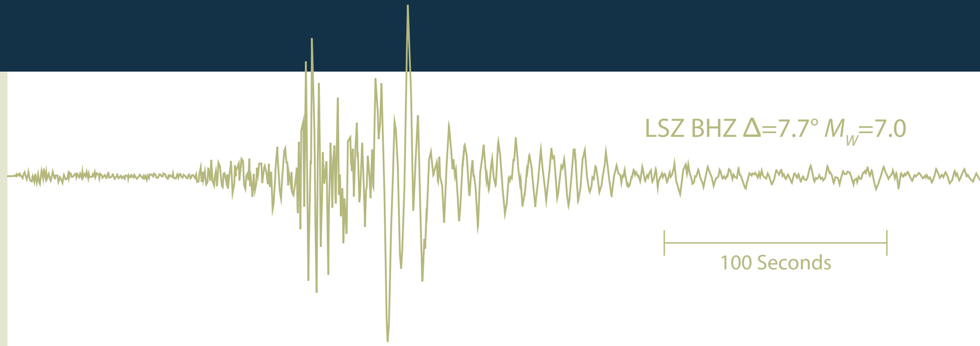
IRIS NEWSLETTER



The M_w 7.0 February 22, 2006 earthquake in Mozambique recorded by GSN station LSZ near Lusaka, Zambia

For more information, see inside back cover.

YEAR 2006 • ISSUE 1

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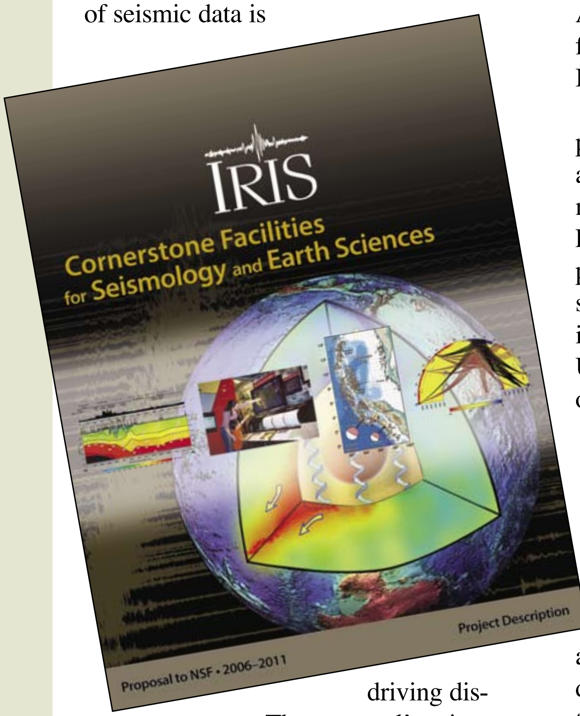
IRIS Proposal Under Review At NSF

In August 2005, IRIS submitted a proposal to renew its cooperative agreement with the National Science Foundation for five more years, from July 2006 to June 2011. "Cornerstone Facilities for Seismology and Earth Science" makes the scientific case for continuing to operate the core facilities – GSN, PASSCAL, DMS and E&O – while innovating to improve the overall efficiency of NSF-supported seismological research.

The essential justification for IRIS's core facilities is that availability of seismic data is driving discovery. The proposal's primary demonstration of this is a collection of over 200 one-page project descriptions, each contributed by project investigators. Since reviewers may lack the stamina to digest such a torrent of new science, the proposal includes a more concise summary of earthquake studies – exotic sources, supershear rupture propagation – and earth structure studies – inner core anisotropy and heterogeneity, mantle dynamics from D″ region imaging, and lithospheric dynamics from cross-disciplinary multi-band imaging.



The proposal has received generally outstanding evaluations from mail reviewers, an NSF special emphasis panel and the EAR Instrumentation and Facilities Panel. NSF's plans for a new Cooperative Agreement are now being developed for presentation to the National Science Board in May.

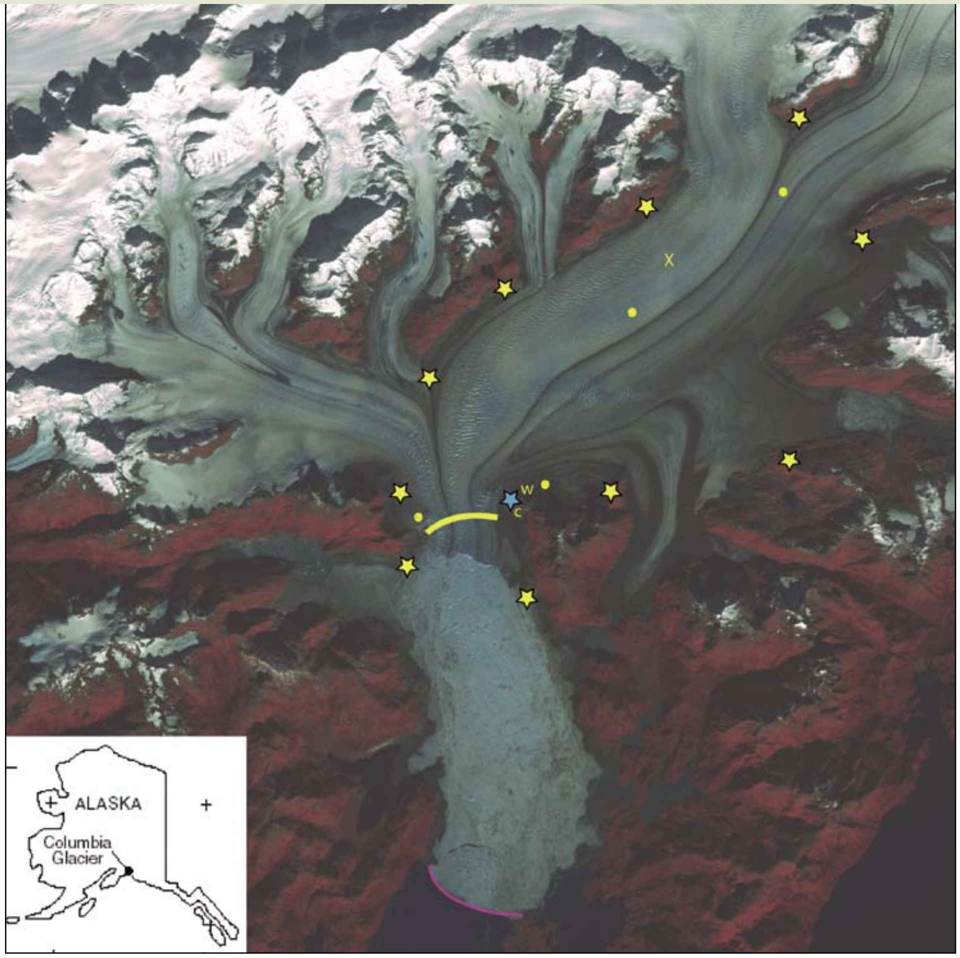
Meanwhile, IRIS is moving ahead with preliminary activities related to the proposal's themes for innovation, which include multidisciplinary integration, incorporating R&D in core operations, partnering in the poles and oceans, and leveraging partnerships. Plans are being laid to develop robust instrumentation for Antarctica jointly with UNAVCO, to increase the number and role of International Affiliates, and to improve cross-program activities of IRIS, such as supporting AfricaArray through long-term loans of reconditioned instruments and provision of data management services. These advances are typical of IRIS's more than 20-year history, which shows that leading development in promising areas depends foremost on strong scientific direction and broad community participation in all of IRIS's affairs. ■

