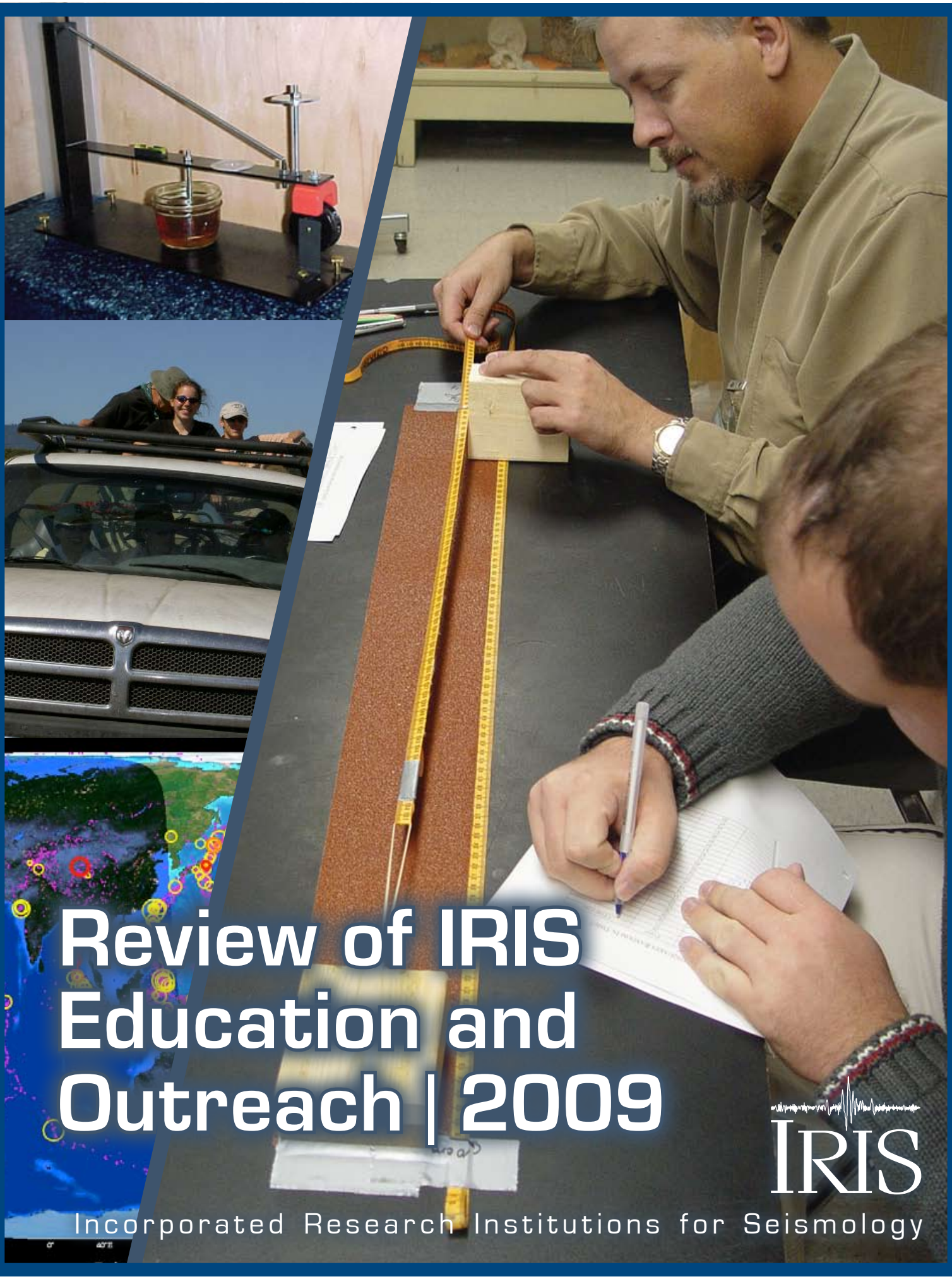


Review of IRIS Education and Outreach | 2009

IRIS

Incorporated Research Institutions for Seismology

Contents

Introduction

The Education and Outreach (E&O) program of the Incorporated Research Institutions for Seismology (IRIS) was initiated in the late-1990's to increase public understanding of Earth science in general and seismology in particular. The IRIS E&O program draws upon the rich seismological research of the IRIS Consortium members in order to create educational and outreach products and activities of the highest quality and significance. Although it is relatively young, the IRIS E&O program has already established itself as a model educational initiative among NSF-funded programs and has made significant impacts in a variety of arenas. The IRIS E&O program undergoes continual internal evaluations and assessments, and has grown and changed in response to these evaluations. The current NSF-mandated review, however, is the first formal external assessment and review of the entire program. As part of that review, this report summarizes the major elements of the first ten years of the E&O program and the structure used to implement them, including interactions with other organizations.

Founded in 1984, IRIS is a consortium of over 100 U.S. research universities and institutions dedicated to monitoring the Earth and exploring its interior through the collection and distribution of seismological data. IRIS has been funded through a series of five-year Cooperative Agreements with the National Science Foundation under the Division of Earth Science's Instrumentation and Facilities Program and contributes to scholarly research, education, earthquake hazard mitigation, and the verification of a Comprehensive Test Ban Treaty. Originally, IRIS developed three core programs to serve the seismological community. These programs are the Global Seismographic Network (GSN) consisting of over 140 globally distributed broadband seismic stations, a Data Management System (DMS) to store and deliver over 80 terabytes of digital data, and a program to support networks of portable seismographs for investigating Earth structure and the tectonics of the lithosphere (PASSCAL).

Over time, IRIS members increasingly recognized the fundamental need to communicate the results of scientific research to the public more effectively and to attract more students to study science. To address this need, IRIS, with strong NSF encouragement, initiated the creation of an Education and Outreach Program with the start of the 1996-2001 Cooperative Agreement and an Education and Outreach (E&O) Standing Committee was formed in 1997. To set the program in motion, the committee convened a conference of representatives from diverse science and science education disciplines, funding agencies, and other Earth science E&O programs to develop a broad vision of how IRIS could uniquely contribute to science education and outreach. The discussions and collaborations that

developed during the conference formed the basis for a program plan published in 2002 and have guided IRIS' E&O efforts since then. The new E&O program began in 1998 with a single staff member, and since 2002 has grown slowly to 4.5 IRIS staff members managing a number of subcontract and consultant awards, with significant contributions from members of the IRIS community.

Based on the vision set forth in 2002, the mission of the IRIS E&O program is to enable the next generation of Americans to have a greater understanding of Earth science and seismology, while helping to attract the best and brightest to our discipline. While numerous paths to achieve this mission exist, the E&O program seeks to maximize the impact of its efforts by defining the bounds of its activities such that they align with the expertise and resources of the IRIS Consortium. This focus on seismology and the use and explanation of seismic data has allowed the IRIS E&O Program to develop and disseminate a unique suite of programmatic offerings ranging from those that impact large numbers of people for brief time periods to those that impact smaller numbers of people through extended interactions. These offerings, or elements, serve a spectrum of audiences with an interest in seismological education, ranging from teachers in Portland, OR to families visiting a museum in DC, or even13 year olds in Dushanbe, Tajikistan. The hallmark of IRIS E&O elements are their strong linkages to the core scientific content of the consortium, quality implementation, and ability to supplement gaps in existing educational offerings and deepen learners' understanding of seismological concepts.

The IRIS E&O program applies several key strategies to order to effectively implement its activities. First, the IRIS E&O program looks inward to the ranks of IRIS member institutions

to enfranchise them and draw on their expertise and talents. By engaging the membership of IRIS in E&O activities, we capitalize on our numbers, geographic diversity, and especially the wealth of creativity and knowledge within our community to sustain an education program of national scope and prominence. Annually, numerous IRIS members donate their time to work along side IRIS E&O staff on elements that range from staffing workshops to serving on the E&O committee or writing text for the newest IRIS publication. In addition, the E&O program also serves as a cornerstone resource that IRIS members may pattern or leverage to construct their own localized E&O efforts. Such efforts are encouraged as they greatly extend the impact and reach of IRIS E&O program.

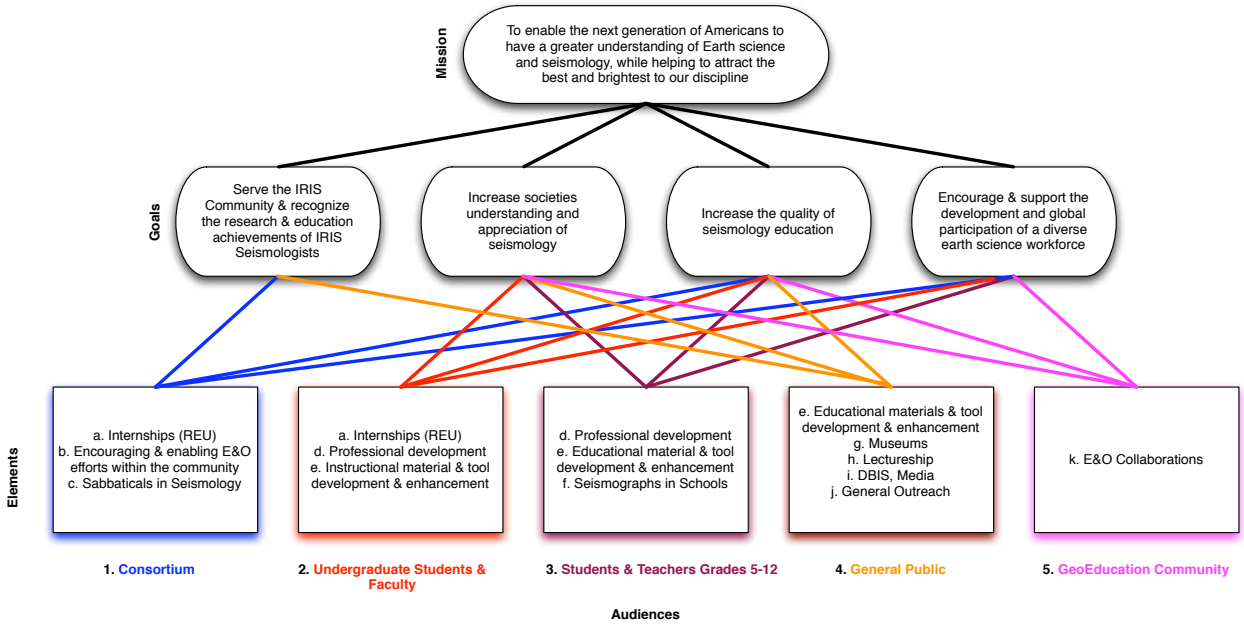
Next, to continuously improve the products and programs offered, and to ensure the most effective use of both time and financial resources, IRIS E&O activities are evaluated via a combination of both internal and external assessments. To date, this strategy has focused primarily on internal formative assessments, given the on-going nature of the vast majority of our efforts. These internal assessments are supplemented by occasional external evaluations used to validate conclusions from our internal assessments. Results from these assessments inform the Program's decision-making process, allowing us to significantly enhance our E&O activities over time. Such enhancements range from cost savings and efficiency changes, to modifying the length and structure of workshops to improve participant outcomes, to providing data to drive the development of major new projects.

Finally, we recognize that while IRIS can make advances in scientific education through the disciplinary depth of its contributions in seismology, an even greater impact is achieved thorough concerted efforts to link seismology across the breadth of scientific disciplines and with national efforts throughout the educational enterprise. A major strategy of the IRIS E&O program is thus to coordinate its activities with those of other

organizations, to leverage impact and actively seek opportunities to openly collaborate on education and outreach activities where mutual interests exist.

IRIS E&O manages a broad portfolio of activities that are outlined in the figure below along with program goals and audiences. These activities include: an undergraduate summer internship program, professional development experiences for teachers and college faculty, seismographs in schools and related collection and use of seismic data, IRIS/USGS museum exhibits, IRIS/SSA distinguished lecturers, publications including videos, animations, online recordings, and classroom modules, and the dissemination of materials, activities, software and data via the IRIS website. Within most of the activity descriptions in the sections that follow are boxed quotes from 1-page submissions by members of the Earth Science community in support of the last IRIS proposal. This report is part of a review of the IRIS E&O Program required by the current five-year (2006-2011) cooperative agreement (EAR-0552316) between NSF and the IRIS Consortium. While not part of this review, the close association between IRIS E&O and EarthScope will also be highlighted at various points. This report reflects input from IRIS staff, the E&O Standing Committee and committee chair, and members of the IRIS community.

Goals, elements and audiences of the IRIS E&O Program



Descriptions of Program Elements

When developing program elements, the IRIS E&O course of action is to examine existing resources related to seismology education and communicate with potential users to identify needs. Then based on these assessments, the program seeks to develop/enhance/implement products and activities that meet these needs and are grounded in research-supported, best practices. To achieve our ambitious mission, IRIS has developed a suite of program elements that serves a spectrum of audiences, including the general public, students in grade 6-12 and their educators, as well as post- secondary students and their faculty, including the IRIS community. The implementation of all elements is reflective of the Program's commitment to enhance the participation of underrepresented groups.

The IRIS E&O program has worked hard to maintain a balance between the education and outreach ends of the program mission. This is a challenging course to maintain because it is often hard to assess the relative worth of an activity that greatly impacts a few people ("education") compared to an activity that minimally impacts a great number of people ("outreach"). However, both ends of the spectrum are of value if done well, and IRIS E&O has striven to do high-quality work in many places along the spectrum between education and outreach. All of these activities draw upon the richness and depth of the seismology research directly available from members of the IRIS Consortium.

