.



Magnetotelluric Array

The EarthScope USArray program has also supported magnetotelluric (MT) surveying across the conterminous United States to determine the electrical conductivity structure of the crust and upper mantle. To date, IRIS and subawardee Oregon State University have occupied ~1,100 MT stations on a grid with ~70 km spacing to record the ambient, long-period magnetic and telluric (electric) fields at each site. These data are also of great interest in assessing the impact of space weather events on the nation's electrical grid.



Thwaites Glacier, West Antarctica

The Thwaites Interdisciplinary Margin Evolution (TIME) experiment is utilizing state-of-the-art geophysical techniques to observe rapidly deforming parts of Thwaites Glacier. Located in West Antarctica, this glacier may have significant control over the future stability of the West Antarctic Ice Sheet and implications for ice sheet models used to predict future sea level rise. This project includes the first active source seismic survey of Thwaites Glacier and is utilizing instrumentation and expertise from both PASSCAL and the IRIS-supported Seismic Source Facility. Recent on-ice testing with above-ice "Poulter shot" sources recorded by PASSCAL polar nodal seismometers and multichannel geophone systems have provided promising early data for this multiyear international experiment.

POLAR PROGRAMS

IRIS Polar Programs provides 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. IRIS has helped advance testing and usage of new nodal-style seismometers in polar regions, allowing scientists to deploy many more seismic sensors at reduced cost. NSF's Office of Polar Programs supports base-level engineering efforts through additions to the polar equipment pool, cold-chamber and testing facilities, and engineering personnel.

PASSCAL nodes in yellow bags staged outside the Thwaites Glacier project tent near the West Antarctic Ice Sheet Divide camp. *Photo credit: Galen Kaip, UTEP*