The complete proposal can be downloaded as PDF documents from www.iris.edu/about/publications.htm

Individual project descriptions are available at www.iris.iris.edu/06_Proposal/Accomplishments.htm

Geophysical Investigations of Rapid Tidewater Glacier Retreat

Shad O'Neel • University of Colorado at Boulder; Daniel E. McNamara • U.S. Geological Survey
W.Tad Pfeffer • University of Colorado at Boulder



Lower Columbia Glacier as imaged by Landsat thematic Mapper on September 26, 1999. Stars mark the location of temporary seismic stations, yellow stars indicate Mark L-22 seismometers and the blue star shows the location of the Guralp 40-T broadband seismometer. The yellow 'w' marks the location of weather observations, and the yellow 'c' marks the time lapse camera. Explosion locations for the active source experiment are shown with yellow circles, and the location of the GPS receiver is marked with a yellow 'X'. The 2004-2005 terminus position is roughly shown as a yellow line. The pre-retreat terminus position is shown in pink.

GLACIER CLIMATE INTERACTION

Although they comprise only 13% of the world's mountain glacier area (3% of total glaciated area of Earth), Alaskan and immediately adjacent Canadian glaciers supply one of the largest measured glaciological contributions to global sea level rise (~0.14 mm/yr, equivalent to new estimates from Greenland). Retreating tidewater glaciers dominate the Alaskan sea level contribution due to their ability to efficiently transfer mass via iceberg calving [*Arendt et al*., 2002]. During retreat phase, a tidewater glacier may retreat on the order of 1-2 km/yr concurrent with dramatic increases in ice velocity. Catastrophic retreats of this style are thought to be irreversible [*Meier and Post*, 1987] until the terminus retreats to a position above local sea level. In contrast, terrestrial glaciers, whose main mass loss mechanism is surface ablation, generally retreat on the order of 10 to several hundred m/yr and are reversible given adequate mass balance forcing.

Unlike their terrestrial counterparts, the relationship between climate and tidewater glaciers is complexly nonlinear; once initiated, tidewater glacier retreats proceed independently of the local climate. This is nicely illustrated by tidewater glaciers in south central and southeast Alaska, which all experience roughly the same climate. The tidewater glaciers of Glacier Bay initiated rapid retreat phases around the turn of the 20th century, while others, such as Columbia and LeConte Glaciers [*Krimmel*, 2001; *O'Neel et al*., 2003], are currently undergoing rapid retreat. Contrarily, Taku and Hubbard Glaciers are slowly advancing [*Motyka et al*., 2003].

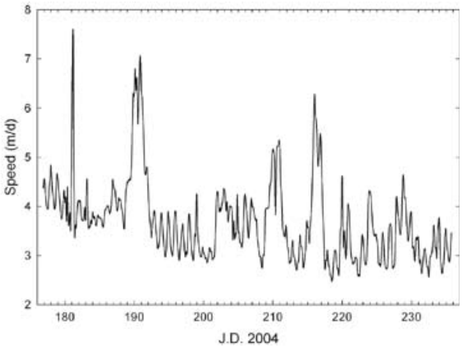
RAPIDLY RETREATING COLUMBIA GLACIER

Columbia Glacier is located in south-central Alaska, approximately 30 km west of Valdez. The glacier flows 52 km from a maximum elevation of 3050 m down the flanks of the Chugach Mountains into Prince William Sound, where it terminates at a grounded ice cliff in deep water. The glacier attained a stable, shallow-water extended position (67 km long, 1100 km^2 surface area) at about 1100 A. D. and suffered only minor length and thickness changes until ca. 1980, after which time rapid retreat began [*Meier and Post*, 1987]. Since then, the terminus has retreated over 15 km concurrent with thinning exceeding 20 m/yr at low elevations. The retreat is propagated by iceberg calving that exceeds incoming ice flux at an average rate of 0.74 km/yr [*O'Neel et al*., 2005]. Although there has been a recent decline in retreat rate, which we attribute to a prominent constriction in the channel (near the 1999 terminus), discharge flux continues to greatly exceed the mass balance flux. Radio echo sounding measurements suggest that the glacier will retreat another ~15 km before the bed rises above sea level.

Columbia Glacier ranks among the world's fastest glaciers; surface speeds commonly exceed 25 m/d. Both observations of large amplitude, short period velocity variations and calculations of internal deformation rates indicate that the flow is predominantly by basal sliding.

FIELD STUDIES

In order to study the role of calving in the dynamics of Columbia Glacier, we made measurements with a variety of geophysical instrumentation around the lower 20 km of the glacier channel. An array of ten high-frequency (1 Hz) Mark L22 seismometers and one broadband (0.33-30Hz) Guralp 40T seismometer were deployed on rock outcrops at the glacier margin during June 2004 for a period of one year. The array recorded over 100 Gbytes of continuous data at a rate of 100 samples/s that included local and teleseismic earthquakes,



Horizontal velocity measured using high-precision GPS, approximately 7 km upstream of the 2004 terminus.

small local seismic events generated by the glacier (icequakes), and four explosions detonated in boreholes on the glacier. Seismometers, power systems and recording equipment were obtained through the IRIS Consortium's PASSCAL program.

The seismic experiment is one component of a larger integrated approach that addresses the role of calving in glacier dynamics. Additional field studies include:

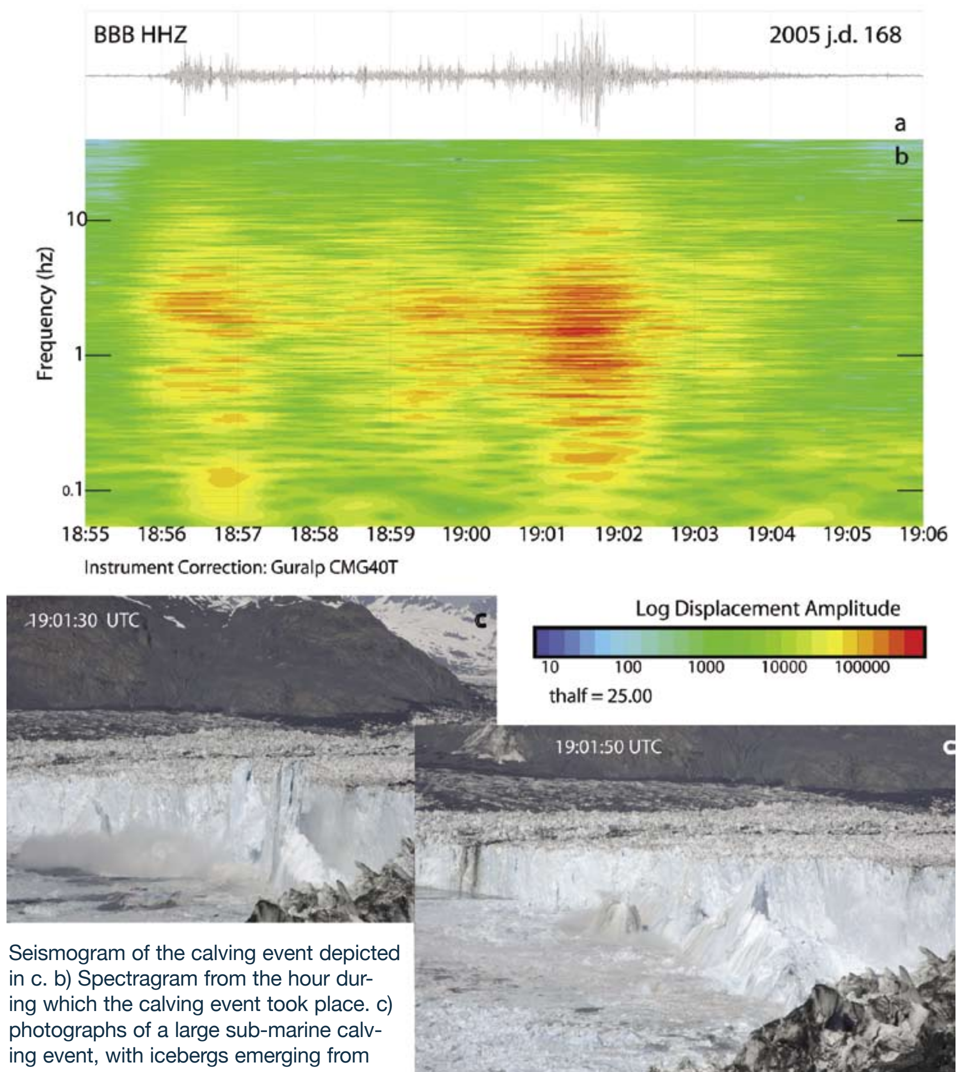
- Measurements of ice motion using both high precision GPS (equipment supplied by UNAVCO) and optical surveying methods. Measurements of surface motion 7 km upstream from the terminus were made from June through September, 2004 and motion near the terminus was measured for 25 days during June 2005. Additional GPS surveys measured short-term average speeds at several locations and established a geodetic control network for photogrammetric analysis.
- Repeat aerial photography, extending from 1976 to the present used to determine glacier geometry and surface velocity fields.
- Terrestrial time-lapse photography (4 images/d) of the terminus (*see http://tintin.colorado.edu/group/columbia/TLC.avi*) which, using single-camera photogrammetric techniques, provides a time series of volume change near the terminus.
- Bathymetry, water temperature and conductivity (salinity) measurements in newly exposed regions of the fjord to infer channel geometry and water discharge rates and patterns emanating from the sub-marine terminus.
- Detailed calving observations including timing, style, location, and subjective magnitude of thousands of calving events, used to ground truth the seismic records.
- Hourly surface air temperature and precipitation measurements, used to investigate forcing mechanisms for the time distribution of calving.

INTEGRATED DATA ANALYSIS

Three primary goals of this experiment are documenting mechanical fracture processes involved in calving (including the location, rupture style, and seismic energy release), understanding the relationship between ice motion and calving, and correlating ice motion and calving with possible forcing mechanisms. Previous studies have identified three characteristic seismic waveforms associated with three different icequake event types [e.g. *Qamar*, 1988; *Deichmann et al*., 2000]. These include: calving events (low frequency, long duration, non-impulsive onsets, surface waves); basal sliding (low frequency, short duration, no surface waves); and surface crevassing (high frequency, short duration, impulsive onsets). Qamar's [1988] work was performed at Columbia Glacier when the glacier extended 10 km further down fjord and provides a baseline for our work.

Calving events span a broad range of style and magnitude, ranging from small isolated pieces of ice dropping from the ice cliff to the water to 1 km square slabs rising up from great depths below the ocean surface. Qamar [1988] showed that the duration of a seismic signal associated with calving correlates with ice volume, but amplitude does not. The position of their camp made differentiation of calving style and determination of ice volume challenging. Using our calving observations and seismic record from the broadband sensor located near the terminus, we intend to characterize the seismic waveforms associated with the primary calving styles and formulate an ice volume relationship using event amplitude, frequency content and duration.

Typically, calving is thought of as a process occurring immediately at the terminus of a tidewater glacier. However, →



Seismogram of the calving event depicted in c. b) Spectragram from the hour during which the calving event took place. c) photographs of a large sub-marine calving event, with icebergs emerging from significant depth below sea level.

Installing the broadband seismometer June 2004. Treelines in the background show the pre-retreat ice thickness at this location. Photo by Tim Parker.

observations of along-flow strain rates indicate that failure processes may be operating significantly upstream of the terminus [*O'Neel et al*., 2003]. Accurate calculations of icequake locations will allow us to investigate this idea. We detonated four explosions of varying magnitude at known locations on the glacier to determine seismic velocities in the local bedrock, which will allow us to more accurately determine icequake locations. Rupture style will also be used to differentiate events generated by calving, crevassing or basal processes.

Our second primary goal is to investigate the relationship between the rate of calving and ice speed. Early predictions of the retreat grossly over-estimated retreat rates, primarily because researchers did not anticipate the large increase in surface speed as the terminus began to retreat. Classically, the calving rate is a derived quantity, calculated as the difference between ice speed at the terminus and change in glacier length. Ice speed and length change are typically measured photogrammetrically [e.g. *Krimmel*, 2001]. Our seismic data allow an independent determination of the calving rate (and potentially calving flux) that can be compared to photogrammatic measures of ice speed and length change.

For our final goal, we will identify statistical relationships between icequake occurrence (seismicity) and possible forcing mechanisms such as ice motion, tidal variations, temperature and precipitation.

Preliminary results suggest that calving events generate unique seismic records that are distinguishable from earthquakes and other events generated by the glacier due to crevassing and basal sliding. The characteristic frequency of calving events is 1-3 Hz. Submarine calving events contain more low frequency energy than subaerial events. In addition to calving, two other event types were recorded; one has a characteristic frequency much lower than calving in the range of 0.05 – 0.1 Hz and may be related to basal sliding or sub-glacial hydraulics, while the second has a higher frequency content and shorter duration (< 1 sec) and is related to crevassing. Preliminary analysis of the GPS and seismic datasets indicates that overall icequake seismicity increases during speed-up events. Our ability to identify and separate icequake types by frequency content will enable us to investigate how calving and retreat are related to external driving processes.

Columbia Glacier demonstrates that ice loss from calving is a critical component in global sea level rise. Analogous, but larger and more rapid, retreat processes are presently underway at several major outlet glaciers of the Greenland Ice Sheet [*Joughin et al*., 2004; *Krabill et al*., 2004]. Rapid retreats result in a substantial new component to global sea level rise and provide strong motivation for a quantitative understanding of calving and rapid ice flow which control such catastrophic retreats. Our multidisciplinary investigations at Columbia Glacier will provide a significant new contribution to our understanding of mechanical controls on marine terminating glacier instabilities including, but not limited to, climate triggering.