Summer Internships for Undergraduates in Seismology

Since its inception in 1998, The IRIS Undergraduate Internship Program has provided undergraduate students with the opportunity to work with leaders in seismological research, to travel to exotic sites for fieldwork, and to produce research products worthy of presentation at large professional conferences. The goal of this program is to provide undergraduate students with research opportunities early in their educational careers, thus encouraging more students who represent a more diverse population to choose careers in Earth science. Based on surveys of program applicants, we have implemented a new recruiting strategy that emphasizes the use of electronic resources and personal contact from faculty or program representatives. Students can consume these electronic resources, such as presentations, podcasts, and video clips, independently. However, most are specially designed to enable IRIS members and other college faculty to easily use them to announce the program in their classes. Building on this new approach, the program has developed a special lecture series to increase the diversity of our applicant pool. Increases will be achieved by providing select program alumni with opportunities to present their research and perspectives on the program to physics majors at minority serving institutions.

Given the distributed nature of the Consortium's human resources, the program has developed an approach that blends mature telecommunications technology and recent research on distance learning to achieve the spirit of a traditional Research Experience for Undergraduates (REU). Each summer experience begins with a one-week orientation held on the campuses of the New Mexico Institute of Mining and Technology and the PASSCAL

Highlights

- 71 undergraduates have participated
- 40 faculty, representing 33 Consortium institutions, have hosted
- 85% of alumni have attained or are pursuing a graduate degree in a field of geoscience
- 6% of alumni are employed in a geoscience career with an undergraduate degree
- 32% of hosts have been women and 10% have been minorities
- All the students agreed the internship was one of the best learning experiences they had ever had
- 45% of interns have come from non-IRIS institutions
- 43% of interns have been female
- 8% of interns have been Hispanic or African-American

Instrument Center. The purpose of the orientation period is to develop a strong sense of community among interns, provide training in distance collaboration, and introduce the interns to some of the most exciting aspects of modern seismology.

During the week, visiting scientists from across the IRIS community donate their expertise to lead in-depth laboratory exercises and artful lectures/discussion sessions. Classroom sessions introduce interns to a variety of topics including: history and theory of seismology, earthquakes and earth structure, geophysical inverse theory, general reflection and refraction theory, and seismological data collection and seismic processing. Lab sessions introduce interns to the basics of the UNIX operating system as well as other computer programs students are likely to encounter (e.g. MatLab, GMT and ProMax), and to research-grade field equipment identical to that used by NSF and other researchers. Additional sessions explore graduate student life, strategies and opportunities to fund graduate education, and a career panel including representatives from industry, academia, and government labs.

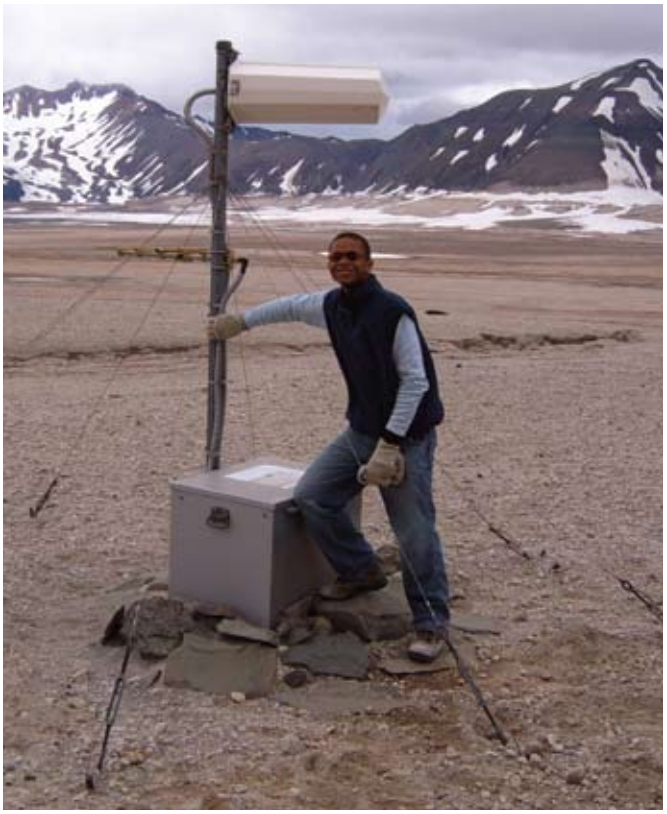
Following the orientation, interns spend 8 to 10 weeks working on a seismological research project with researchers at an IRIS member institution. Research projects may involve the deployment of seismic instruments in the field (within the US or internationally), and/or analyses of seismic data in a lab setting with the ultimate goal of producing results to be presented at a national scientific meeting. Each project provides interns with ample opportunities to:

- conduct research with state-of-the-art geophysical data and leading researchers at IRIS institutions,
- develop an understanding of scientific inquiry including designing and conducting scientific investigations, defending scientific arguments, and preparing publications,
- gather, manage, and convey information, using various skills, strategies, resources, and
- learn, use, and evaluate technologies for the collection and study of geophysical data.

Interns' progress towards the development of these core research skills and their specific research project are monitored through regular meetings with their host. In addition to regular mentoring by hosts, we have found that an alumni mentor is a critical component of the model for maintaining the cohort through the summer. The alumni mentor, a student advanced in a PhD program, assists during the orientation week as well as monitoring and interacting with each intern through the cyber infrastructure as their research is ongoing. In this way the mentor serves as a both a role model and an unbiased, outside, and experienced third-party to the mentor/mentee relationship. Additionally the alumni mentor position also provides PhD students with experience mentoring undergraduates in research early in their careers.

Based on needs identified from annual surveys of the interns, the IRIS REU program has also developed a set of strategies to enable interns to self-monitor their own progress. This requires the conscious development of metacognition (thinking about one's own thinking). For the interns, this metacognition includes planning how to approach given learning tasks, monitoring their comprehension, and evaluating their progress toward the completion of tasks. These strategies are initially introduced during the orientation week. However, the cyber infrastructure that maintains the cohort throughout the summer also serves as a medium to facilitate intern self-monitoring. Through the internship website, www.iris.edu/internship, interns are encouraged to "blog" their projects in their own words, identify and structure overarching and periodic goals, monitor and evaluate progress, and discuss the broader reaches of their work. Hosts are also encouraged to regularly review interns' web posts to gain insights into interns' current thinking and development.

The culmination of each student's REU internship experience is the opportunity to present the results of their summer research at the Fall American Geophysical Union (AGU) meeting. Not only does attendance at AGU bring closure to the research project, it is an important opportunity for students to gain meaningful exposure to Earth science research as a viable career option. The longevity of the IRIS internship program allows much of this exposure to occur through networking with our numerous internship alumni and potential graduate advisors present at AGU. To encourage and support the development of this alumni community, IRIS annually holds a casual alumni mixer. This mixer allows interns to meet again face-to-face and presents an opportunity for interns to network with internship alumni who can provide valuable information about graduate school opportunities and facilitate connections with potential advisors.



> The summer after my junior year, I had the great opportunity to participate in the IRIS summer internship. I worked with Dr. Catherine Snelson at the University of Nevada Las Vegas, where I was able to work and learn about seismic studies and instrumentation. Before this internship, I had no experience with anything remotely close to seismology. From that moment, I was hooked. I am now a graduate student at the University of Nevada Las Vegas with Dr. Cathy Snelson as my advisor. Without this internship, I would not be where I am today and I would not have realized my true passion.
>
> *Aaron Hirsch, IRIS Intern Alumnus '03*

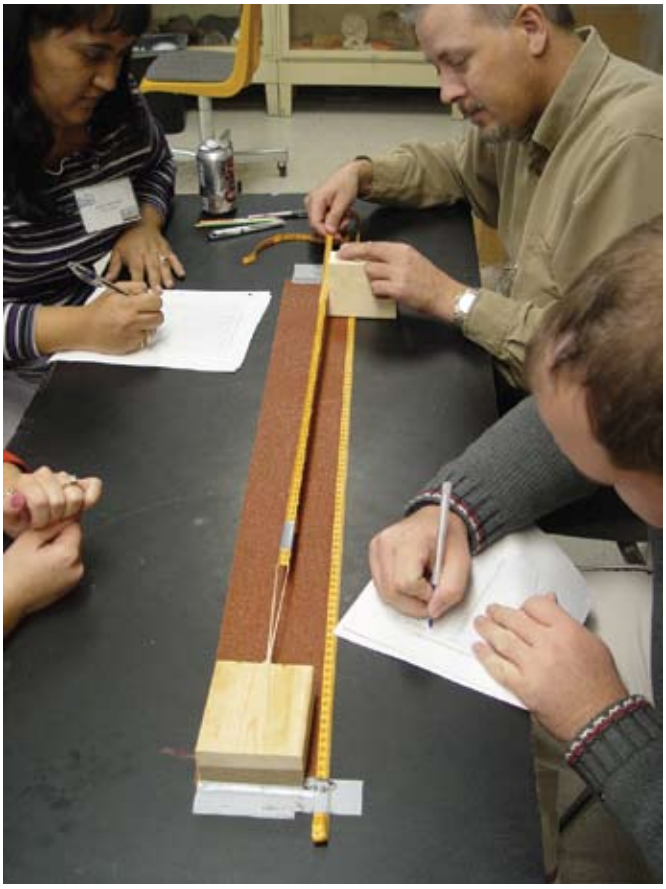
Professional Development

Stimulating an interest in seismology requires access to high quality educational resources designed for specific educational audiences. To enable educators to use these resources, providing accurate and efficient professional development in Earth science and seismology is critical. This is especially important for the teachers in middle and high school grades, many with very limited course work in geophysics, who currently teach the bulk of the Earth science concepts that the majority of Americans will ever learn. To serve this need the E&O Program organizes an annual set of highly effective, 1-3 day-long professional development experiences for middle and high school teachers, as well as for college faculty. These workshops are offered free of charge and are frequently held in conjunction with a variety of venues such as state, regional, or national science and science education conferences. Content covered at teacher workshops emphasize topics required by national and/or state standards including; plate tectonics, Elastic rebound theory, propagation of seismic waves, Earth's interior structure, and earthquake prediction. Current research and relevant topics such as recent earthquakes are also discussed to keep teacher's knowledge up to date. Workshops for faculty also review core seismology principles but place more emphasis on cutting-edge research topics and methods to access and use seismic data in lab experiences. To capitalize on both the instructional and content expertise of the IRIS Consortium, all learning experiences are developed by IRIS E&O staff members and are implemented jointly with faculty from IRIS member institutions who generously donate their time to support such efforts.

Over the course of the past decade, the E&O program has used formative evaluations in coordination with literature on the best practices of science professional development to refine and improve the IRIS professional development model. At the core of the teacher professional development model is the philosophy that increases in teacher self-efficacy and content knowledge have the ability to influence a teacher's instructional behavior. Such behaviors include the type of activities selected to introduce content to students, the amount of time a teacher spends on a particular topic, and the attitude used by the teacher when presenting the material to students. For example, a teacher who is uncomfortable with seismology content is more likely to be less confident in their instruction. As a result they tend to

Highlights:

- Over 975 teachers and college faculty have attended 1-day or longer IRIS workshops
- These instructors have the potential to reach over 74,000 students annually
- 100% of participants report an increase in their preparedness to teach about seismology related topics
- 98% of participants report the workshop to be one of the best they have ever attended
- One year later, 74% of participants reported increasing the amount of time spent teaching seismology or related topics
- 86% of participants report using at least one of the activities presented in the workshop with a mean usage of 4.5 activities per participant
- Yuma High School District (predominately Hispanic) reported an improved Earth science pass rate after the first year of three years of collaboration
- Activities, agendas and other materials are provided to support of workshops conducted by other groups (26 such workshops in 2005).
- Educational modules used in our workshops are available via the website and printed publications (e.g. NESTA and NSTA journals)
- Tens of thousands of teachers are reached regularly by E&O staff monitoring regional and national Earth Science & Physics listservs



be less enthusiastic when covering the content, select activities that require students to use lower-order thinking skills, are less inquiry oriented and take less time. Thus, to increase the use of seismic data (both event and waveform) in the classroom, increase the duration of seismology instruction in the classroom, and encourage teachers to select engaging instructional activities that involve learners in higher-order thinking skills when presenting seismology-related content to students, our professional development seeks to:

- improve participants' foundation in seismology,
- provide participants with a variety of high-quality, relevant, and scientifically accurate activities to deliver content to their students, and
- provide participants with experiences involving both the content and the educational activities as the primary means of knowledge transfer.

Formative evaluation strategies used during workshops allows us to tune the content and delivery mechanisms of the workshop and make them more efficient as well as more effective for participants.

The E&O program seeks out venues that offer the opportunity for the professional development delivered to have an impact on minority communities. For example, IRIS E&O staff members have been collaborating with faculty from Penn State University to offer professional development workshops on the campus of NCA&T state (a Historically Black College or University, or HBCU) since 2006. These workshops serve two purposes: 1) to train faculty in the physics department of NCA&T State to facilitate their own professional development opportunities and 2) to deliver greatly needed Earth science professional development to teachers of a largely African-American community in the greater Greensboro area. Beginning in the summer of 2009 these workshops will be expanded from 25 to 50 participants to better serve the demands of the local school systems.

In addition to the 1-3 day workshops, the IRIS E&O program also regularly delivers additional professional development as part of the National Science Teachers Association annual meeting. These one-hour sessions are patterned after the full-day workshop in that they are designed to increase both the teachers' content knowledge and their pedagogical content knowledge through an exploration of a single activity. Attendance at each session can vary greatly but on average each session reaches 40-50 participants. Below are several examples of the eight one-hour sessions that IRIS E&O will offer at the 2009 National NSTA meeting.

- Discovering Earth's Layered Interior with Seismic Waves—Finally an Activity That Addresses This Standard!
- Determining What Is Beneath Our Feet: Applying the Reflection and Refraction of Waves
- Why Can't Scientists Predict Earthquakes?