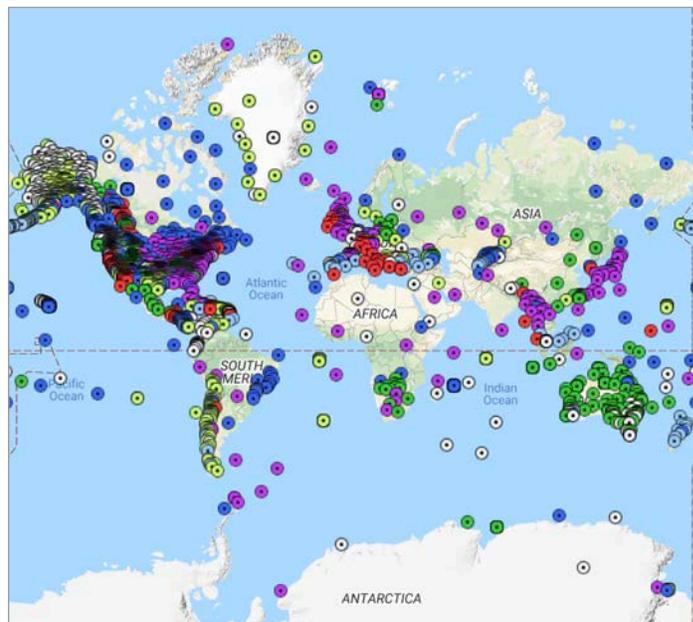


DATA SERVICES

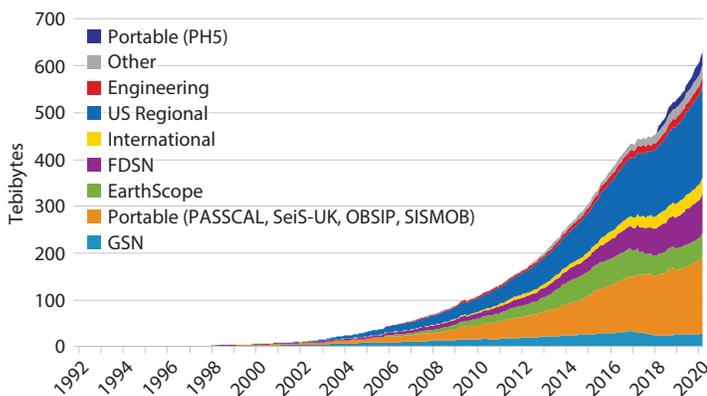
The mission of Data Services is to provide reliable and efficient access to high-quality seismological and related geophysical data generated by the SAGE facility and its domestic and international partners, and to enable all parties interested in using these data to do so easily. The SAGE Data Management Center (DMC), a node of Data Services, archives and distributes seismic data from the Global Seismographic Network, backbone stations of networks that are members of the International Federation of Digital Seismograph Networks (FDSN), regional networks supported by the U.S. Geological Survey, stations operated by partner organizations worldwide, and stations used in temporary deployments for both active and passive experiments. Collectively, the DMC is one of the largest scientific archives of globally distributed observational data in the world.

Data Services offers a wide and growing variety of services that Earth scientists rely on in over 150 countries worldwide. Data distribution is nearly one petabyte in volume annually, extensive data quality metrics are computed and made available to users, and products derived from the data are accessible through web pages and web services. Among the derived products offered are visualizations of wave propagation, specialized products for public outreach, and a repository of Earth models known as the Earth Model Collaboration (EMC), which to date contains nearly 100 Earth models.

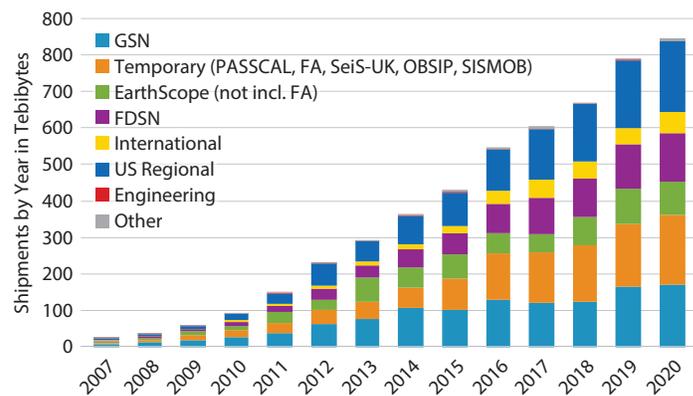
Locations of 3,954 Stations Providing Data in Real Time