ACKNOWLEDGEMENTS

This work was supported by NSF OPP 0327345. We thank Tim Parker, Mary Templeton, Eliana Arias, and Bruce Beaudoin from PASSCAL for invaluable help in the field and with data formatting and timing corrections. Jake Walter, Ellie Boyce, H.P. Marshall and James McCreight provided essential volunteer field support. Martin Truffer provided active source timing and developed the single-camera photogrammetry code. Thomas Hart was essential in the blasting efforts. None of the work would have been possible without the steady hands of Jim Harvey (Air Logistics) and Jan Gunderson (ERA Helicopters).

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IRIS/UNAVCO Joint Workshop 2005

THE PROGRAM FROM THIS WORKSHOP IS AVAILABLE FOR DOWNLOAD HERE.

Skamania Lodge in Stevenson, WA, on the slopes of the Columbia River Gorge was the setting for the IRIS/UNAVCO Joint Workshop, June 9-11, 2005. The Workshop brought together over 300 Earth scientists to review recent progress in multidisciplinary studies and to explore opportunities for further work. Greg Beroza and Anne Trehu served as workshop chairpeople from IRIS, while Herb Dragert was the lead chairperson from UNAVCO with assistance from Eric Calais and Mark Tamisiea.

PLENARY SESSIONS

The Sumatra-Andaman Earthquake of 2004 was a predominant topic of discussion since the Workshop was one of the first major geophysical meetings after the event. Roger Bilham spoke about the rate at which rupture propagated along the fault and discussed the implications for seismic hazard throughout the region. Phil Cummins described tsunami threats for Australia and how improvements to Indian Ocean tide gauges could mitigate the hazard. Kerry Sieh reviewed the history of thrust events on different segments of the Sunda Thrust as inferred from paleogeodetic evidence. Emil Okal reviewed the effects on science and society that resulted from the unusually long interval of more than 40 years since the last megathrust.

Polar Geoscience was addressed in the first afternoon, partly in anticipation that seismologists and geodesists could work together to improve geophysical infrastructure instrumentation. Doug Wiens gave an overview of recent accomplishments in Antarctica from broadband seismology and Carol Raymond reviewed the current status and goals of GPS monitoring. Rick Aster highlighted gains from an interdisciplinary approach to monitoring volcanic activity on Mount Erebus by combining broadband seismic, video and geochemical data for new insights about deep linking between crater vents. Sridhar Anandakrishnan also presented results from an interdisciplinary study, in this case combining GPS and seismic data to give a fuller picture of the viscoelastic response of ice streams to tidal forcing.

Explosive Volcanism was on everyone's mind as we met in the shadow of the Cascades Range during an eruptive phase of Mount St. Helens. Seth Moran reviewed lessons learned from seismic monitoring of recent Mount St. Helens explosions and noted the difficulty making generalizations about predictability or even seismic detectability. Steve McNutt reviewed seismic monitoring of volcanoes more broadly and pointed out hoped-for gains from adding InSAR and GPS to the existing monitoring tools. Glen Mattioli described lessons learned in monitoring the Souffriëre Hills Volcano, Montserrat, with strainmeters, tiltmeters, seismometers and GPS receivers. Michael Lisowski took a look at the need for improving geodetic models so that geodetic measurements can be used to make better inferences about the processes leading to eruption.

Next-Generation Imaging was the topic in the concluding plenary session. Roland Bürgmann showed how large earthquakes can be used as known forcing functions to image lithospheric rheology from GPS and InSAR measurements of the post-seismic displacement resulting from viscoelastic relaxation. Jessica Murray showed that geodetic data collected over an entire earthquake cycle from the dense instrumentation at Parkfield, California, can be used to image the temporal and spatial patterns of slip on the San Andreas Fault. Michael Ritzwoller brought the latest news on cross-correlating ambient noise to assemble tomographic images with greater resolution than has been achieved thus far with techniques based on known sources. Peter Shearer showed how the dense array of seismic stations in Japan could be used to image rupture propagation at teleseismic distances.

OTHER FORUMS

The plenary sessions bring everybody together and contribute the most widely shared memories of the Workshop. As always, however, different elements of the community gathered in a wide variety of forums. This year, these meetings occurred during a field trip to Mount Hood as well as during special interest group meetings and pre- and post-workshop symposia. The posters are simultaneously the most "cutting edge" aspect of the Workshop – they present the latest ideas from individuals – and the most difficult to summarize, since the discussions about them are one-on-one exchanges that take place throughout the meeting. ■

The CIG SIG

Alan Levander • Rice University; Mike Ritzwoller • University of Colorado at Boulder;
Jeroen Tromp • California Institute of Technology; Michael Wysession • Washington University in St. Louis

On June 8, 2005, a one-day workshop on Computational Seismology was held prior to the annual IRIS/UNAVCO Workshop in Stevenson, Washington. The meeting was attended by about 25 people, and lively group discussions continued all day until 5:00 PM. Discussions held during this meeting had two main purposes: to establish a structure for future Computational Infrastructure for Geodynamics (CIG) activities in the area of computational seismology, and to establish a set of both short-term and long-term goals.

A "Seismology Working Group" was formally established, with an initial membership of Alan Levander, Mike Ritzwoller, Jeroen Tromp, and Michael Wysession. This working group will work closely with the seismologist who will be on the CIG Scientific Steering Committee to set and carry out seismology priorities for CIG. The Working Group may expand its membership for disciplinary breadth as appropriate to accommodate changing priorities and needs of CIG, and will discuss its composition and the duration of service with the CIG Scientific Steering Committee. A principal job of the Seismology Working Group is to establish and oversee a number of Seismology Task Groups whose role it is to implement specific seismology priorities within the context of CIG.

During the one-day workshop, the short- and long-term goals were established. These goals span a wide variety of areas, and involve a great deal of collaboration and communication with other scientists and organizations.

The European SPICE group (Seismic wave Propagation and Imaging in Complex media: a European network) has an interesting funding model that might be successfully tried by CIG. SPICE provides training fellowships for post-docs and graduate students. For CIG, such awardees would develop existing codes for the CIG framework as part of their responsibilities for funding. The awardees could be institutionally based, but be funded with the understanding that they would spend a substantial amount of time at Caltech learning framework coding.

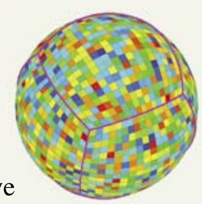
The CIG Seismology Working Group welcomes comments and suggestions from the community as to the future activities and priorities of computational seismology activities within CIG. ■

FOR MORE INFORMATION ABOUT CIG, SEE HTTP://GEODYNAMICS.ORG

SHORT-TERM GOALS

Open-Source Codes– CIG can be of great benefit to the seismological community by overseeing the availability of open-source synthetic seismogram codes. These may include 1-D codes (e.g., Generalized Ray Theory, reflectivity, WKBJ, and normal mode) and 3-D codes (e.g., finite-difference, finite-element, spectral-element, and eikonal solvers).

Model Parameterization– Particular attention will be focused on defining model parameterization, which includes source, receiver, and Earth model parameterization. There will likely be a need for development of translators to move from one Earth model definition to another.



Coordination of Efforts– Whenever possible, CIG seismology efforts will be coordinated with SPICE, GEON, IRIS, and SCEC. Many organizations are interested in advancing the state of computational seismology and it is vital that these efforts occur without unnecessary redundancy of efforts.