An evolving focus of the professional-development program is to further increase the impact of its professional development and to reach an audience of teachers that do not traditionally seek out external professional development opportunities. To do this, IRIS pursues multi-year partnerships with school districts as well as other science education programs to create science professional development that

- is focused on generating a perceptible change in student knowledge and skill,
- seeks to enhance teacher content and pedagogical content knowledge
- effects change in classroom practice,
- is relevant and coherent for teachers, and
- is customized, not only for individual participants, but also recognizes the distinctiveness of each school setting.

An initial pilot of this integrated professional development model was completed in the spring of 2008 after a three-year partnership with the Yuma Union High School District (YUHSD), a primarily Hispanic-serving district located in Yuma, AZ. The focus of this effort was on increasing student achievement in Earth science classrooms by enhancing the content and pedagogical content knowledge of the district's 9/10th grade and 7th grade Earth science teachers. A motivating factor for YUHSD to establish this partnership with IRIS was a combination of a shortage of certified Earth science teachers in the district, which resulted in many sections of Earth science

being taught by teachers teaching out of content area, and an upcoming, statewide, high-stakes Earth science assessment.

To assist in addressing the school district's need, the IRIS Consortium staff and district personnel collaborated to develop a plan and implement high quality content-based professional development to all teachers teaching any sections of Earth science. This plan contained various models of professional development and involved staff and researchers associated with IRIS as the leaders of training sessions. In the later years of the partnership additional outside content experts from groups such as JOI, UNAVCO, Project Wet, and Arizona Western College were brought in to extend the content coverage beyond seismology. Throughout the year, department chairpersons and mentor teachers served as facilitators of a variety of on-going staff development. Such on-going professional development efforts included individually-guided collaborative problem solving, and observation and assessment of teaching. The result was a content-focused professional development effort that used a variety of active learning strategies, was coherent with the district's priorities, had sufficient duration, both in contact hours and span, and addressed a collective and representative group of teachers.

Workshops for college faculty have been traditionally offered at the national Geological Society of America meetings. However, due to recent declines in attendance of such workshops, attributed to changes in the GSA meeting itself, IRIS has begun to explore alternative venues to offer professional development to undergraduate faculty. Such efforts include partnering with IRIS community members and the Science Education Resource Center at Carleton College to assist in a week-long workshop, *Teaching Geophysics in the 21st Century*, as part of the SERC *On The Cutting Edge* workshop series. Additionally, IRIS is offering or supporting seismology professional development at the regional meetings of the National Association of Geoscience Teachers (NAGT). The transition to NAGT as opposed to GSA will allow the IRIS professional development reach a significantly greater number of community college faculty.

Yuma Earth and Space Science Professional Development Project

"From my perspective as a mentor and evaluator of teacher instruction, this collaborative effort (with the IRIS Consortium) has had a dynamic impact on both teachers and students in the district. Following the training, teachers that had avoided teaching geoscience content and active-learning activities for the first half of the year, had their students out of their seats actually doing earth science. As a result, students were exposed to the latest data available and were analyzing this data in the manner of a true scientist. Even teachers who were already highly qualified in the teaching of earth science gained new insights, and were renewed and energized. Most importantly the students of Cibola became more motivated to participate in Earth Science class. The impact of this effort is evidenced by the decline in the failure rate of earth science students during the semester following the professional development."

Richard McClure, Science Dept. Chairperson
Cibola High School

Museum Displays

Museums are an important mechanism for scientific outreach to the general public, and the display of the seismology community's continuous collection and dissemination of real-time data offer the opportunity to capitalize on visitors' enthusiasm for current information. The IRIS/USGS museum displays have used this interest to present seismology to large numbers of interested lay people. This occurred, first via a few large displays in major museums and more recently through a smaller, more flexible, and more widely distributed display. The IRIS/USGS museum displays are designed to engage many visitors for a short time and to convey the frequency and global distribution of earthquakes. The large displays have been developed as partnerships with major museums that have sufficient staff to maintain them and are based on a successful traveling display originally constructed for the Franklin Institute in 1998. The four original museums with permanent displays are the New Mexico Museum of Natural History, Carnegie Museum of Natural History (display now retired), American Museum of Natural History, and the Smithsonian Institution National Museum of Natural History. IRIS and USGS provide hardware and software support for the displays, usually remotely, but also onsite if necessary. As part of the partnership, we rely on the museums to let us know if there are any problems with the displays, and we have the ability to log in remotely to help troubleshoot any problems. The museums themselves are responsible for developing and maintaining the physical display and signage that is associated with the IRIS donated hardware and software.

The exhibits portray earthquakes not as destructive events, but as part of the Earth system and as signals of near real-time geological processes that build our mountains and shape our landscapes. The real-time aspect of the displays allows visitors to see the location and size of global and local earthquakes that occur every day and to see the recorded movement of the ground as seismic waves travel around the globe. Visitors are surprised that earthquakes happen every day and they are led to draw their own conclusions about the data. The success of the displays, as indicated by external assessment, is attributed to: 1) real-time global data streams, 2) state-of-art electronic displays combined

Highlights

IRIS/USGS Large displays:

- Annually 13 million people visit the 3 museums where we currently have major displays.
- A recently retired traveling display visited 12 museums over a 7-year period
- Evaluation of our American Museum of Natural History (AMNH) and Smithsonian Institution National Museum of Natural History displays in 2004 showed:
  - The displays are very popular in both museums, with audiences particularly interested in the presentation of near real-time seismic data
  - In the two galleries surveyed the display had the largest percentage of visitors who stopped to view it, compared to the other exhibits. At AMNH the display also had the longest median visitor stop time of the observed elements in that gallery

Active Earth Display:

- Over 50 accounts have been applied for, 30 of which are schools, colleges, or community colleges, and this number is rapidly increasing
- 24 displays in operation in the past month (January, 2009)
- Users estimate over 50,000 people per year will visit the existing displays

with traditional "three-dimensional" mechanical displays (retired drum recorders), and 3) sustaining strong partnerships that allow each exhibit to be customized to the specific needs of the individual host museum.

On the basis of demonstrated audience interest in real-time information, a need from the IRIS community to attract students, and the evaluation results from the large displays, IRIS has recently developed a more-versatile, and less-costly Active Earth Display (AED) that is aimed at smaller formal and informal learning institutions. Displays have been installed in locations ranging from visitor centers in national parks to small museums, NSF headquarters, departmental lobbies in universities, and the South Pole Station. The content, including both real-time and longer-term information, is delivered via a web browser. This requires less support and maintenance and allows the displays to be individually tailored to provide content and data relevant to each institution. Unlike the large displays, in most cases IRIS provides the software and content but not the hardware for the display. Because the hardware is relatively low cost, most institutions can obtain it with relative ease; allowing IRIS to potentially support hundreds of the displays.

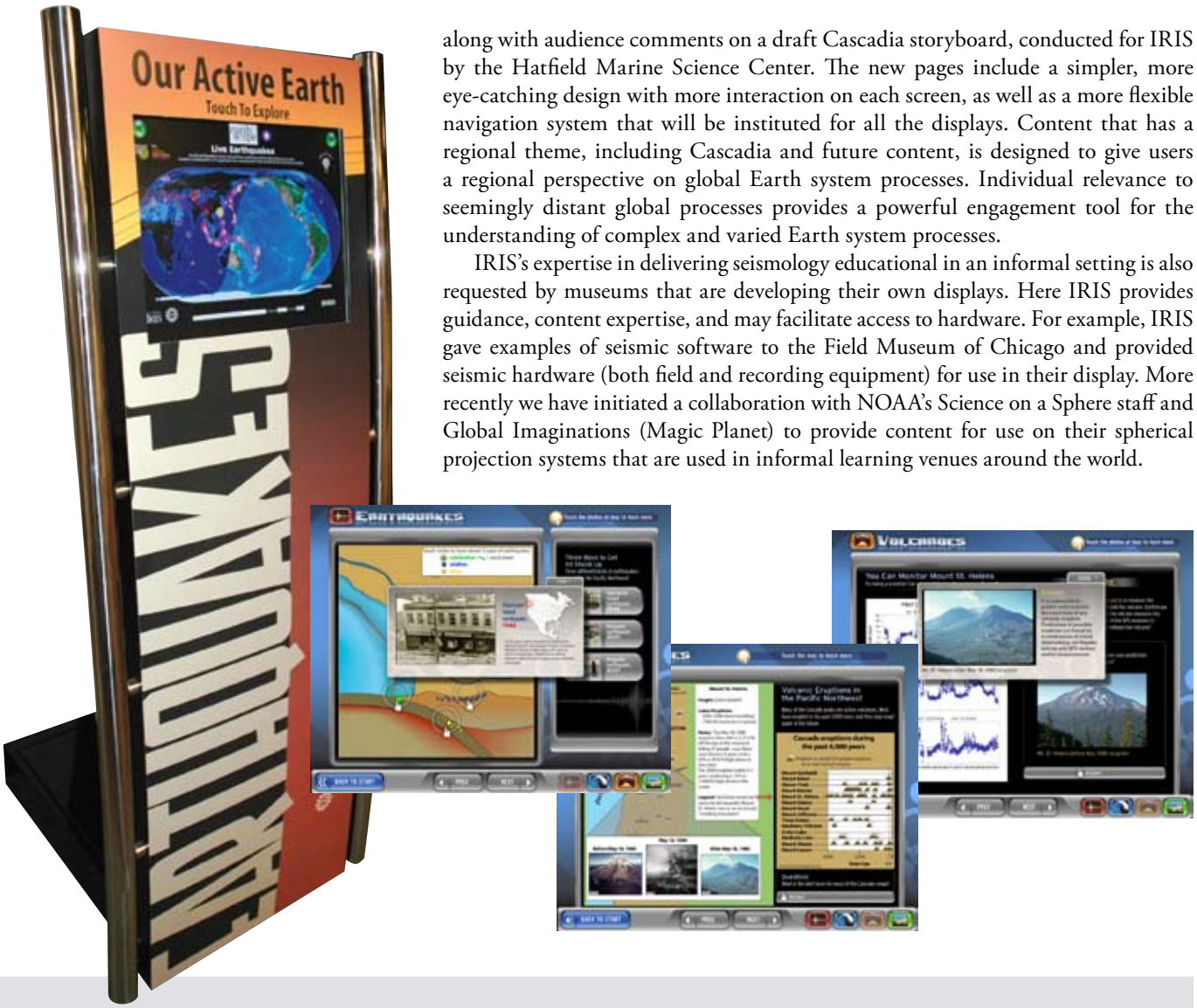
The components of the Active Earth Display can be separated into three parts: hardware, software (the "engine"), and content. IRIS provides suggestions on hardware via the E&O website, and through EarthScope funding has purchased a number of kiosks for use in both temporary and longer-term installations. Content, particularly the new Cascadia pages, has been developed in collaboration with UNAVCO and the EarthScope National Office. The engine has been developed by IRIS with primary funding from the cooperative agreement and some additional EarthScope funding.

The AED content pages are designed for interactive use with a touch screen but the display can also be cycled in a non-interactive mode. For assessment purposes, users are asked to estimate the number of expected visitors when they apply for a display. Daily statistics are also collected automatically from each site, including the timing and number of page advances for interactive sites, allowing for a continuous assessment of the use of the displays. The customizable nature of the display encourages community involvement through the development of additional content tailored to their region or institution. Several groups have already done this, including displays in Oregon, Yosemite, Hawaii, and New Mexico, and we will be providing a forum for groups to share content that they have created. Currently there are 21 seismology-related pages to choose from, including map views of current seismicity, 24-hour plots of ground motion at nearby locations (selectable by the display host), and related information about earthquakes, volcanoes, and tsunamis.

A new set of 18 AED content pages focusing on earthquakes, volcanoes, tsunamis, and plate tectonics in Cascadia is about to be released. The design is based on lessons learned from audience testing of the original Active Earth Display pages

along with audience comments on a draft Cascadia storyboard, conducted for IRIS by the Hatfield Marine Science Center. The new pages include a simpler, more eye-catching design with more interaction on each screen, as well as a more flexible navigation system that will be instituted for all the displays. Content that has a regional theme, including Cascadia and future content, is designed to give users a regional perspective on global Earth system processes. Individual relevance to seemingly distant global processes provides a powerful engagement tool for the understanding of complex and varied Earth system processes.

IRIS's expertise in delivering seismology educational in an informal setting is also requested by museums that are developing their own displays. Here IRIS provides guidance, content expertise, and may facilitate access to hardware. For example, IRIS gave examples of seismic software to the Field Museum of Chicago and provided seismic hardware (both field and recording equipment) for use in their display. More recently we have initiated a collaboration with NOAA's Science on a Sphere staff and Global Imaginations (Magic Planet) to provide content for use on their spherical projection systems that are used in informal learning venues around the world.



IRIS/USGS Seismology Displays at the American Museum of Natural History, New York

"IRIS has become an important partner with the American Museum of Natural History in educating students and the public alike about earthquakes. There are two venues in which this education takes place. The first is in the Hall of Planet Earth. A nearly identical IRIS/USGS seismology display exists in the Discovery Room at AMNH. The Discovery Room is a permanent interactive exhibit that offers families, especially children between the ages of five and twelve, the opportunity to engage in the process of science. The IRIS/USGS display constitutes an important part of Earth science activities in the Room. The drums were installed at the eye level of grade school children, who are fascinated to learn that the pens they see moving are "taking the pulse" of the Earth. Older visitors are drawn to the screen showing the changing map and the color print of the tectonic plates beside it. After they have studied the display or heard an explanation by the Discovery Room staff, single visitors often run off to bring the rest of their party to see. Those visitors then become the explainers for others."