**SAGE DMC Archive
629.5 Terabytes as of March 1, 2020**

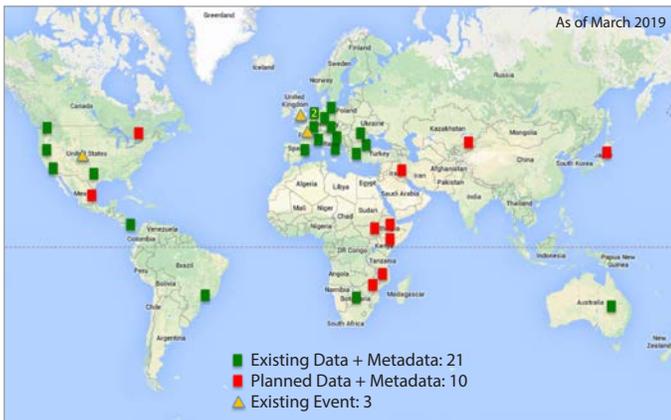


**Shipments by Network Category
1,064 Terabytes Projected on February 29, 2020**

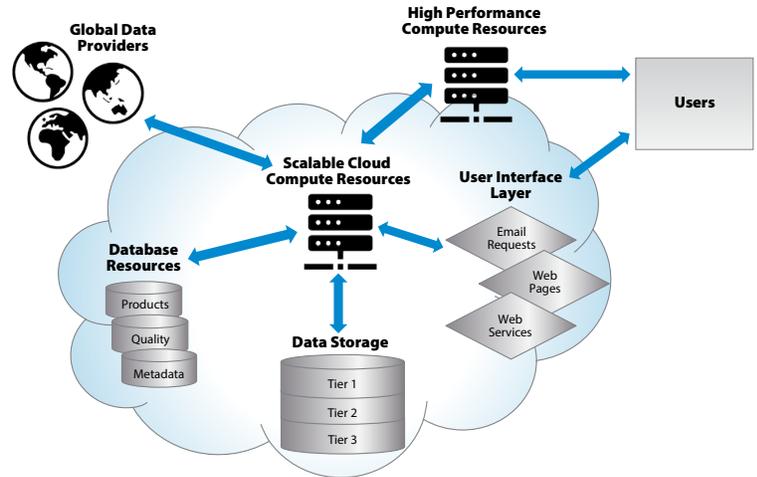


Seismological Data Center Federation

The goal of the Seismological Data Center Federation is to make it easier to exchange seismological data among different data centers that adhere to FDSN standards and specifications. The FDSN has established specifications for web-based service architectures that allow scientists to access data in a consistent manner. Leveraging the uniformity in services across FDSN data centers and using a newly established registry for FDSN federated data centers, it is possible to obtain a complete inventory of the time-series holdings at all of the federated data centers. By employing this federated data model, researchers can make a single data request based on network codes, channel types, distances from event locations, or a multitude of other types of queries and obtain all of the data that meet these criteria regardless of where the data are archived. The data requester need not know which data center manages data from a particular seismic network. Currently, standardized, FDSN-approved services are available at many different data centers around the world (see map), and the number of participating data centers is expected to grow as more and more data centers become federated.



Common Cloud Platform



Cloud Data Services for Seismology and Geodesy

The Data Services directorates of IRIS and UNAVCO are working together to create a combined cloud-based data services system that will serve both the seismic and geodetic communities. Having both the seismological and geodetic data archives served by a single cloud-based system will provide more scalability, place data closer to high-performance computational resources, allow greater data throughput, and foster greater collaboration between the two scientific communities. The project to develop this new system is already underway and will last through September 2023. The UNAVCO and IRIS data ingestion, archival, curation, and distribution functions will be integrated and not simply share the same infrastructure. The resulting system is being designed to be both nimble (supporting multiple data types) and horizontally scalable (supporting increases in data volumes). While this integrated system may offer new data access methods, traditional methods of data access that are not scheduled for retirement will continue to be supported.

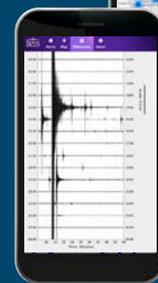


EDUCATION AND PUBLIC OUTREACH

The Education and Public Outreach program combines the expertise of Consortium members and IRIS staff to create products and activities that advance awareness and understanding of seismology and geophysics and inspire careers in Earth science. These products and activities include: self-directed exploration over the web and via social media, interactive museum exhibits, public lectures, and lessons for middle school through undergraduate classrooms that explore Earth's interior. Each year, a select group of undergraduates spends the summer conducting research under the guidance of scientists at Consortium member institutions and affiliates. IRIS staff also widely distribute "Teachable Moment" slide sets for use in classrooms within a day of major earthquakes, as well as animations and videos of earthquake and related processes.