1-D Codes at the IRIS DMC– One obvious area of immediate collaboration is for conversations to be held with the IRIS DMS and IRIS leadership to establish a highly benchmarked global 1-D code at the IRIS DMC. The code will produce synthetic seismograms that will accompany data orders shipped from the DMC.

CIG Seismology Workshop– A theoretical and computational seismology workshop will be organized. In addition to scientific presentations, the meeting will offer hands-on experience with the CIG framework and the seismology codes then available through the CIG framework.

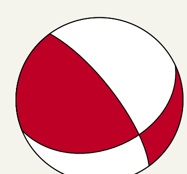
LONG-TERM GOALS

Automated/On-Demand Simulations– CIG should work to establish a Seismology Science Portal, involving both automated and on-demand simulations. Automated simulations would provide near real-time 1-D and/or 3-D synthetics to accompany IRIS data for all events over a certain magnitude threshold using past and emerging events in the Harvard CMT catalog.

Seismic Model Database– There is the need for a database of seismic models, including structural models of the crust and mantle together with databases of topography and bathymetry. Various resolutions are needed to match the capabilities of codes being developed under CIG. Mechanisms for the contribution of models must be established.

Data Processing Tools– CIG should investigate the feasibility of facilitating the development of data processing tools for field and laboratory use. These could include low-level routines for standard data manipulation (e.g., filtering, simple array analyses); higher-level functionality such as earthquake location, travel-time picking, and moment tensor analysis; and high-level functionality such as tomography, receiver functions (perhaps with migration), and shear wave splitting.

Visualization– 2-D and 3-D visualizations of seismic models are increasingly important in seismology and present an area of great overlap with other CIG efforts that require coordination. Imaging/tomographic tools may be included productively within the CIG framework.



CMT Data– CIG may be able to help in ensuring continued operation of the Harvard CMT project.

IRIS Educational Affiliate Workshop

FOR MORE INFORMATION SEE, WWW.IRIS.EDU/EDU/EA.HTM

The first Educational Affiliate workshop was held on June 8th, 2005, at Skamania Lodge, the day before the IRIS/UNAVCO Workshop. The Educational Affiliate (EA) membership category was created with the purpose of advancing communication and collaboration between the research and undergraduate communities and enhancing the teaching of seismology and related Earth science at the undergraduate level. It is the newest IRIS membership category, with a current total of eleven member institutions. Six of these institutions were represented at the workshop, as well as a potential member. The workshop was very successful in providing networking opportunities and in outlining both the long-term vision and short-term needs of the EA community.

FIVE TO TEN YEAR VISION

The IRIS Educational Affiliate members are a community of institutions with a common interest in the promotion and enhancement of seismology education. As such, members of this community are consumers of both seismology educational products and seismological research. Besides being consumers, the EA members view themselves as uniquely positioned to explore seismology educational issues across a spectrum of learners. Therefore, the relationship between IRIS members and EA members should be a positive, reciprocal interaction where both groups have an opportunity to benefit.

To enable and enhance this community over the next five years, the IRIS E&O program will:

- Explore three new areas (see below) designed to support and enable the EA community and its interests, and institutionalize the "Sabbatical in Seismology" pilot program;
- Gradually recruit additional institutions with a proven dedication to seismology education; and
- Continue to foster a sense of community among EA members and interactions/collaborations between EA members and IRIS full member institutions.

SHORT TO INTERMEDIATE TERM NEEDS

Through discussions at the workshop, the Educational Affiliate community generated a substantial list of needs that impact their ability to communicate seismology to the learners at their home institutions. From this list, three key needs were identified for program development over the next five years. These needs were:

- Improved access to and knowledge of seismological data. This should include a special emphasis on uses for classroom and laboratory instruction as well as identifying key concepts that can be introduced using data.
- Efficient and timely access to electronic resources (e.g. slide shows, animations, video clips, images and figures) to supplement courses.
- A distillation of core global seismology topics to include in a geoscience course as well as highlights of cutting edge research, e.g., "I want to teach more seismology but what content should I cover?"

The community felt that if these needs were adequately addressed via program development, then at the end of a five-year window, a substantial improvement in seismology education in the arenas of undergraduate and informal education would have been achieved. These efforts would not only benefit EA members but they would also support the seismology instruction offered at IRIS full member institutions.

The first needs-based program developed by the IRIS E&O program to serve the EA community was piloted this spring by EA member Laura Wetzel from Eckerd College working with Cliff Frohlich from UTIG. The "Sabbatical in Seismology" (SIS) program is designed to provide travel funds for geoscience faculty at IRIS EA institutions to allow them to engage in geophysics research during their sabbaticals, for the purposes of faculty professional development. The targeted outcomes of this effort are enhanced seismology instruction by the faculty member as well as enhanced opportunities for undergraduates at the EA institution to participate in research during and/or after the sabbatical.

In addition to the SIS program, a new program designed to further the professional development of the EA community will also be developed within the next five years. Unlike the SIS program, which emphasizes a research experience as the means of learning, this effort would have a classroom focus. The design of the multi-day workshop would enable EA members and other participants to access seismological data for use in classroom and laboratory activities, identify interesting topics that can be explored and highlighted through the use of seismological data, and provide training on software necessary to manipulate the data. This program will greatly →

A COMMUNITY RATHER THAN A PROGRAM

The paradigm of a community:

- increases the importance of the activities of the membership rather than the number of EA members as a measure of success,
- encourages collaborations between all members of IRIS,
- cultivates the development of needs-based programming by IRIS E&O while targeting specific IRIS E&O goals as set by the E&O committee,
- forces the metrics of success to become individualized to each activity and therefore meaningful, and
- maintains the concept of IRIS and IRIS E&O as a service organization to its membership.

PARTICIPANTS

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John Taber	IRIS Education & Outreach
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augment and expand our current one-day workshop offered annually at GSA meetings that includes but does not focus solely on data.

The third new program to be developed within the next five years would be the development of an IRIS collection of seismology teaching resources. Such resources should be diverse and include animations, slide shows, images, maps, video-clips etc. Once compiled, such a collection could benefit many other users well beyond the EA community including full IRIS members and middle and high school educators. The development of such a collection, including the creation of a system for individuals to rapidly contribute material, would create critical infrastructure to allow the IRIS E&O program to rapidly respond to exciting seismological events as they occur. The automated creation of collections such as the Sumatra–Andaman Island Earthquake webpage, *http://www.iris.iris.edu/sumatra/*, would provide timely and accurate resources for use in classrooms within the US and around the world. Such a system would augment special event pages generated by the USGS by allowing the community to compile value-added resources that are ready-to-roll in classrooms.

The final new program to be developed within the next five years is the development of a flexible electronic "primer" on global seismology. Such a primer could be used by non-seismologists to introduce more in-depth coverage of global seismology in core undergraduate courses such as structural geology or tectonics. The primer would consist of a small set of pdf "few-pagers" which, together with some selected graphics and animations, could be used at no cost as a supplement to undergraduate course texts. Discussions and IRIS-wide community input could flesh out an outline of basics that would include topics often ignored or poorly covered in non-seismology texts, e.g., magnitude scales (M_S vs. m_b vs. M_W) surface wave dispersion, and the depth distribution of earthquakes. Since no "hard copy" would be published, an annual "cutting edge" section could be developed to help circumvent the often decade-long lag in textbooks adopting new research. Editorial duties for such an effort could be a collaboration between EA and full members.