Edmond A. Mathez, American Museum of Natural History

Seismographs in Schools

One of the best ways to engage people in scientific content is to give them opportunities to work with real scientific instruments and data and enable them to experience the discovery of scientific information. The "Seismographs in Schools" program is now doing this for scores of students in physics and Earth science classes around the country. The goals of the Seismographs in Schools (SIS) program are to:

- promote and facilitate the installation and effective use of educational seismographs and seismic data both within the US and globally,
- disseminate high-quality curricular materials and educational services that promote the use of seismology in science education, and
- provide community resources to both individuals and regional educational seismograph networks to bridge geographic divides between classrooms and the international educational seismic network.

The foundational activity of the SIS program has been the dissemination of educational seismographs (the AS1) to classroom teachers and the development and distribution of display software written by Alan Jones (AmaSeis). Since 2000, the IRIS E&O program has donated over 180 instruments to schools on a permanent loan. These simple seismographs are capable of recording earthquakes from around the world yet cost only about $600. Their open design allows students and teachers to see the components of the instrument and conceptualize their function. Thus, having their own seismograph in the classroom gives students a way of collecting real-world data and making measurements that provide them with an understanding of the interior structure of the Earth and processes by which Earth changes. Although the primary purpose of the instruments is for education, the data have also been used for scientific analysis such as relocating a small earthquake under Portland using the local network of 6 schools.

To ensure that the seismometers are promptly and properly installed, the IRIS E&O program annually offers a 2.5-day Educational Seismograph Operators Workshop. This workshop enhances teachers' content knowledge of geophysics and the fundamental principles of seismometry. The workshops, staffed by volunteers from the IRIS community and E&O staff, provide teachers with experience in setting-up and troubleshooting hardware and software issues, manipulating and analyzing seismic data, sharing data both locally and globally, and practicing activities to use the data with their students.

To enable teachers to maintain the functionality of the instruments for many years to come, the IRIS E&O program provides a range of technical support to any educator with a seismometer. For example, IRIS has supported the development and maintenance of a manual to accompany the most popular educational seismograph in the US, the AS1. More recently, the members of the IRIS community have developed a collection

Highlights

- Over 140 schools are currently operating the seismographs provided by IRIS
- Over 175 users of educational seismographs from 38 states and 6 countries have registered their station in the Seismographs in Schools database
- Over 40 of these stations have displayed real-time views of their data on the web.
- Since 2004, 120 teachers have attended an AS1 users training workshop.
- Evaluations have shown that the workshops are capable, even two years following the workshop, of significantly increasing a teacher's confidence in their ability to
  - set-up and maintain the instrument,
  - analyze seismic data, and
  - use the resultant data for instruction with students
- IRIS has helped foster and collaborates with educational seismology efforts of local and regional groups in states throughout the US, including New Mexico, Michigan, Ohio, Indiana, South Carolina, Nevada, Massachusetts, Oregon, and California.
- IRIS has provided seed equipment and shared expertise with school seismograph programs at various stages of development in New Zealand, Great Britain, Ireland, France, Italy, Khazakstan and Costa Rica.

of technical video clips featuring "how-to's" for common tasks with both AmaSeis and the AS1. These resources along with many other sets of documentation are freely available via the IRIS Seismographs in Schools website. IRIS E&O also supports users by providing technical consultations via email, phone, or in some cases personally to ensure that users' instruments are up and running when they are needed.

To keep pace with the growth of the program and to provide better service to the community, IRIS has recently rolled out a new website for the Seismographs in Schools program (http://www.iris.edu/hq/sis). This site has a number of new or enhanced functions that enable web resources to help teachers make use of seismic data and communicate with other educational seismology users. Important features of the website include tools to share data, curriculum ideas and links, background information on seismology and instruments, multiple options for teachers to ask questions and receive assistance, as well as a database storing station and contact information of participating teachers. Users can view near-real-time helicorder displays of other participating schools and obtain value-added "Event Reports" on earthquakes likely to be of particular interest to the community. In order to sustainably promote and maintain program participation and communication, the site features a discussion forum to encourage and support the growing global community of educational seismograph users. The forum allows teachers to share and discuss information and ideas with other teachers and scientists and allows technical questions to be answered in a public manner that can benefit multiple users. The community section also includes a "find a teacher" tool designed to allow users to contact nearby schools that also may be operating seismographs.

Finally, to enable teachers to easily use the seismographs and resultant data as an instructional element, the IRIS E&O program has encouraged and supported the development and testing of a core set of instructional resources. This core curriculum has been designed to guide students in their own inquiry, investigating what is recorded by their seismograph, and is currently being piloted in classrooms for broad dissemination. IRIS E&O envisions that this core curriculum will be accompanied by a set of supplemental resources, developed by the SIS community, to help teachers tailor their instruction to their particular setting and instructional needs.

Not only has this program impacted the classrooms of the teachers that received the instrument, but the testimonials of teachers, expressed both in print and on various national and regional list-servers, have significantly increased the Earth science teaching community's awareness of the excitement and value that a seismograph can add to the classroom. Schools often become the point of contact for the local media after local or major global earthquakes. For example after a felt earthquake in Illinois in 2008, a number of schools in Illinois and Indiana were featured with their seismic records in local news reports. As a result of this increase in perceived value, the SIS program is in the process of transitioning away from donating instruments to classrooms and is shifting its resources to enabling powerful learning experiences for students. A final 15 IRIS-supplied instruments will be distributed in the fall of 2009. In the future, teachers will be encouraged to purchase an instrument to join the network.

"It does not take a particularly complex seismograph to record earthquakes from across the globe... Thus, having their own seismograph in the classroom gives students a way of collecting real-world data and making measurements that provide them with an understanding of the interior structure of the Earth and processes by which the Earth changes."
Alan Kafka, Boston College

"In my 19 years of teaching science I have never had something as hands-on as the seismograph that has impacted my students."
Karen Urick, Erie Middle School, IL

"As I post the recordings the students get a good feel for how far away the events are. The kids recognize these seismograms as having a relatively small "P", a relatively larger "S", and no clear surface waves. These quakes are frequent and range in magnitude from 3.9 to 5.5. Those events from "across the big puddle" typically have a relatively large "P" no "S" and fairly obvious surface waves."
AJerry Cook, Phoenix Country Day School, AZ

"I was teaching an Earth Science class when the waves rolled in, providing another great learning moment, courtesy of the AS-1."
Ed Roberts, Pottsville

Web Resources and Interactive Software

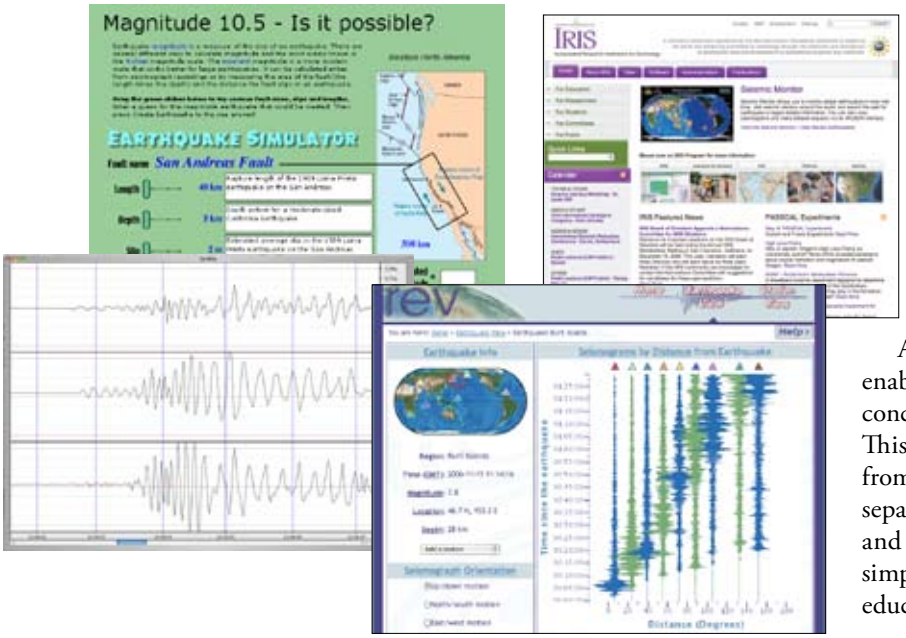
The IRIS website is the primary face of the consortium that IRIS E&O presents to both members of the consortium and the general public. That face was significantly updated in June of 2008, when a new version of the site was launched using content management system (CMS) technology. The new look is more professional while also encouraging the content of the site to remain fresh. The CMS allows this to occur by making it easy for IRIS staff to make updates and add new information. An image gallery section was also added to help educate the public about the activities of IRIS and to serve as a resource for educators and researchers seeking seismology related graphics and images to use in their presentations.

In addition to providing a face for the consortium, the IRIS website is the primary means of distributing educational and seismic data resources for consumption by both educational and general public audiences. Such resources include both timely information about recent seismological events and longer lasting information such as classroom activities and animations. With the growing trends toward digital mechanisms for archiving and conveying scientific information and education, IRIS E&O has continued to increase its development of resources in these areas with products ranging from training videos to seismic wave visualizations, web data viewers and school seismograph software. To handle this increase in materials, the resource area has been completely reorganized, and now allows users to search via audience and resource type.

E&O's web resources are anchored by the ever popular IRIS Seismic Monitor. The Seismic Monitor uses an attractive interface to display recent global seismicity as a set of circles that are color coded to show how recently earthquakes occurred

Highlights

- Updated with a new look and feel in June 2008
- Provides multiple audience-based paths to information and data
- 2,190,000 visitors to the IRIS web site in 2008, with the largest percentage of these viewing the Seismic Monitor.
- SeisMac, developed in collaboration with IRIS, allows every Mac laptop to act as a seismograph
- Waveform data available in three mouse clicks via the Rapid Earthquake Viewer (collaboration with Univ. South Carolina and DLESE)
- IRIS-supported software (Seismic Waves) allows users to visualize how seismic waves from their recording travel through the Earth to their station
- Over a dozen new animations on seismology topics are available in the Animation of the Month library



and scaled to indicate the magnitude of the event. This allows users to monitor the frequency and distribution of global earthquakes in near real-time, visit seismic stations around the world, and search the web for earthquake or region-related information. Designed to be intuitive and easily interpreted, millions of visitors each year reach the same conclusion as Daliwolf, a "YouTuber" who featured the Seismic Monitor in a video post that received over 5,000 views since August of 2007. "Wow! There are Earthquakes just everywhere! In Russia, in the ocean… I just find this fascinating and interesting."

Related to the display of event data in the Seismic Monitor, The IRIS DMS has released a new tool called the IRIS Earthquake Browser (IEB). The IEB uses a Google map-based interface that allows users to interrogate the IRIS event catalog. Users can intuitively specify a region of interest for their search as well as selecting the zoom level using familiar controls. Casual users can customize their searches by controlling the time, magnitude, and depth ranges of the search while more advanced search options may be turned on to meet the needs of the scientific community. Results of the search are displayed on the map for analysis, but can also be downloaded in a variety of formats for analysis. While not initially developed for an educational audience, the ease of use and intuitive interface lends itself to exploration by the educational community and the general public.

IRIS E&O, in collaboration with the University of South Carolina and DLESE, has also developed a web-based tool to make the waveform data, archived at the IRIS DMC, easily accessible to a non-technical audience. The Rapid Earthquake Viewer (REV) helps individuals get to waveforms recorded at a single station in three mouse clicks. To ensure its ease of use, REV is constructed using a interface that displays events using symbols patterned after the successful Seismic Monitor website; circles on the map are events and the size of the circles indicates the magnitude of the event while color indicates how recent it is. Waveforms are displayed both as record sections, useful for classroom activities exploring Earth structure, and as three-component station output, useful for traditional labs such as S-P location exercises. In addition to having an easy to use interface, REV also increases the ease of using waveform data by only providing data that pass certain quality control criteria. This significantly increases the likelihood that users will get data that is meaningful for use in an educational setting.

A suite of educational software designed to enable or facilitate learning of core seismology concepts also supplements IRIS's web offerings. This suite, developed by Alan Jones with support from the IRIS core funding, features three separate programs; AmaSeis, Seismic/Eruption, and Seismic Waves. AmaSeis is a recording and simple analysis software package for use with educational seismographs. Seismic/Eruption

allows users to watch how earthquake and volcanic activity change in space and time across the earth, while Seismic Waves allows users to explore how waves propagate from an earthquake hypocenter to seismic stations showing travel paths through the earth.

All programs are MS Windows only and are only minimally supported due to the retirement of their developer. Recognizing these limitations, IRIS has begun to develop strategies to develop the next generation of two of these programs. In the case of AmaSeis, IRIS E&O has been collaborating with faculty and students at Moravian College, an educational affiliate member of IRIS, to develop the next generation of AmaSeis. This version will be Java-based to support multiple computing platforms and will include a more modern user interface, and enhanced functionality to allow users to stream seismic data over the web despite the intensive firewalls common to many school settings. Such streaming capabilities will enable users to emulate a connection to a seismograph, thereby expanding the Seismographs in Schools program to include teachers not interested in the care and upkeep of a seismograph.

Much of the functionality of Seismic/Eruption has already been developed in the web-based IRIS Earthquake Browser (IEB) described previously in this section. While both allow a user to easily interrogate the earthquake catalogue, only Seismic/Eruption allows users to "play" the events through time. However, new advances in web-based programming suggest that this functionality could become available as early as next year.