IRIS Station Monitor

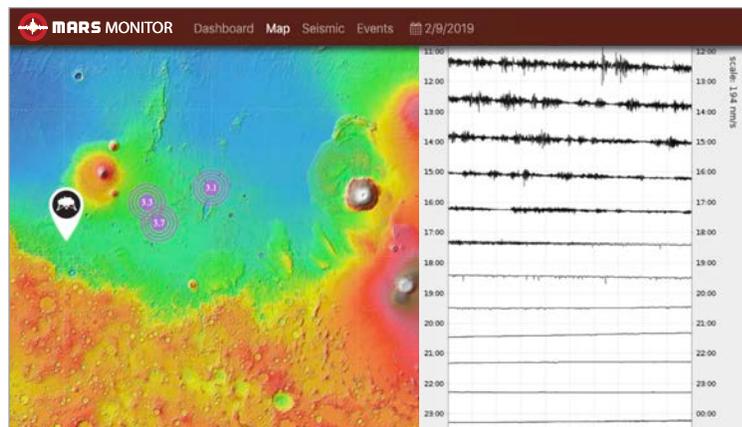
The IRIS Station Monitor provides access to continuous, real-time ground motion from thousands of locations around the globe. This easy-to-use app allows users to view seismic recordings, choose from any station that sends near-real-time data to IRIS, learn about recent events, display recordings from past earthquakes, and see annotations of wave arrivals. Station Monitor also links to other products from IRIS Data Services. For notable events, there are links to IRIS educational products, including the Teachable Moments PowerPoint slide set and other general information, the IRIS Global Seismogram Viewer, and information provided by the USGS. Station Monitor is available on the IRIS website and as a free app for iOS and Android devices.



Summer Internships for Undergraduates

Since its inception in 1998, the IRIS Undergraduate Internship Program, with support from NSF's Research Experiences for Undergraduates program, has provided 235 students with the opportunity to work with leaders in seismological research and to produce research products worthy of presentation at large professional conferences. IRIS provides centralized support for both students and mentors, but the program takes advantage of the Consortium's extensive host pool to expose the interns to research opportunities across the full spectrum of seismology. Although students conduct research at different IRIS member institutions, program activities have enabled each summer's cohort to successfully bond, starting with a week-long orientation at New Mexico Tech and the PASSCAL Instrument Center. Mentoring is a critical component of the program and involves both a near-peer intern alumni mentor and structured support from research mentors. A research experience has been shown to be a key element in the selection of a career, and our long-term tracking of intern alumni indicates that over 75% go on to geoscience careers.

As an Educational Partner in the NASA InSight Mission, IRIS uses the seismic data recorded on the surface of Mars to engage students in geoscience. IRIS Data Services releases the Mars data and makes them publicly available, enabling students to watch for marsquakes and meteorite impacts. After one year, the Seismic Experiment for Interior Structure (SEIS) has recorded more than 450 seismic signals. While marsquakes are recorded every day, the largest quakes thus far have only been magnitude 3 or 4. There are multiple ways to access the Mars data—by using the IRIS Mars Monitor (<https://www.iris.edu/app/mars-monitor>), by downloading the IRIS jAmaSeis software, or by accessing data directly through the SAGE Data Management Center web services and Mars event catalog, with the event information provided by the InSight Mars Quake Service team.



IRIS Animation Series

Because seismology concepts can be difficult to convey through text or images alone, IRIS has developed a suite of over 120 animations that cover an array of seismology-related topics. The clips range from a few seconds to several minutes in length, sometimes animating plate tectonic and earthquake processes by compressing time from centuries to seconds and scaling dimensions from hundreds of kilometers to centimeters. The animations are not meant to turn lectures into entertainment, but rather to walk the viewer through both basic seismology-related topics and tricky concepts such as magnitude, intensity, and focal mechanisms. As a result of the concise format and their dynamic nature, there have been over 6.5 million views of IRIS animations through our YouTube channel alone.

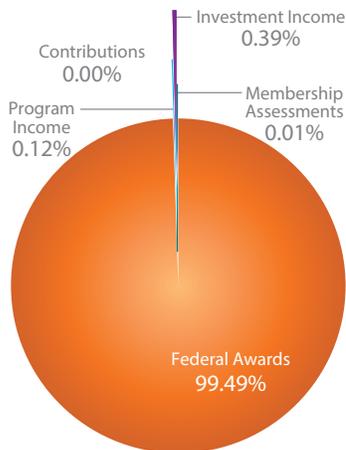
FINANCIAL OVERVIEW

Founded in 1984, the Incorporated Research Institutions for Seismology is a 501(c)(3) not-for-profit consortium of research institutions. IRIS is incorporated in the State of Delaware.