Web Services Workshops

Spearheaded by David Okaya from the University of Southern California, the IRIS DMS sponsored two workshops on web services in 2005. The purpose of the first workshop in June was to examine across-the-Internet on-demand methods in contrast to more familiar script or Java-based methods. While evolving, four principal IT methods are currently widely used to provide distributed computing services: Java servlets, CORBA, Java-RMI, and web services. These methods have strengths and weaknesses, and some are better than others at different types of computing purposes. The workshop explored these differences and examined in-depth the method of web services. Web services can be used to create a true community library of remote computing modules ranging from the very simple (e.g., latitude-longitude to UTM conversion) to the heavy duty (modeling codes). The goal of the workshop was to provide conceptual understanding to the scientific community about the technology.

The second web services workshop was held in September in Monterey, CA and was aimed at students and programmers who wished to learn how to work with web services, either building clients or providing web service access to the seismology community.

The workshop focused on learning how to create a web service with the SOAP protocol. Topics covered included basic XML and namespaces, XML data binding, writing a client to an existing web service, building a WSDL, and developing and deploying a web service.

LEADING IN NEW TECHNOLOGY

IRIS has always been a leader in advancing the use of enabling technologies within the seismological community, including the development and adoption of a comprehensive data file format and tools, web browser-based access mechanisms, distributed archive access, and CORBA-based programmatic interfaces into the archive. The IRIS Data Management Center continues in that role with the development of web services-based interfaces and services.

WHY WEB SERVICES?

Distributed computing is a complex problem, with no single "one size fits all" solution. When choosing a technology to support distributed computing, many different aspects must be considered. Web services provide some unique features, making them important components in the services offered by IRIS.

One of the most important features of web services is the ability to use the http communication protocol, and therefore communicate in the presence of all but the most restrictive firewalls. Many system administrators have responded to the onslaught of malicious viruses by shutting off access on most Internet communication ports, except that used by web browsers (port 80). By running on the same port as common web browsers, web services can be accessed by anyone with web access.

Web services are also becoming a ubiquitous tool with support in many programming languages and scripts. Scientific users can access data supplied through web services from within MATLAB, Java or C, while web developers can use Flash or Perl. Web service clients don't require advanced programming skills to successfully implement.

WEB SERVICE PROJECTS AT THE DMC

Current efforts at the DMC include a web service front-end to the Data Handling Interface (DHI-WS), a framework to support time series processing (seismoproc), and the Searchable Product Archive (*SPADE*). The DHI-WS service provides a subset of the DHI interface to provide the commonly accessed DHI functionality to clients behind firewalls. Seismoproc enables the publishing of seismic data processing algorithm implementations for use by external client applications. SPADE will provide a coherent web services-based system to manage the submission, searching, and access of USArray XML-based Data- and Informational Products.

The DMC strives to provide tools and services that best fit the needs of the community. Given the flexibility and ease-of-use that web services offer, we feel that web services are the components on which a broader community-oriented service framework can be built.

Global Seismology Workshop: A Vision and Partnership with GEOSS

Rhett Butler • The IRIS Consortium
William Leith • US Geological Survey

WORKSHOP TALKS ARE AVAILABLE HERE.

In February 2005, the Third Earth Observation Summit established the Group on Earth Observations (GEO), whose membership is open to all member States of the United Nations and to the European Commission. The Group on Earth Observations has resolved that understanding the Earth system—its weather, climate, ocean, atmosphere, water, land, geodynamics, natural resources, ecosystems, and natural and human-induced hazards—is crucial to enhance human health, safety and welfare, to alleviate human suffering and to reduce disaster losses (*http://earthobservations.org/*). In a series of international meetings held since the first Summit in July 2003, GEO has defined the concept of a Global Earth Observation System of Systems (GEOSS) to provide the critical Earth observations and coordinated delivery of information from which decisions and actions for the benefit of humankind can be made. The Global Seismographic Network (GSN) and Japanese seismic networks have already been put forth by U.S. and Japan, respectively, as Observing Systems within GEOSS.

On August 23-24, 2005, the USGS, IRIS and NSF held "An International Workshop On The Utilization Of Seismographic Networks Within The Global Earth Observation System Of Systems". Over 50 scientists from 14 countries gathered at the American Association for the Advancement of Science in Washington, DC, for talks and discussions on policy, in-situ networks, data management, data products, capacity building, synergy, and science for the societal benefits encompassing the GEOSS plans.

Global seismic monitoring networks, exemplified by the Global Seismographic Network (GSN) and the member networks of the Federation of Digital Seismic Networks, offer data and infrastructure that broadly meet the goals and requirements of GEOSS, including those for standards, interoperability and open data access. The global seismological community, with over 100 years of practical service in international cooperation for global observing and data sharing, serves as a useful model for a GEOSS "community of practice". Moreover, the scientific desire to collect seismic data in remote areas often coincides with opportunities for capacity-building in less-developed nations.

Workshop participants also included representatives of other geophysical disciplines, including global geodesy, geomagnetism and infrasound. Each of these communities has a strong potential for contributing to societal concerns and for capacity building, as well as providing essential data for scientific investigations. To varying degrees, the observing networks of these allied disciplines complement and augment seismological networks. Good opportunities for sharing infrastructure and cross-disciplinary science were recognized.

Left: Vice Admiral (ret.) Conrad Lautenbacher, Undersecretary of Commerce for Oceans and Atmosphere and NOAA Administrator, presents a Keynote Address on "The GEO Initiative".

Right: Dr. Patrick Leahy, Acting Director of the U.S. Geological Survey, presents a Keynote Address on "In Situ Observing Systems within GEOSS".

Both talks were given at the August 23-24, 2005, GEOSS Workshop in Washington DC. (photos by Lew Thompson, USGS)

The workshop participants endorse the Federation of Digital Seismic Networks (FDSN, a Commission of the International Association of Seismology and the Physics of Earth's Interior), to represent the seismological community to the Group on Earth Observations. The FDSN is already a GEO "Participating Organization", and represents the Global Seismographic Network and those national and regional seismographic networks that are FDSN members.

The workshop participants recommend that the FDSN appoint representatives of the seismological community to serve on each of the five GEOSS Working Groups (Tsunami, Capacity Building & Outreach, Architecture & Data, Science & Technology, and User Interface), and encourage the FDSN to work to broaden its advocacy for the community to encompass other seismic monitoring efforts, such as strong motion monitoring and ocean-based seismic monitoring, and to collaborate with other in-situ networks in GEOSS. Other geophysical communities should make contact with GEOSS through the FDSN where appropriate, or to develop formal relations with GEOSS independently. The existing GEOSS targets in the areas of Disaster, Architecture, Data & Users, and Capacity Building that pertain to seismic networks and their products were endorsed, and prospective tasks under these targets were encouraged to be submitted to the GEO Secretariat, either →

via FDSN or through respective National delegations to GEO.