IRIS/SSA Lectureship

There is a strong demand at informal learning institutions like science museums to provide local communities with direct contact with distinguished scientists. In 2003, IRIS and the Seismological Society of America (SSA) initiated the IRIS/SSA Distinguished Lecture Series to help meet this need. Two or three speakers are selected each year for the Lectureship from a pool of nominees generate from the E&O committee and the IRIS community as a whole. Selections are based on scientists' ability to convey both the excitement and the complexities of seismology to a general audience in a form that is engaging and enlightening. These lectures reach a broad sector of the public with an interest in science through venues that often have a well-established lecture series. In many cases, following the talk we receive requests from K-12 educators interested in receiving electronic versions of these lectures so that they may incorporate the information into their own classroom lectures. Beginning in 2009, we will proactively address such requests by working with the lecturers to ensure that their presentations are suitable for distribution via the web or CD-ROM. This will increase the reach of the series by making the talk available for use after the lecture and by groups (schools, etc) unable to attend a live lecture.

The impact of the Lectureship program is increased by having many venues arrange additional events in conjunction with the lectures, such as webcasts, radio interviews, teacher workshops, and IMAX films. In addition, the speakers frequently give a separate technical talk on their research at nearby university geoscience departments while they are in town.

Highlights

- 13 IRIS/SSA Distinguished Lecturers have given over 81 presentations to public audiences of up to 400 people per lecture at major museums and universities throughout the country.
- Average attendance is 165 per venue.
- 50% of venues felt attendance for the IRIS/SSA lecture was more than normal, while 42% felt it was about the same as normal.
- 83% of venues strongly agree that the audience was engaged with the speaker.
- All venues surveyed in 2007 described the lecture as a success and 83% were interested in having a lecturer for the coming season (the remaining were undecided until the topics were announced).
- Some lectures are available in electronic format via the web.

2009

Richard Aster:
Taking Earth's Pulse and Temperature Using Seismology: Roaring Oceans and Singing Icebergs

Aaron Velasco:
Can a Large Earthquake in Another Country Cause One in Your Backyard?

2008

Uri ten Brink: *Peace and Science in the Middle East*

Cliff Frohlich: *Deep Earthquakes and the Secrets of Seismology*

2007

Brian Atwater: *The Orphan Tsunami of 1700 - A Trans-Pacific Detective Story*

Anne Sheehan: *Seeing Beneath Mt. Everest: Probing a Breeding Ground of Destructive Earthquakes*

2006

Mary Lou Zoback: *The 1906 Earthquake – lessons learned, lessons forgotten, and looking forward*

Seth Stein: *Great Earthquakes*

Edward Garnero: *Vibrations from the Deep: Deciphering the Birth and Death of Earth's surface*

2005

Michael Wysession: *Earthquakes, Tsunamis and a Modern Journey to the Center of the Earth*

Susan Hough: *The Very Long Reach of Very Large Earthquakes*

2004

David Wald: *Rapid Earthquake Information: Citizen Science and the New Tools for Emergency Response*

David E. James: *Revealing the Mysteries of the Earth's Deep Interior: Plates, Plumes and the Birth of Modern Seismology*

2003

Walter Mooney: *The Discovery of the Earth: The Quest to Understand the Interior of the Planet*

Roger Bilham:
Death and Construction: Earthquakes on an Urban Planet

Experiences with the IRIS E&O Lecture

"**NOVA programs are great.** Interactive high-tech museum displays are very cool. Web-based teaching tools can be very instructive. However, there is still nothing that can take the place of contact with a knowledgeable human being, and that is why classroom teachers will not be replaced with computer screens and why the IRIS E&O Lectureship is so successful. I have been fortunate to be able to represent the seismological community in a series of about a dozen lectures that I have given at Science Centers and other venues across the country (e.g., Smithsonian Institution, Chicago Field Museum, National Science Teachers Convention, etc.).

Presenting the IRIS E&O Lecture has not only been an honor, but a tremendously rewarding experience. You never know what will be the inspiration that will cause someone to decide upon a field of study or research. And though there was nothing in my talk that someone couldn't have found with a little work in a library or over the internet, the excitement I felt from people as they participated in a personal exchange with me, as well as the enthusiasm of the email correspondences that followed, demonstrated that these kinds of lectures can be very influential for people of all ages, professions, and interests."

Michael Wysession,Washington University

Publications and General Outreach

IRIS produced its first educational poster ("Exploring the Earth Using Seismology") in 1998 and continues to give out thousands of copies of that poster each year. This poster utilizes real data to show how seismic waves from the 1994 Northridge earthquake propagated throughout the Earth, and is widely used by teachers to illustrate Earth science concepts, particularly the determination of Earth structure. IRIS has continued to develop new posters since then, on topics of general interest such as "History of Seismology", which highlights how the science of seismology has advanced through the efforts of individuals, or related to current events such as the 2004 Sumatra earthquake and the commemoration of the 1906 San Francisco earthquake (Century of Great Earthquakes). Recent posters have been aimed at high school and college students, and the full range of posters can be found at schools and universities throughout the world, as well as appearing as iconic Earth science images in popular media such as the movie *The Core*, and the television series *The O.C.*

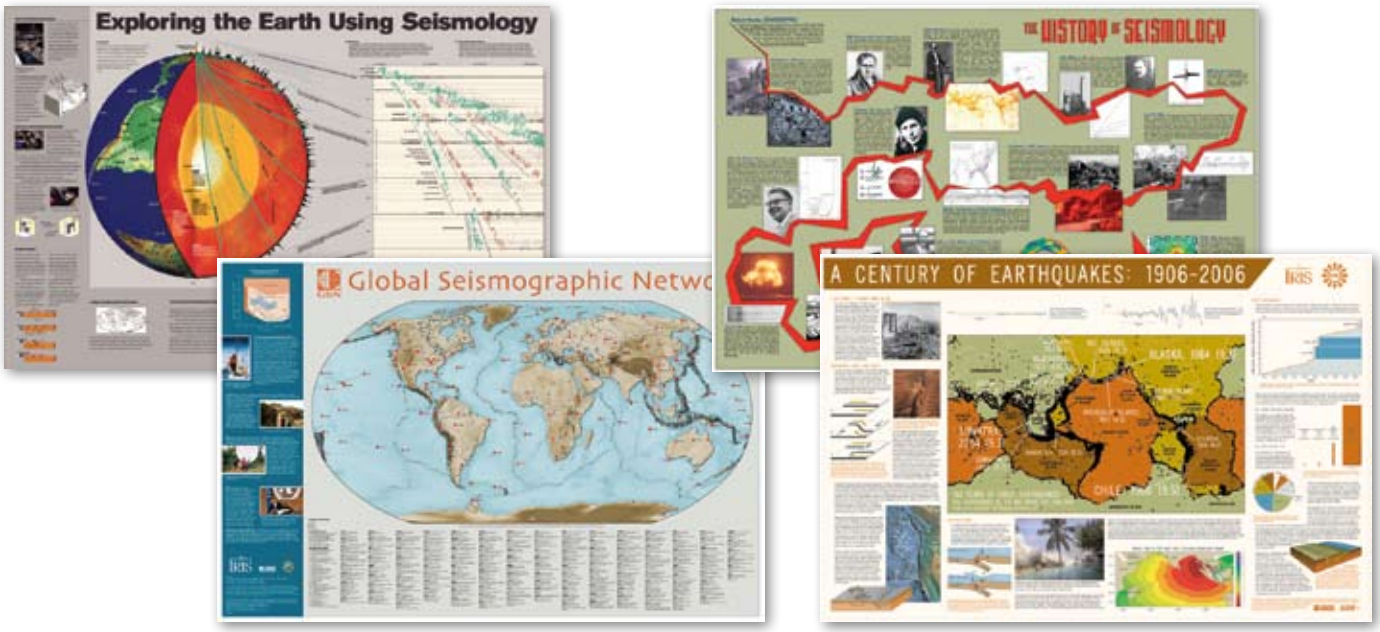
The posters are visually engaging, using appealing graphics and personal stories, and contain accurate cutting-edge scientific content. These posters are highly sought after by K-12 educators, who continue to line up at the IRIS booth at NSTA meetings to obtain copies. To maximize the effectiveness of future posters, we have recently conducted a case-study of the use of the posters in classroom to help determine how posters are used and what features of posters are most desired. We found that teachers use posters to contribute positively to the creation of a visually stimulating and content-related atmosphere. However, we have also concluded that our current posters have several design elements that limit their usefulness to directly support the instructional process. To improve the next generation of IRIS posters we are experimenting with novel approaches to science wall-posters that are informed by this study and are likely to expand their usefulness to teachers.

Highlights

- Five educational posters and seven "1-pagers" have been developed.
- Over 100,000 IRIS educational posters have been distributed to schools, colleges, and universities, including institutions in 22 different countries.
- Several of the posters and all of the 1-pagers are available in Spanish.
- Articles published in EOS, NSTA Science Teacher, The Earth Scientist, and Seismological Research Letters.

In addition, IRIS E&O creates "one-pagers" that provide clear and concise short summaries of fundamental aspects of seismology. Topics covered by the one-pagers include how earthquakes are located, using seismic waves to determine Earth structure, and how seismometers work. These one-pagers continue to be widely used and frequently requested by teachers.

While IRIS E&O will continue to supply paper materials because of the important role they play in several education and outreach venues, particularly school classrooms, we are

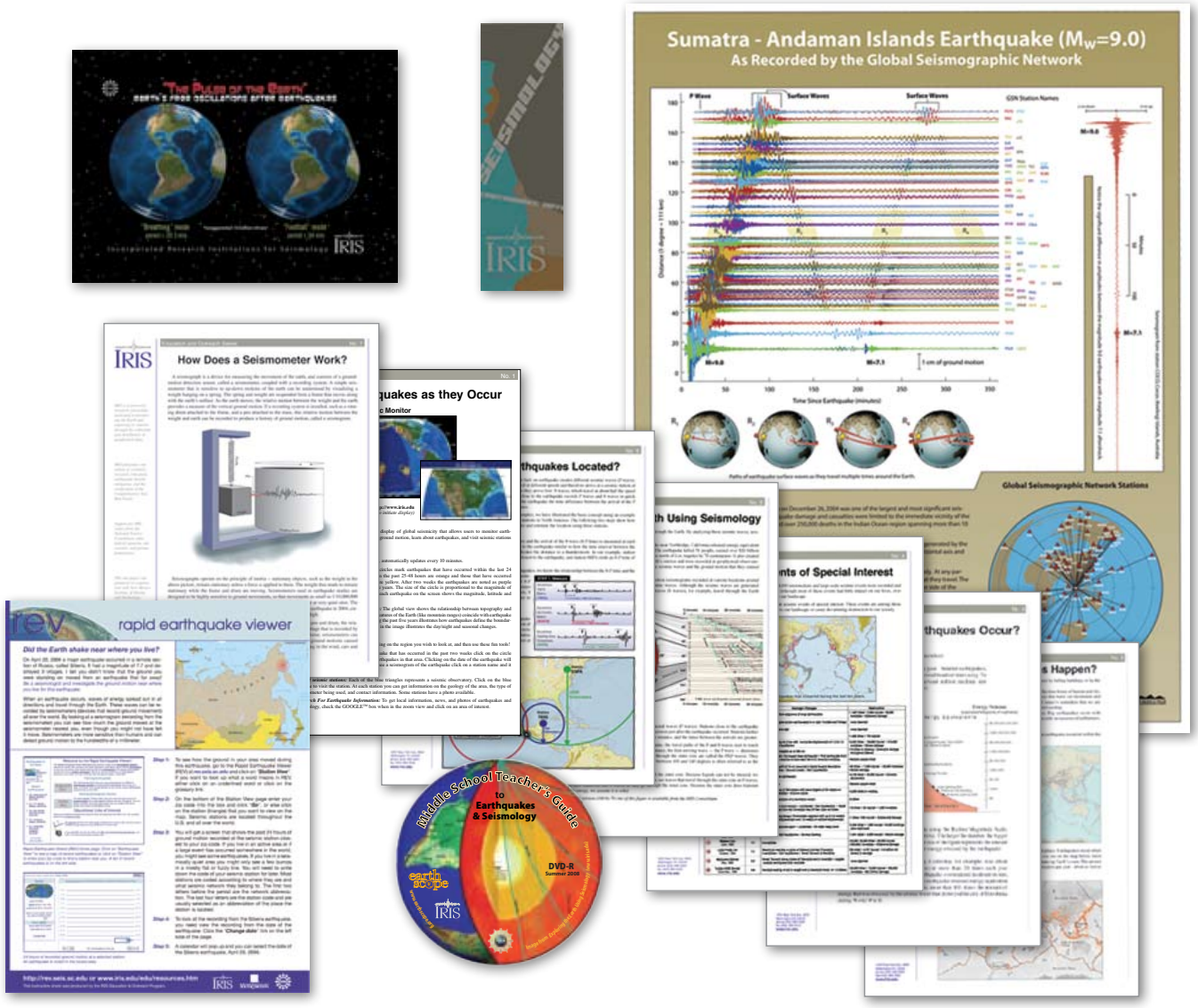


moving toward greater electronic distribution of materials such as videos, animations, and podcasts. An example is the new series of *Animations of the Month* that can be seen as the next generation of one-pagers. Materials are now also distributed via DVD, as with the "Earthquakes" DVD produced by Jenda Johnson in collaboration with EarthScope. This DVD is an organized collection of electronic earthquake education resources including both IRIS material (text, images, video, and animations) and high-quality activities from other sources.

IRIS E&O staff members have also been involved in writing articles published in geophysical and education journals. These publications explore a variety of geophysical education and outreach topics. These topics include descriptions of activities and models which can be used to teach seismology in classrooms such as using portable laptop-based computers as means of seismology instruction. E&O staff also frequently disseminate the results of their internal evaluations through conference papers, talks and posters at various geophysical and educational conferences. (See Appendix A)

As the public face of a scientific organization, the E&O Program also has a responsibility for general outreach to a broader community. In addition to the examples presented elsewhere in the text, IRIS engages in public and scientific events were appropriate, including:

- Booths at scientific and and educational meetings of the following organizations (in some cases shared with EarthScope and UNAVCO, and not all meetings are attended every year): National Science Teachers Association, Geological Society of America, American Geophysical Union, Association of Science-Technology Centers, National Society of Black Physicists, National Association of Black Geologists and Geophysicists, Society for Advancement of Chicanos and Native Americans in Science, California Science Teachers Association, Seismological Society of America.
- Temporary exhibits for the public including for example, Family Science Days organized by AAAS, AGU, NSF, and Celebra La Ciencia
- Annual visits from a local (nearly 100% African American) charter school.