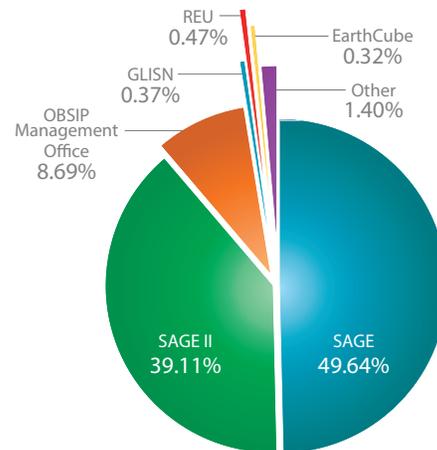
Revenues

In FY19, IRIS had total revenues of \$29,542,926. More than 99% of this revenue was from the National Science Foundation. The two largest awards were SAGE (Seismological Facilities for the Advancement of Geoscience and EarthScope) and SAGE-II (Seismological Facilities for the Advancement of Geoscience), both supported by NSF's Division of Earth Sciences and Office of Polar Programs.

FY19 REVENUES
\$29,542,926



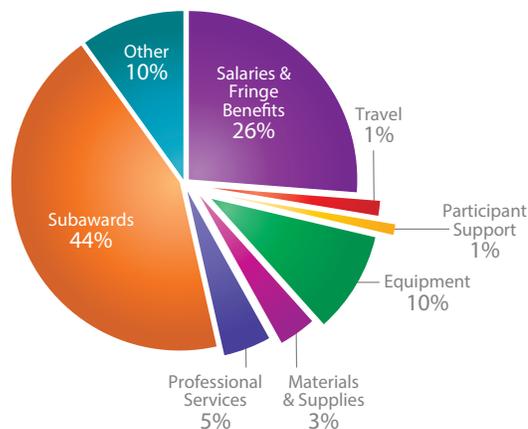
FY19 FEDERAL AWARD REVENUES
\$29,390,795



Expenses

In FY19, IRIS had total expenses of \$29,583,251. About 44% of these expenses were associated with subawards. The largest go to the New Mexico Institute of Mining and Technology, which operates the PASSCAL Instrument Center, the University of California San Diego (UCSD), which maintains part of the Global Seismographic Network and operates the Array Network Facility for USArray, and Lamont-Doherty Earth Observatory, UCSD, and Woods Hole Oceanographic Institution, each of which operate ocean bottom seismometers for the IRIS-managed Ocean Bottom Seismograph Instrument Pool.

FY19 EXPENSES
\$29,583,251

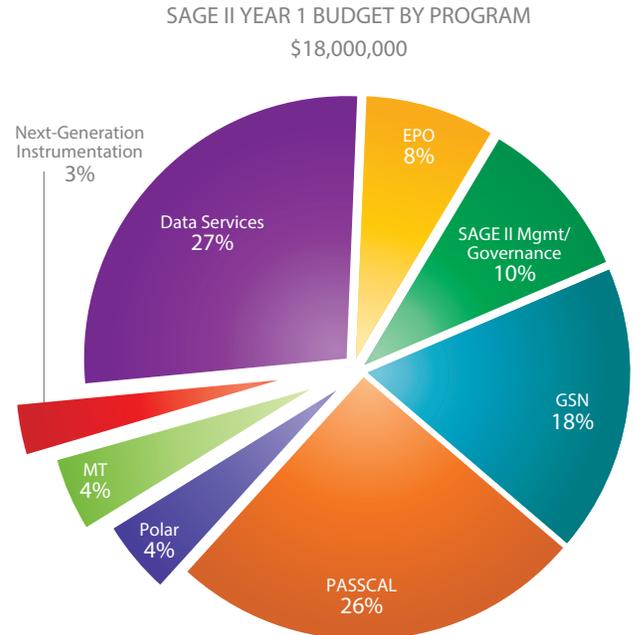


SAGE-II Budget

We are currently in the second year of the SAGE-II Cooperative Agreement with the National Science Foundation, which is funded by NSF's Division of Earth Sciences and Office of Polar Programs. The SAGE-II award, which runs through September 2023, supports IRIS core programs in Instrumentation Services, Data Services, and Education and Public Outreach.