The GEOSS structure is largely focused on societal benefits, and there was recognition of the need to improve and expand the societal benefits derived from seismic networks—including those that come from earthquake monitoring, hazard and risk assessments, tsunami warning, and rapid damage estimation—through capacity building, research, product sharing, and product development. Discussion focused on specific tasks to further global and regional seismology within GEOSS, for example, sustaining GSN/FDSN operations and maintenance; expanding real-time telemetry capabilities and robustness for the GSN/FDSN stations; improving operational uptime and data availability of GSN/FDSN; advocating free, open access to real-time seismic data from GEOSS in-situ observing systems; facilitating data-sharing among GEOSS members; and facilitating data management coordination within GEOSS for seismological data, metadata, and products.

In addition to establishing the GSN/FDSN as existing baseline sites for global in-situ networks and reviewing GSN/FDSN as a logistical framework for other GEOSS in-situ measurements, representatives of geophysical disciplines outside seismology were encouraged to develop similar goals and tasks within the GEOSS targets. Two additional GEOSS targets were suggested to advance seismology within GEOSS: development of new, very-broadband seismometers for seismology and tsunami warning and extending global seismological coverage into the oceans through synergy and shared logistical infrastructure with GEOSS in-situ ocean observing systems.

The workshop participants expressed interest in GEO-sponsored workshops on sharing in-situ ocean observing infrastructure with seismology and for coordinating the implementation of the Indian Ocean Tsunami Warning System. Interest and encouragement was expressed for the newly developing seismological networks in the Indian Ocean region with hope that those not already participating in FDSN would join and adhere to its standards.

In many ways, the global seismological community, through its seismic networks, leads other sciences in developing common practices and standards; establishing worldwide real-time communications; promoting open data exchange with rapid data availability; and building integrated, multi-sensor Earth observatories. Now, independently and through collaboration with scientists from many disciplines, these vital "network characteristics" have become, in large part, the vision of GEOSS. It is therefore only natural that we engage with GEOSS and GEO and further that vision, with benefits to be accrued before and upon the next great earthquake. ■

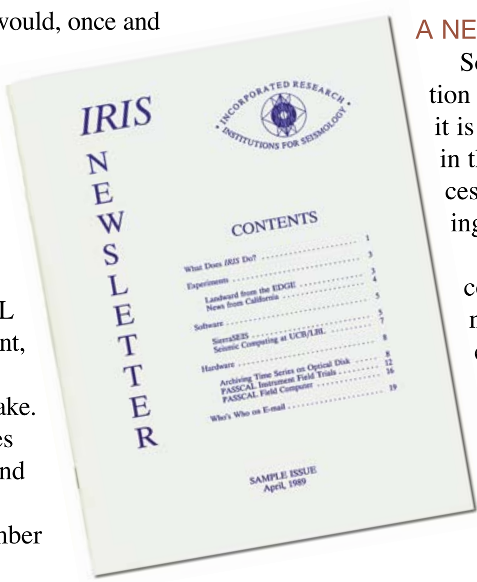
IRIS Newsletter Back In Publication

A NEWSLETTER WITH HISTORY

The IRIS Newsletter has a history of facilitating communication across the consortium and to the geophysical community. The earliest newsletter that can still be found on the shelves at IRIS headquarters is a "sample issue" from April 1989. There is no color, of course, but there is a now-unfamiliar logo that resembles an eye with an iris crisscrossed by seismic ray paths. Just glancing at it makes my own eyes itch.

Even the earliest issues include reports from Jim Fowler on new PASSCAL instrumentation and from Tim Ahern on new DMC software that would, once and for all, make data retrieval a snap. Field work descriptions were features from the outset, including David Simpson and Art Lerner-Lam's report on the first PASSCAL aftershock deployment, which followed the Loma Prieta earthquake.

Production values improved quickly, and the first photograph includes a staff member representing Congressman Ed Markey at the opening ceremony of the Moscow Data Center – IRIS recognized the importance of acknowledging movers and shakers from the outset.



IRIS newsletters were published less frequently in the late 1990's and there have been none at all in recent years. But the decline resulted from difficulty finding time to produce issues rather than lack of demand. Indeed, the ongoing utility of the Newsletter, despite – perhaps because of – the consistency in the content from year to year, is still widely recognized.

A NEW START

So in restarting publication of the IRIS Newsletter, it is appropriate to carry on in the traditions of predecessors, rather than looking to overthrow them.

One difference, of course, is that there are now more PASSCAL experiments each year than could be described in a few concise issues. Thus, some selection of unusual experiments is possible. This issue features two experiments that share the objective of investigating glaciers rather than the silicate structures that seismologists more often target.

With over 100 Member Institutions, today's IRIS community includes researchers from diverse disciplines and with interests that extend broadly across the Earth sciences. Thus it is not surprising that numerous special interest group meetings include, but are hardly limited to, seismologists. To spread the word among everybody with essential interests, it is as important as ever for the Newsletter to include reports on meetings, workshops and policy studies.

MOVING FORWARD

IRIS plans to publish the Newsletter three times annually and complement it with an Annual Report in the fourth quarter. As ever, Newsletter content will require individuals who are willing to contribute.

Articles are welcome at any time but, as is common with other periodicals, authors will be asked to work with IRIS staff as text and images are edited and prepared for publication. The compensation, of course, is the attention of your peers and an opportunity to collaborate with a larger group in working towards the goal of the research science effort on which you report. ■

Tides Experiment and IRIS

Sridhar Anandakrishnan • Pennsylvania State University

For the listener, who listens in the snow,
And, nothing himself, beholds
Nothing that is not there and the nothing that is.

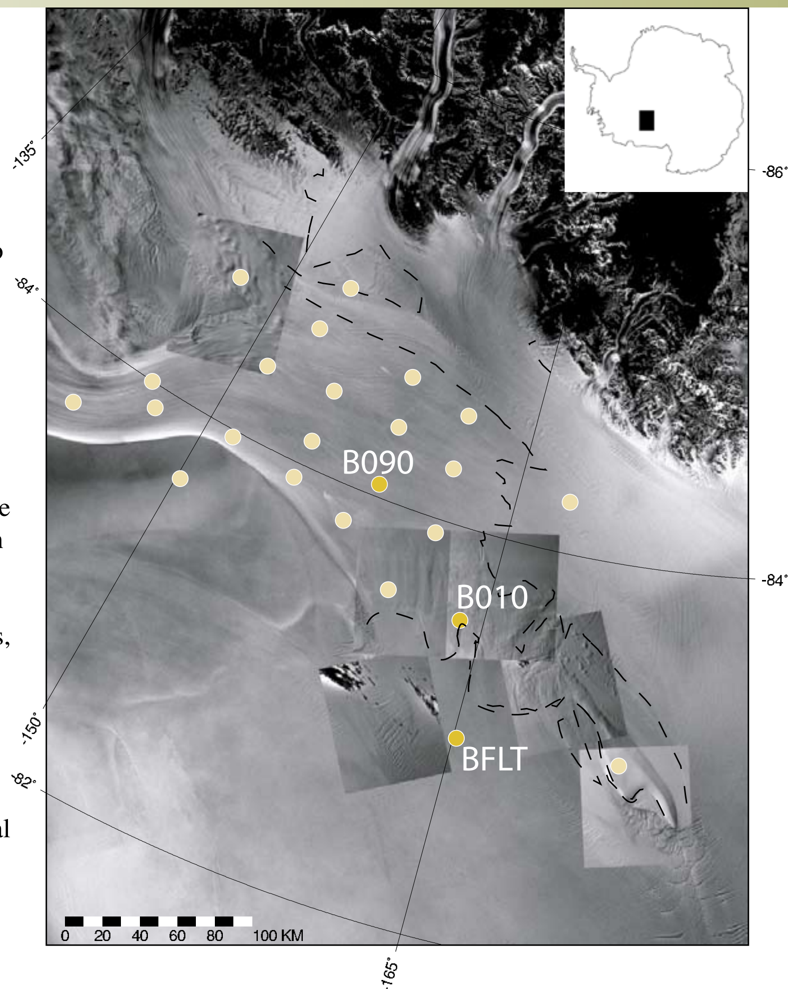
Wallace Stevens, *The Snow Man*

LISTENING...