Cooperation with Other Organizations

Additional audiences, far beyond those approachable solely by IRIS individual program efforts, are reached via collaboration with local, regional, and other national geoscience programs. Interactions range from single events of mutual interest to ongoing activities addressing key audiences. In addition, as IRIS E&O has become a well-respected program within the Earth science education community it has taken a role in the planning and/or development of new E&O programs for geoscience organizations that include NEES, UNAVCO, IODP, and EarthScope.

UNAVCO

The IRIS and UNAVCO E&O programs have worked very closely together on a number of activities since the inception of the UNAVCO program, with both independent and joint funding. A number of the collaborative projects are related to EarthScope E&O, where IRIS and UNAVCO are natural partners covering related geodetic and seismic topics relevant to the EarthScope facilities that they each operate. Joint ongoing EarthScope E&O activities are planned in conjunction with the EarthScope National Office that also has an important E&O component. IRIS-UNAVCO EarthScope E&O activities include teacher workshops, Active Earth displays, the creation and distribution of EarthScope materials, and shared booths at national meetings. Another important partnership is the Research Experience in Solid Earth Science for Students (RESESS) program that is focused on providing a supportive summer research environment for underrepresented minorities. RESESS allows students to transition from research within a small student community to involvement with scientists throughout the US. The program is led by UNAVCO, and in the past IRIS has assisted through the sharing of student applications and research mentors between the programs so that the best match is found for students and hosts. IRIS is now a co-PI on a RESESS renewal proposal which will provide even greater integration of the programs and opportunities for students. IRIS and UNAVCO have also co-sponsored Earth science field trips for students at the annual SACNAS meeting (Society for the Advancement of Chicanos and Native Americans in Science) to introduce additional students to geoscience.

EarthScope

There are two interrelated parts of the IRIS contribution to EarthScope E&O. The first, as partially described above, has been more focused on education and is a collaborative effort among IRIS, UNAVCO, and now the EarthScope National Office (ESNO, based at Oregon State University). Oversight is provided by the EarthScope E&O Steering Committee, and each of the three organizations takes lead responsibility for different aspects of the program. For example, UNAVCO has led the organization of teacher workshops, ESNO is responsible for the Speaker Series, and IRIS has led development of the Cascadia Active Earth Display. EarthScope and IRIS activities are closely related with the structure and experience of IRIS E&O being leveraged for EarthScope E&O activities. The Active Earth Display is an example of this where the software "engine" was developed primarily via IRIS E&O funding while much of the Cascadia module was funded via EarthScope E&O.

The second major E&O contribution to EarthScope is through USArray Siting Outreach, which is designed to support

the construction and operation of the USArray facility. The two key elements of this effort have been the engagement of undergraduate and graduate students in the reconnaissance of Transportable Array seismograph sites, and the development and editing of *onSite*, a quarterly newsletter for landowners (originally shared with UNAVCO and now the responsibility of the EarthScope National Office). Over 2000 sites will be needed across the continental United States by 2013 for the Transportable Array and students have been responsible for the majority of them: 72 students from 19 universities have so far identified over 670 sites in 15 western and Midwestern states.

National Earth Science Teachers Association

The IRIS E&O Program guest edited and funded an issue of the National Earth Science Teachers Association (NESTA) journal *The Earth Scientist* in 2005. The partnership produced a Seismology/IRIS-focused issue of the journal that closely followed the great Sumatra-Andaman Islands Earthquake of 2004. This publication was designed to keep Earth science teachers abreast of relevant scientific and pedagogical research in seismology as well as serving as a place to share practical instructional strategies for the Earth science classroom. At that time *The Earth Scientist* had a regular distribution of 1100 members and was printed as a black and white newsletter containing many reprinted articles. IRIS and NESTA staff saw the collaboration as an opportunity to create a new face for the organization. The IRIS special issues featured full color on glossy pages, all original manuscripts recruited from within the IRIS community and featured a pull-out seismology poster. The issue greatly increased NESTA visibility, and was followed by an increase in membership of over 10%. As a result the partnership created a new model for NESTA to work with other professional associations to publish subsequent themed issues while maintaining the new more professional look and feel of the journal.

U.S. Geological Survey

The large museum display has been a joint project with the USGS Albuquerque Seismological Laboratory since the inception of the display. The USGS provides event location and live ground motion data via the Internet, as well as technical support for the display hardware, particularly the triple-drum recorders. In other areas, IRIS works to supplement the information that the USGS provides via its website and USGS staff have served on the IRIS E&O Standing Committee to foster cooperation between the organizations.

Seismological Society of America

The IRIS/SSA Distinguished Lectureship was initiated as a joint project between IRIS and SSA. Nominations are solicited through both organizations and speakers are recommended via a nominating committee comprised of representatives from IRIS and SSA. Each year's speakers are approved by the governing boards of the both organizations and both groups actively promote the speakers.

American Institute of Physics

IRIS is a partner in the Discoveries and Breakthroughs Inside Science (DBIS) program that provides accurate science, technology, engineering, and mathematical news in an easily understood, visual format to the millions who watch local TV news on a daily basis. The goal of DBIS is to increase the public's awareness and appreciation of the role of science and technology in society. It does this via the production of twelve 90-second TV reports a month (a total of 144 reports a year) with rich visuals and diverse science, technology, engineering, and mathematics (STEM) representatives. Syndicated to local TV news stations across the USA, DBIS also has a Spanish language version and a Website component. Through nearly 140 US news station subscribers, there are over 47 million audience views per month on television, 276,000 view per month via Web portals such as Science Daily, and 322,000 streams of DBIS news from viewers visiting local news Websites. IRIS is one of 23 STEM partner societies and organizations. IRIS provides ideas and potential contacts for stories, as well as reviews of the content. In the past year, an estimated 11 million households may have viewed the 5 segments related to seismology that were produced.

Earth Science Literacy Initiative

Based on IRIS E&O's standing in the community, NSF asked IRIS to lead the creation of a document outlining the key concepts in Earth science that a literate public should know, building on similar successful projects in the Ocean, Atmospheric and Climate science communities. Active involvement of the research community was considered a key element of the process and Michael Wysession, as chair of the IRIS E&O Standing Committee, agreed to chair the initiative. He led two successful workshops; first an online community workshop for 150 invited scientist participants and 200 scientist and educator observers, and then a writing workshop for 35 scientists and educators from academia, K-12, and representative agencies. The last of two open review periods has just ended and the document outlining the Big Ideas and supporting concepts of Earth science will soon be published (http://www.earthscienceliteracy.org/).

Educational Affiliates

In 2001, IRIS established a new Educational Affiliate membership category for institutions that teach seismology and other Earth sciences but do not necessarily share the professional research interests of the traditional consortium members. The objective of this membership category is to cultivate a base of institutions committed to excellence in geoscience education through the co-development of E&O activities designed to address their needs. By becoming an EA member of IRIS, institutions gain entrance into a community of educators that is closely connected to the excitement and cutting-edge results of the research community. EA members pursue their common interests and goals within the IRIS community, and enjoy benefits such as discounts on seismometers and access and input to special E&O programs. The first Educational Affiliate members were accepted in 2002 and the total has grown to 17. (See Appendix B) These members are assisting IRIS in developing E&O activities to address their classroom and research needs. One of the successful programs has been the Sabbatical in Seismology where travel funds were provided to an Educational Affiliate faculty member and an undergraduate to conduct research at an IRIS institution. Educational Affiliate members have also been sponsored to attend the annual (now bi-annual) IRIS workshop.

Other IRIS Programs — The Data Management System (DMS) and PASSCAL

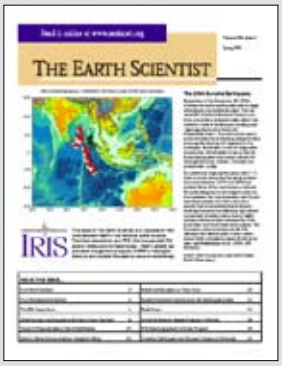
The E&O Program coordinates with the other core IRIS programs in a number of ways. The DMS and E&O originally shared a software engineer who now works full time for E&O but is still based at the Data Management Center. This helps ensure a coordination of software developed by each of the programs. The DMS focuses on software for the research community and E&O is primarily concerned about applications for educational and general public use, but there is overlap in the audiences for products of both groups.

The PASSCAL instrument center is the host for the annual REU Internship Program orientation, providing facilities, equipment, and staff during the week. A graduate student is also supported each summer by PASSCAL to acquire detailed knowledge of many aspects of seismographic instrumentation and data collection and this student typically takes part in the orientation week. PASSCAL provides multi-channel cabled seismic systems for shallow refraction and reflection experiments, and these systems are used frequently by universities for student field experiments.

Other Examples

- Undergraduate engineering – IRIS partnered with the Colorado School of Mines (CSM) and the USGS to expose the 2002 CSM freshman engineering class to geophysical instrument design. A group of 350 students worked to design inexpensive seismic recording systems for use in educational environments as part of the Engineering Practices Introductory Course Sequence.
- Earth Science education community support – IRIS organized the Coalition for Earth Science Education mega-booth for three years at NSTA (over 90 ft of booth space). This provides the opportunity for smaller Earth Science organizations to exhibit at NSTA and ensures that there is a common area for Earth science at the meeting.
- Joint workshops – Southern California Earthquake Center, Geological Society of America, UC San Diego, National Oceanic and Atmospheric Administration
- Joint Products – IRIS provided activities for a GSA educational CD.
- Support for other programs -
- Provided content for the SCEC Electronic Encyclopedia of Earthquakes.
- Providing materials annually to AGI for their Earth Science week packets (16,000 distributed in 2008). Submissions have included posters, 1-pagers, postcard animations, and an annual activity in the ESW calendar.
- Providing data and expertise for the *Musical Plates* online curriculum developed by the Center for Innovation in Engineering and Science Education at the Stevens Institute of Technology.

The IRIS Education Program in Support of the National Earth Science Teachers Association



"The IRIS Education Program has assisted the National Earth Science Teachers Association (NESTA) through several efforts, most notably in the cooperative work to develop and publish the Spring 2005 issue of The Earth Scientist, NESTA's quarterly journal. With assistance and funding from the IRIS Education Program the Spring 2005 issue featured the first color cover in the journal's history… Throughout these ventures with NESTA the IRIS Education Program has provided support with a "can do" attitude and enthusiasm. This support has enhanced NESTA programs and provides for a richer experience for NESTA members. NESTA looks forward to a continued relationship with the IRIS Education Program."

M. Frank Ireton, NESTA

Management, Evaluation, and Oversight

The IRIS E&O Program operates through a combination of permanent staff, consultants, small sub-awards and the volunteer efforts of the IRIS community. A total of 4.5 FTE are currently budgeted under the cooperative agreement though part of one position is temporarily being filled by a part-time consultant. Some staff members are also shared with EarthScope E&O, USArray Siting Outreach, and IRIS headquarters. The current E&O staff members include:

John Taber - E&O Program Manager

Michael Hubenthal - Education Specialist

Patrick McQuillan - E&O specialist (50% E&O, 50% EarthScope E&O)

Russ Welti - Software Engineer

Matt Toigo - Web Developer (50% E&O, 50% IRIS headquarters)

Tammy Bravo - E&O specialist (50% E&O, currently a half time consultant).

IRIS E&O works closely with Perle Dorr who is funded partially via EarthScope/USArray Siting Outreach and also makes use of support staff at IRIS headquarters including Rick Callender, media and graphics specialist, and Mary Baranowski, meeting planner.

Part-time consultants have been and continue to be engaged for a number of tasks including developing and maintaining software (Alan Jones - Seismic Eruption, Seismic Waves, AmaSeis, EqLocate; Dan Griscom - SeisMac), developing animations, videos and a DVD (Jenda Johnson, with EarthScope funding), and providing support for the Seismographs in Schools program (John Lahr, Kay Wyatt). The involvement of consultants has been very cost effective for the program as it provides access to expertise not available within the E&O staff and allows specific projects to be completed without the need to hire additional staff. In addition, several of the consultants also donate time to the program.

Michael Hubenthal with teachers.

John Taber teaching a workshop.

The E&O Program is spatially distributed with staff located at the IRIS DMC in Seattle, at the University of Binghamton, and at IRIS headquarters in Washington, DC. While this presents some challenges, it also provides valuable interaction with other groups. Coordination of activities is achieved via twice monthly conference calls and regular electronic interaction between staff members.

The E&O Program Manager is responsible for the overall E&O Program, including the development of budgets, managing sub-awards and consultant contracts, scheduling decisions, review of materials, and the tracking of expenditures. EarthScope E&O and USArray Siting Outreach awards and activities are closely integrated with IRIS E&O and are coordinated by the IRIS E&O Program Manager. Coordination of activities within the E&O Program is divided between the E&O staff members. For example, Michael Hubenthal coordinates summer internships, professional development, seismographs in schools (along with Tammy Bravo) and Educational Affiliates, Patrick McQuillan coordinates museum displays, distinguished lectures, and publications, Matt Toigo is in charge of the Web site and Web applications, and Russ Welti is in charge of the Active Earth Display software and other online software and data access.

Patrick McQuillan

As described in the introduction of this document, the IRIS E&O program was founded on the broad vision for seismology education set forth by a collection of IRIS community members in the "Making Waves" program plan. In its executive summary, the

Russ Welti

document explicitly mentions the value of an on-going assessment plan to measure the impact of the work of the IRIS E&O program. However, specifics for assessing the program were not included in the document. In 2003, the IRIS E&O program adopted a quality based continuous improvement strategy that provided structure to the management of the program and filled the assessment void in the program plan.