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

	YEAR 1 10/2018– 9/2019	YEAR 2 10/2019– 9/2020
GSN	\$3,181,189	\$3,210,421
PASSCAL	\$4,583,471	\$4,635,907
POLAR	\$800,000	\$896,000
MT	\$768,397	\$758,333
Next-Generation Instrumentation	\$549,692	\$806,421
Data Services	\$4,887,700	\$4,937,316
EPO	\$1,427,057	\$1,418,325
SAGE II Mgmt/Governance	\$1,802,494	\$1,777,277
Total	\$18,000,000	\$18,440,000



THE IRIS TEAM

The IRIS Board of Directors

Rick Aster, Chair	Colorado State University
Clifford Thurber, Vice Chair	University of Wisconsin, Madison
Charles Ammon	The Pennsylvania State University
Jackie Caplan-Auerbach	Western Washington University
Samantha Hansen	The University of Alabama
Sarah Kruse	University of South Florida
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Susan Schwartz	University of California, Santa Cruz

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Major Subcontractors

New Mexico Tech	Portable Networks
University of California San Diego	Project IDA, USArray
University of Texas at El Paso	Seismic Source Facility
Oregon State University	USArray Magnetotelluric Instruments

IRIS Staff

Kasey Aderhold	Senior Project Associate
Josephine Aka	A/P Manager
Kent Anderson	Portable Programs Manager
Robert Austin	Business Analyst/Purchasing
Manochehr Bahavar	Product Specialist
Rick Benson	Deputy Director, DMC Operations
Ryan Bierma	Station Deployment Coordinator
Wendy Bohon	Informal Education Specialist
Tammy Bravo	Seismology Education & Outreach Specialist
Robert Busby	Transportable Array Manager
Jerry Carter	Director of Data Services
Rob Casey	Deputy Director, Cyberinfrastructure
Adam Clark	Lead Web Developer
Gale Cox	Office Manager, DMC
Robert Detrick	President
Mladen Dordevic	Web Developer
Perle Dorr	Public Outreach Manager
Nicholas Falco	Software Engineer
David Fillebrown	Accounting Manager
Andrew Frassetto	Magnetotelluric Manager
Katrin Hafner	Global Seismographic Network Program Manager
Michael Hubenthal	Senior Education Specialist
Un Joe	Data Control Technician
Autumn Johnson	Software Engineer
Laura Keyson	Data Quality Analyst
Michael Lane	Systems Administrator
Dee Mann Wilkinson	Staff Accountant
Jeph Mathurin	Assistant Controller
Maureen McMahon	Senior Grants & Contracts Administrator
Jeremy Miner	Station Specialist
Robin Morris	Project Cost Controller
Anh Ngo	Operations Programmer
Krystin Poitra	Meeting Planner
Rhonda Porter	Executive Assistant
Tim Ronan	Data Engineer
Gillian Sharer	Deputy Director, Quality Assurance
Candy Shin	Chief Financial Officer
John Soderquist	Materials Handler
Molly Staats	Alaska Permit Coordinator
Yazan Suleiman	Web Services
Danielle Sumy	Project Associate
Marlo Swanson	Business Operations/HR Manager
Justin Sweet	Project Associate
John Taber	Director of Education & Public Outreach
Mary Templeton	Quality Control Analyst
Forrest Thompson	Real Time Systems
Chad Trabant	Deputy Director & Chief Architect
Trayce Turner	HR Generalist/Administrative Assistant
Mick Van Fossen	Web Services
Inge Watson	Senior Systems Administrator
Robert Weekly	Quality Assurance & Deployment Engineer
Robert Woodward	Director of Instrumentation Services