The implementation of this strategy began by extracting the mission and goals from the text of the program plan and connecting them to the vision for change the program hoped to affect. Next, the elements of the E&O program "tested" to see if they created an alignment between the goals of the program, and the change hoped for in the program plan. This process of aligning provided clarity of purpose and made the direction for future developments to each element clearer. In addition to showing how existing elements fit together, the exercise also highlighted where gaps existed in the E&O program offerings.

The adoption of a continuous improvement strategy required embracing the regular collection of data to inform future decisions as well as creating definitions of success for our own efforts. Such efforts serve as the basis for making programmatic changes to ensure the most effective use of both time and financial resources. As a result all IRIS E&O programs are enabled to continuously improve over time. Data are collected through a combination of regular internal assessments and supplemented by occasional external assessments used to validate conclusions from our internal assessments. Given the on-going nature of the vast majority of our program elements, the finite resources available for evaluation, and the E&O Program's mandate to implement education and outreach rather than conduct educational research, the majority of these assessments have largely been formative in nature.

Examples of the type of assessment data we have collected and used to drive the continuous improvement of our programs include:

- Website statistics
- Quantities of materials distributed
- Number of participants
- Participant attributes and perceptions
- Follow-up surveys and interviews.

We collect assessment data for all new activities and continue to collect assessment data for ongoing activities where new data may be of use in improving the activity.

In addition to informing IRIS E&O staff's day-to-day activities, summative and formative assessment data are reported to the IRIS E&O Standing Committee. (See Appendix C) This oversight body, comprised of members of the seismology and geoscience education communities, meets twice each year to review the elements of the E&O Program, provide regular guidance to the running of the key elements of the program, recommend improvements and additions to the program, and to approve the annual budget. This committee, through its chairman, then reports to the IRIS Board of Directors. Overall budget levels and final budget approval are provided by the Board of Directors. The E&O Standing Committee is also involved in the implementation of the program through review of publications, assistance with workshops, providing material for the Web site, serving on the internship selection panel, and acting as instructors at the intern orientation.

Matt Toigo

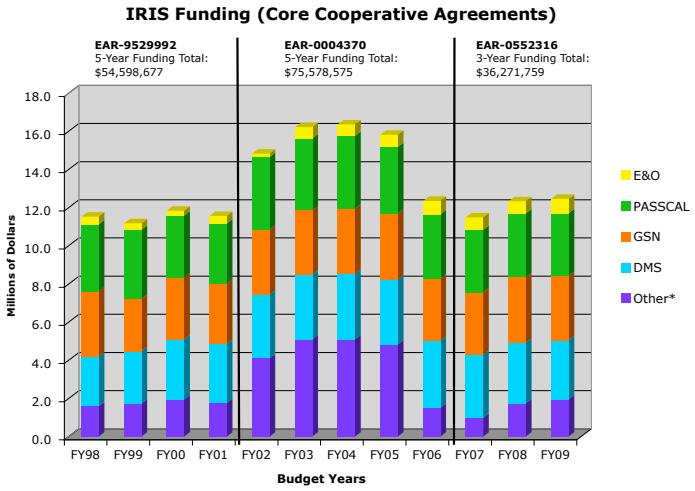
Tammy Bravo

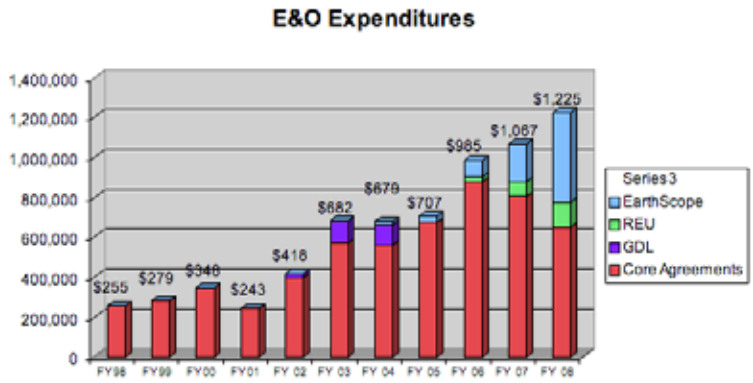
Budget

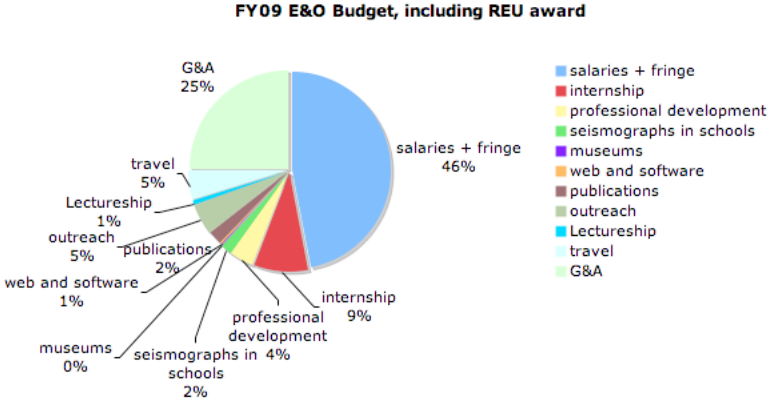
The primary source of E&O core funding has been through the 5-year Cooperative Agreements between IRIS and NSF. The top figure shows the overall IRIS core funding budgets over the past 10 years (not including EarthScope). The E&O portion of the budget has varied from about 2.5 to 6.5% over that time. The spending history of the program, including EarthScope, the REU award, and an earlier Geophysical Data Library award is shown in the next figure. The increase over time is due to both the increase in funding from the Cooperative Agreement as well as other NSF sources. This figure includes sub-awards to community members and other organizations, the largest of which have gone to University of South Carolina, UNAVCO, Indiana University, and Boston College. Sub-awards to Consortium members have been used in a number of ways to involve the community and to implement particular projects more quickly. Projects have included development of the Global Earthquake Explorer and the Rapid Earthquake Viewer, coordination of seismographs in schools among different groups, development of an AS1 seismograph online curriculum, seed money awards to create seismology education modules, and collaborative EarthScope E&O activities.

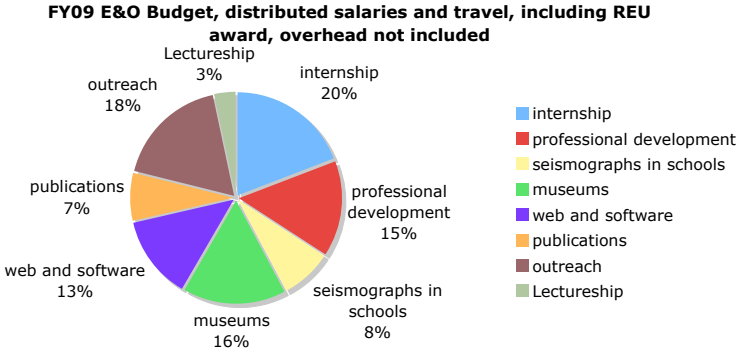
The lower two plots show the distribution of funds for the current year's budget, including the REU award but not EarthScope. The first shows the budget line items, and it can be seen that salaries are nearly 50% of the total budget, with participant support for interns, professional development, and travel being the next highest categories.

The last plot shows the approximate percentage of the budget planned for each activity, including salaries. Internships are again the largest category, followed by outreach, which includes the cost of booths at meetings such as AGU, GSA, and NSTA, and our participation in the production of short TV videos by AIP's *Discoveries and Breakthroughs Inside Science*. Professional Development includes the creation of new activities as well as the running of workshops. The museum budget is primarily for salaries related to the creation and maintenance of the Active Earth Display software and content.









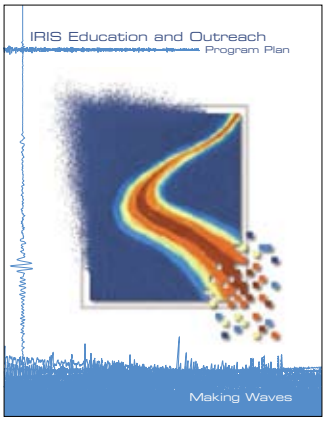
E&O Timeline

1996 Development of the Seismic Monitor web display

1997 E&O committee formed
IRIS/USGS Traveling museum exhibit completed
First three educational one-pagers published
First "Teaching the Seismologists to Teach the Teachers" workshop

1998 First E&O program manager hired
E&O program planning workshop
First teacher workshop at annual NSTA meeting
Exploring the Earth poster (Northridge earthquake) published
First 3 undergraduate summer interns

1999 First undergraduate faculty workshop at annual GSA meeting
Museum displays installed at the American Museum of Natural History in New York and the Carnegie Museum of Natural History in Pittsburgh



2000 AS1 school seismograph program initiated
New museum display installed at New Mexico Museum of Natural History

2001 Educational Affiliate membership category approved by Board of Directors
Educational 1-pagers translated into Spanish

2002 Education and Outreach Program Plan published
First three Educational Affiliate members

2003 First 2 IRIS/SSA Distinguished lecturers speak at venues throughout US
50th AS1 seismograph distributed to a school
IRIS/USGS exhibit installed at the Smithsonian Institution Museum of Natural History

2004 1st AS1 training workshop
1st Active Earth displays installed Sunset Crater Volcano National Monument and Bruce museum of Arts and Science
Large museum display installed in the Hall of Planet Earth at the American Museum of Natural History

2005 1st Sabbatical in Seismology completed
Rapid Earthquake Viewer released (joint project with University of South Carolina and DLESE)
1st Yuma district-wide workshop

2006 1st summer intern orientation week
Active Earth Display installed at South Pole Station
1st AfricaArray workshop held at North Caroline A&T

2007 150th AS1 distributed to a school
1st Active Earth display kiosk
SeisMac released

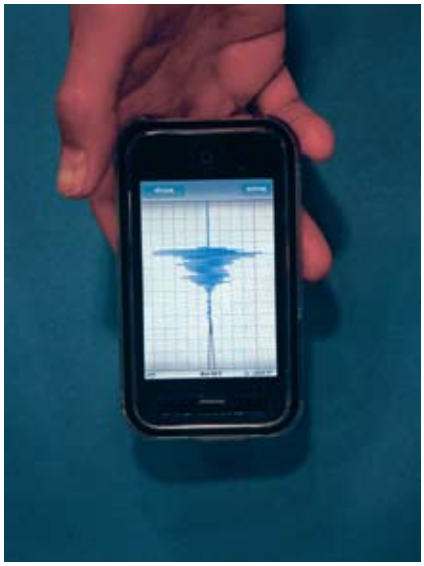
2008 Seismographs in Schools online database launched (transferred from SpiNet)
New IRIS Web pages launched

Future Directions

"Education" and "Outreach" are moving targets. New opportunities are consistently arising, as are the technologies that facilitate them. The IRIS E&O Program is mindful of the ever-changing possibilities for growth, while keeping in mind its strengths and foundations within the IRIS seismology research community. The E&O Program has historically focused more on middle school and high school audiences because of the great need for resources at those levels and the importance of capturing the imagination of students before they lose interest in science. However, with the growing IRIS Educational Affiliates membership, IRIS E&O has the opportunity to use its university linkages to engage an extensive educational community, with a broad scientific base, that can impact future practitioners in both research and education. Because of the importance of engaging undergraduates in real data analysis and providing them with current research examples, the E&O Program has begun to plan for a shift in focus towards undergraduate education. This has included two recent hires (one still part-time) with appropriate experience and content knowledge. This shift will allow us to leverage the talent and resources that are already available within the Consortium membership, and to make those resources available to a wider audience.

Examples of this shift are the creation of PowerPoint presentations highlighting recent seismology-related events and the sharing of labs from the REU Internship summer orientation that can be used in undergraduate classrooms. The Science Education Resource Center at Carleton College is interested in adding our current and future materials to their already established set of online undergraduate geophysics resources. We are exploring distance-learning opportunities with several universities and are beginning conversations with oil exploration industry representatives who have a critical need to increase geoscience majors in the coming decades. To reach larger audiences with our professional development, and accommodate the limited time of instructors, will require more short video segments and podcasts with supporting activities and fewer in-person workshops. We will need to evaluate and, if appropriate, adapt efficiently to new methods of information dissemination as they continue to become available, whether it be iPhone, twitter, or Second Life. IRIS E&O is also aware of the need to reach a diversity of audiences, and is constantly working toward finding additional mechanisms for reaching minority and international audiences.

As IRIS enters its 25th year, all of the Consortium's programs are reviewing their goals and core services, and exploring ways in which leveraged support, external to NSF's Earth Science Division, might be used to expand these activities, while remaining faithful to the Consortium's core mission. With stable support and strong encouragement from EAR's Instrumentation and Facilities Program, the Education and Outreach Program has been able to establish a focused framework of activities and services that serve the missions of NSF and IRIS in advancing education, and forging strong links between national and international research and educational communities. The E&O Program seeks to strengthen the existing activities and extend their reach, and evolve new activities that build on emerging opportunities, but additional resources must be found if the high quality of the current activities is to be maintained. The future directions of the E&O program will be strongly influenced by the outcome of the current review process, in concert with advice from NSF and guidance from the IRIS Board of Directors.



Appendix A

Publications and Conference Abstracts by IRIS E&O staff: 2002-2009

Publications

- Gao, S., Niemi, T., Black, R., Liu, K., Anderson, R., Joeckel, R., Busby, R., Taber, J. (2008) Rationale for a permanent seismic network in the U. S. Central Plains utilizing US Array. *Eos, Transactions, AGU 89*, no. 9: 85.
- Hubenthal, M., Braile, L., Taber, J. (2008) Redefining earthquakes & the earthquake machine. *The Science Teacher, 75*(1), 32-36.
- Hubenthal, M. (2008) Connecting students to seismic waves. *The Science Teacher, 75*(1), 69.
- Wysession, M., Hubenthal, M., Taber, J., (2008) Using SeisMac to Turn Your Laptop into a Seismograph for Teaching. *Seismological Research Letters, 79*(5), 723.
- Hubenthal, M., Bleacher, L. (2007) AS-1 operators workshop: Providing a foundation for school seismograph use. *IRIS Newsletter, Issue 1*, 8-9.
- Hubenthal, M., Aster, R. (2006) The IRIS undergraduate internship program gets "Orientated" with new funding from NSF. *IRIS Newsletter*. Issue 3.
- Hubenthal, M. (2006) BOSS Lite; A discrepant event demonstration for the Earth Science classroom. *The Earth Scientist*, 22 (2) 12-16.
- Smith, M., Taber, J., & Hubenthal, M. (2006) Public Appeal of Real Time Seismic Information in Science Museums. *Eos Trans. AGU, 87*(8), 85.
- Hubenthal, M. (Ed.) (2005) Seismology and Seismology Education – Special Issue. *The Earth Scientist* 21(2).
- Hubenthal, M., Boyd, T., Lahr, J., Taber, J., (2003) Undergraduate Engineering Students Investigate Inexpensive Seismometer Design. *Eos Transactions AGU, Vol. 84, no. 18*, Page 166, 2003.
- Hamburger, M., and J. Taber, (2004), Focusing on seismology education, *EOS, Trans. AGU, 85, no. 12*, 116.
- Braile, L., Hall-Wallace, M., Aster, R., Taber, J. (2003), The IRIS Education and Outreach Program, *Seismological Research Letters, 74*, 503-510.
- Hamburger, Michael W.; Taber, John. (2003) Toward Integration of Educational Seismology Programs: The U.S. Educational Seismology Network. *Seismological Research Letters, 74*(5), 603-604.
- Hennet, C., G. van der Vink, J. Taber, and R. Hutt, (2003), Earthquakes and Museums, *Seismological Research Letters, 74*, 628-634.

Conference Abstracts

- Hubenthal, M. (2009) Wallpaper or instructional aids: A preliminary case study of science teachers' perceptions and use of wall-posters in the classroom. *Paper accepted to the National Association of Research in Science Teaching Meeting.*
- Hubenthal, M., Taber, J., Dorr, P., Woodward, R. (2009) Attracting and encouraging future geophysicists through IRIS undergraduate research experiences and EarthScope/USArray siting, oral presentation at IASPEI meeting, Capetown, South Africa, January 2009.
- Wysession, M., LaDue, N., Budd, D., Campbell, K. Conklin, M. Lewis., G., Raynolds, R., Ridky, R., Ross, R., Taber, J, Tewksburry, B., Tuddenham, P. (2008) Earth Science Literacy: Building Community Consensus, *Eos Trans. AGU, 88*(52), Fall Meet. Suppl., Abstract ED13D-03.
- LaDue, N., Wysession, M., Budd, D., Campbell, K. Conklin, M. Lewis., G., Raynolds, R., Ridky, R., Ross, R., Taber, J, Tewksburry, B., Tuddenham, P. (2008) Earth Science Literacy: Big Ideas and Supporting Concepts, *Eos Trans. AGU, 88*(52), Fall Meet. Suppl., Abstract ED21A-0601.
- Wysession, M., Taber, J., Budd, D., Campbell, K. Conklin, M. Lewis., G., Raynolds, R., Ridky, R., Ross, R., Tewksburry, B., (2008) Developing a Framework for Earth Science Literacy II: Big Ideas and Supporting Concepts, oral presentation at GSA annual meeting, Houston, Texas, October 2008.
- Hubenthal, M., Stedman, L., and Taber, J. (2008) Wallpaper or Instructional Aids: Teacher's Perceptions and Use of Science Wall-Posters Produced by the Science

Community, oral presentation at GSA annual meeting, Houston, Texas, October 2008.

- Wysession M., Taber, J. (2008) Using SeisMac to teach fundamental seismology. SSA 2008; abstracts of the annual meeting. Seismological Research Letters. 79, no. 2 (200804): 331.
- Busby, R., Dorr, P., Taber, J. (2007) Opportunities for participating in Earthscope's transportable array. *Seventy-ninth annual meeting of the Eastern Section of the Seismological Society of America; abstracts Seismological Research Letters 79*, no. 1 (200802): 138.
- Dorr, P., R. Busby, M. Mercurio, and J. Taber, 2007, *Site Reconnaissance and Outreach Activities for the Transportable Array*, poster presentation at the EarthScope National Meeting, March 27-30, 2007.
- Hubenthal, M., Taber, J., Aster, R., (2007) IRIS Undergraduate Internship Program and Orientation Enters its Second Year, EarthScope National Meeting abstract.
- Hubenthal, M., Taber, J., Wysession, M. (2007) Conceptualizing the Abstractions of Earthquakes Through an Instructional Sequence Using SeisMac and the Rapid Earthquake Viewer. *Eos Trans. AGU, 88*(52), Fall Meet. Suppl., Abstract ED51C-03.
- Hubenthal, M., Aster, R., Frassetto, A. (2007) Developing virtual REU cohorts: Reflections from the IRIS Undergraduate Internship Program. *EOS Trans. AGU 88(*52), Fall Meet. Suppl., Abstract ED33B-1226.
- Johnson, J., J. C. Lahr, and R. Butler, (2007) An Educator's Resource Guide to Earthquakes and Seismology, *EOS Trans. AGU 88*(52), Fall Meet. Suppl., Abstract ED31B-04.
- Taber, J. L. Braile and L. Bleacher, (2007), *IRIS Seismographs in Schools Program*, oral presentation at IUGG meeting, Perugia, Italy, July, 2007.
- Wilson, T J, Carroll, K, Eriksson, S, Konfal, S, Mayer, H, Reading, A, Stutz, J, Taber, J, Willis, M, Education and Outreach Initiatives for the POLENET Project for IPY, *EOS Trans. AGU 88*(52), Fall Meet. Suppl., Abstract ED12A-02.
- Dorr, P R. Busby, M. Mercurio and J. Taber, (2006) Engaging Students in USArray Site Reconnaissance Activities, GSA fall meeting abstract.
- Eriksson, S C, Wilson, T J, Anandakrishnan, S, Aster, R C, Johns, B, Anderson, K, Taber, J. (2006) Disseminated Museum Displays and Participation of Students from Underrepresented Populations in Polar Research: Education and Outreach for Joint Projects in GPS and Seismology Solid Earth Science Community, *Eos Trans. AGU, 87*(52), Fall Meet. Suppl., Abstract ED23B-1250.
- Hubenthal, M. (2006) Stretching ourselves beyond simply running workshops: An integrated model of professional development. GSA Annual Meeting, Paper No. 99-6
- Hubenthal, M., Loos, C., Taber, J. (2006) Using web-based tools for community interaction: The IRIS summer internship program. Poster presented at Annual IRIS Workshop, Tucson, AZ.
- Welti, R. J. Taber, G. Levy and C. Loos, (2006) Web-based, real time data for museum and visitor centers, Poster presented at Annual IRIS Workshop, Tucson, AZ.
- Barker, J., Jones, A., Hubenthal, M. (2005) Student-centered Experiments on Earthquake Occurrence Using the Seismic/Eruption Program *Eos Trans. AGU, 86*(52), Fall Meet. Suppl., Abstract ED52A-07.
- Taber, J., Smith, M. Welti, R. Hubenthal, M. (2005) Real-time Earthquake Displays for Museum and Visitor Centers, oral presentation at IASPEI meeting, Santiago, Chile, October 2005.
- Ingate, S., Ahern, T., Butler, R., Fowler, J., Taber, J. (2005) EarthScope and USArray; the first eighteen months and the year ahead. *Abstracts of the annual meeting, Seismological Research Letters 76*, no. 2 (200504): 228.
- Hamburger, M., Pavlis, G., Taber, J. (2004) The U.S. Educational Seismology Network (USESN). *Eos, Transactions, AGU 85*, no. 47, Fall Meet. Suppl., Abstract ED32A-01.
- Hubenthal, M., Braile, L., Taber, J. (2004). Assessing the IRIS Professional Development Model: Impact Beyond the Workshop. New Member Round Table Presented at Association for Educators of Teachers of Science (AETS) Annual International Conference, Nashville, TN.
- Hubenthal, M., Taber, J., Aster, R., Schwartz, S. (2004). Inputs to the Seismology Student Pipeline: The IRIS Undergraduate Internship Program. Poster presented at Annual IRIS Workshop, Tucson, AZ.
- Ingate, S. Ahern, T., Butler, R., Fowler, J., Taber, J. (2004) EarthScope and USArray; the first six months and the year ahead. *Abstracts of the annual meeting, Seismological Research Letters 75*, no. 2 (200404): 263.

- Levy, G., Braile, L., Taber, J., Lahr, J. (2004) AS1 seismographs in the classroom. *Eos, Transactions, AGU 85*, no. 47, Fall Meet. Suppl., Abstract ED32A-04.
- Smith, M., Taber, J., Hubenthal, M. (2004) Providing Seismic Data to the Public: Evaluation and Impact of IRIS/USGS Museum Displays. *Eos Trans. AGU* Fall Meeting Suppl., Abstract S137491.
- Hall-Wallace, M., Boyd, T., Richard, G., Ellins, K., Meertens, C., Semken, S., Taber, J., Benthien, M., Wald, L., Marvinney, R. (2003) Building a collaborative and distributed E&O program for EarthScope. *Eos, Transactions, AGU 84*, no. 46, Fall Meet. Suppl., Abstract ED32E-04.
- Hubenthal, M., Braile, L., Taber, J. (2003) Assessing the IRIS Professional Development Model: Impact Beyond the Workshop. *Eos Trans. AGU, 84*(46), Fall Meet. Suppl., Abstract ED21C-1223, 2003.
- Taber, J., Hubenthal, M., Aster R., (2003) Fine Tuning the IRIS Education and Outreach Program: Choosing an Optimal Balance of Activities. *Eos Trans. AGU, 84*(46), Fall Meet. Suppl., Abstract ED32D-07, 2003.
- Baldwin, T., Ortiz, A., Hall-Wallace, M., Taber, J., Braile, L. (2002) Teaching with real-time seismic data. *Eos, Transactions, AGU 83*, no. 47 Fall Meet. Suppl.
- Braile, L. Hall-Wallace, M., Aster, R., Taber, J. (2002) Making waves; the new IRIS education and outreach program plan. SSA 2002; *abstracts of the 97th annual meeting Seismological Research Letters 73*, no. 2 (200204): 257-258.
- Hamburger, M., Pavlis, G., Taber, J. (2002) The U.S. Educational Seismology Network (USESN). *Eos, Transactions, AGU 83*, no. 47 Fall Meet. Suppl.
- Taber, J., Aster, R., Braile, L., Hall-Wallace, M. (2002) The promotion of the use of seismic data via the IRIS Education and Outreach Program. *Eos, Transactions, AGU 83*, no. 47 Fall Meet. Suppl.

Appendix B

Educational Affiliates

Michael Conway	Arizona Western College
Robert Cicerone	Bridgewater State College
Gerry Simila	California State University, Northridge
Suzanne M (Suki) Smaglik	Central Wyoming College
Steve Jaume	College of Charleston
Margaret Mayer	Diné College
Laura Reiser Wetzel	Eckerd College
Greg Geehan	IslandWood
Tina Niemi	University of Missouri, Kansas City
Joseph Gerencher	Moravian College
Frank Revetta	State University of New York at Potsdam
William Harbert	University of Pittsburgh
Rev. Ronald Wasowski	University of Portland
Glenn C Kroeger	Trinity University
David Voorhees	Waubonsee Community College
Alan Goldin	Westminster College
Prajukti (juk) Bhattacharyya	University of Wisconsin – Whitewater

Appendix C

IRIS E&O Standing Committee Members

Current

Michael Wysession (Chair) ..... Washington University, St Louis
Bob Butler..... University of Portland
Ines Cifuentes..... AGU
Glenn Kroeger ..... Trinity University
Gary Pavlis..... Indiana University
Wayne Pennington ..... Michigan Technological University
Laura Serpa..... University of Texas, El Paso
Christa von Hillebrandt..... University of Puerto Rico
Susan Eriksson (ex officio) ..... UNAVCO
Bob Lillie (ex officio)..... Oregon State University

Past standing committee members and affiliation at the time of service

Richard Aster* ..... New Mexico Tech
Jeffrey Baker ..... SUNY Binghamton
Thomas Boyd..... Colorado School of Mines
Larry Braile* ..... Purdue University
Kathy Ellins..... University of Texas, Austin
Karen Fischer..... Brown University
Kevin Furlong..... Penn State University
Lind Gee..... University of California, Berkley
Michelle Hall-Wallace ..... University of Arizona
Michael Hamburger..... Indiana University
David Herring ..... NASA, Goddard Space Flight Center
Sue Hough..... USGS
Charles Hutt..... USGS
Alan Kafka ..... Boston College
John Lahr..... USGS
Robert Mellors..... San Diego State University
Guust Nolet..... Princeton University
Susan Schwartz..... University of California, Santa Cruz
Steven Semken..... Arizona State University
Catherine Snelson..... University of Nevada, Las Vegas
Seth Stein..... Northwestern University
Aaron Velasco ..... University of Texas, El Paso
Lisa Wald..... USGS
Laura Wetzel..... Eckerd College
Robert Woodward ..... USGS

* Denotes chair of E&O committee

Incorporated Research Institutions for Seismology

www.iris.edu