The IRIS Consortium Voting Members

Arizona State University	North Carolina State University	University of California, Berkeley
Auburn University	Northern Arizona University	University of California, Davis
Baylor University	Northern Illinois University	University of California, Los Angeles
Binghamton University, State University of New York	Northwestern University	University of California, Riverside
Boise State University	Oklahoma State University	University of California, San Diego
Boston College	Oregon State University	University of California, Santa Barbara
Boston University	Pennsylvania State University	University of California, Santa Cruz
Brown University	Princeton University	University of Colorado Boulder
California Institute of Technology	Purdue University	University of Connecticut
California State Polytechnic University, Pomona	Rensselaer Polytechnic Institute	University of Delaware
California State University, East Bay	Rice University	University of Florida
Carnegie Institution of Washington	Rutgers University	University of Georgia
Central Washington University	Saint Louis University	University of Hawaii at Manoa
Colorado School of Mines	San Diego State University	University of Houston
Colorado State University	San Jose State University	University of Illinois, Urbana Champaign
Columbia University	Southern Methodist University	University of Kentucky
Cornell University	Stanford University	University of Maryland, College Park
Drexel University	Stony Brook University	University of Massachusetts Amherst
Duke University	Syracuse University	University of Memphis
Florida International University	Texas A&M University	University of Miami
Georgia Institute of Technology	Texas Tech University	University of Michigan
Harvard University	Tulane University	University of Minnesota
Idaho State University	Virginia Tech	University of Missouri, Columbia
IGPP/Lawrence Livermore National Laboratory	Washington University in St. Louis	University of Nevada, Las Vegas
IGPP/Los Alamos National Laboratory	West Virginia University	University of Nevada, Reno
Indiana University–Purdue University Fort Wayne	Western Washington University	University of New Mexico
Indiana University	Woods Hole Oceanographic Institution	University of New Orleans
James Madison University	Wright State University	University of North Carolina at Chapel Hill
Kansas State University	Yale University	University of Oregon
Lamar University	The University of Alabama	University of Pittsburgh
Lawrence Berkeley National Laboratory	The University of Arizona	University of Puerto Rico
Lehigh University	The University of Kansas	University of Rochester
Louisiana State University	The University of Oklahoma/Energy Center	University of South Carolina
Macalester College	The University of Tennessee, Knoxville	University of South Florida
Massachusetts Institute of Technology	The University of Texas at Arlington	University of Southern California
Miami University of Ohio	The University of Texas at Austin	University of Washington
Michigan State University	The University of Texas at Dallas	University of Wisconsin–Madison
Michigan Technological University	The University of Texas at El Paso	University of Wisconsin–Milwaukee
Missouri University of Science and Technology	The University of Tulsa	University of Wisconsin Oshkosh
Montana Tech/University of Montana	The University of Utah	University of Wyoming
New Mexico State University	University of Alaska Fairbanks	
New Mexico Tech	University of Arkansas at Little Rock	

For names of IRIS Educational Affiliates, U.S. Affiliates, and Foreign Affiliates see https://www.iris.edu/hq/about_iris/membership.

PASSCAL Polar Field Engineer Aurora Roth inspects a seismic station in Kasatog Valley in southeastern Greenland during a servicing trip for the Greenland Ice Sheet Monitoring Network (GLISN) in August 2018.
Photo credit: Kevin Nikolaus



The material in this document is based, in part, upon work supported by NSF's Seismological Facilities for the Advancement of Geoscience (SAGE-II) which is a major facility funded by the National Science Foundation. Any opinions, findings and conclusions or recommendations expressed in this material do not necessarily reflect the views of the National Science Foundation.