We are listening in the snows of Antarctica for what we can learn about the flow of the great ice sheet and glaciers. Snowfall in the interior of the continent makes its way to the coasts and thence to the oceans, where it begins the hydrologic cycle again. The flow of the ice[1] has a few distinct regimes: as slowly-flowing deformation of the ice in the interior of the ice sheets and as rapidly-flowing glaciers and ice streams closer to the coasts. An ice stream is a massive flowing "river" of ice (hundreds of kilometers long, tens of kilometers wide, and one to two kilometers thick) that is bordered by walls of slowly-moving ice. The ice streams flow at speeds of hundreds of meters per year, and the ice on either side (the slow-flowing ridges) flow at speeds of a few meters per year. There is little apparent difference between the ice within an ice stream and within the ridges, yet the ice flow speeds differ by orders of magnitude. Understanding why these ice streams form, why they flow at these high speeds (by glaciological standards, hundreds of meters per year is blazingly fast!), whether they are stable, and their response to ongoing climate change are all questions of great importance [*Oppenheimer*, 1998; *Paterson*, 1994].

These ice streams are critical elements in the mass balance of the Antarctic, which is defined as the difference between accumulation of snow in the interior and removal of ice at the margins of the continent. The mass balance of the continent is directly related to global sea level, with West Antarctica containing the equivalent of 5 m of water, if spread across the oceans of the world[2]. Ice streams are dynamic, changing speed on millenial, century, and decadal time-scales, for poorly-understood reasons, with implications for ice-sheet modeling efforts aimed at predicting the future of large ice sheets.

Recent startling observations of dynamic behavior on *daily* time scales, where the ice streams change flow speed in a pattern controlled by the ocean tides, has prompted us to study the system in greater detail [*Anandakrishnan et al.*, 2003; *Bindschadler et al.*, 2003]. One ice stream, Whillans Ice Stream acts like a "slow fault" with slip of tens of centimeters occuring over a few minutes, and a quiescent, no-slip behavior in between. This slip is repeated on a regular and relatively rapid interval (generally a few hours), with the timing and size of slip controlled by the amplitude and phase of the ocean tide in front of the glacier. A neighboring ice stream, Bindschadler Ice Stream, displays a different behavior, where the tide modulates the flow speed by a factor of two, but the ice never fully stagnates, or displays the "fault-like" slip behavior.

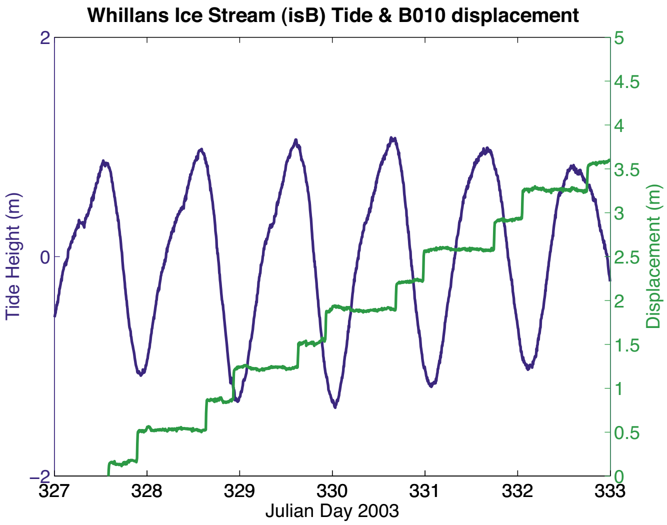


Satellite image mosaic of Whillans Ice Stream (flowing west from the left of the frame), and mountain glaciers flowing through the Transantarctic Mountains (the distinct flow stripes at the top of the frame). Whillans Ice Stream is bounded by slowly-flowing ridges to North and South. The circles indicate the locations where we deployed GPS and seismic stations. There is a region of heavy crevassing that marks the transition from ridge to ice stream. In the Radarsat imagery, the crevassed areas are bright due to the strong backscatter from the angular crevasses. The rectangular mosaic elements are Landsat-7 optical images. South is to the top-right of the frame.

SEISMICS & GPS & RADAR, OH MY...

To better understand this behavior, we realized that we needed to measure both the flow of the ice as well as the dynamic behavior at the base of the ice stream. The field experiment is made up of a "backbone" array of widely-spaced geodetic-quality GPS receivers, and two seismic arrays. The goal of each deployment is slightly different, but complementary: the GPS arrays →

[1]Accumulation of successive years of snow changes to ice in a few decades to centuries
[2]East Antarctica contains the equivalent of approximately 70m of water, but is hypothesized to be more stable than West Antarctica.



The blue curve (left axis) is the tide height in front of Whillans Ice Stream. The green curve (right axis) is the longitudinal displacement of one of the stations (B10, 10 km from the grounding line) on Whillans. The station displays stick-slip behavior controlled by the tide.

will record the times and size of the slip of the ice; the seismic array will record the source-locations and mechanisms of the seismicity associated with the slip. The backbone GPS array has a spacing between elements of approximately 50 km. We wished to record the slip of the ice, and changes in the slip of the ice, from the "grounding line" (the transition from floating ice shelf to grounded ice stream) upstream to regions where the effect of the tide is negligible. We also wanted to understand the lateral variability and the role of the marginal shear zones in the flow of Whillans. On the other hand, the seismic deployment needed to have close spacing between elements (1–5 km) in order to locate and characterize the local seismicity from beneath the ice stream. We met both goals by using Twin Otter aircraft to deploy the GPS backbone array, and then establishing a camp on Whillans to deploy the seismic array.

The Tides experiment has benefited from strong support from a number of organizations, foremost among whom are IRIS/PASSCAL and UNAVCO who have provided the instrumentation.

We deployed the seismic and GPS receivers on the ice with exemplary support from the New York Air National Guard (NYANG), Raytheon Polar Services (RPSC), and Kenn Borek Air. The path to Whillans Ice Stream from State College, PA is a long and tortuous one, made considerably smoother by support that the National Science Foundation provides. Equipment is flown from the US to Christchurch, New Zealand by commercial air carriers or is carried by vessel. Once in New Zealand, the equipment is carried by US Air Force cargo planes to McMurdo Station, Antarctica. In McMurdo, we unpack and test the equipment before sending it on to the final destination.

Raytheon (the prime contractor for NSF) has established a base camp at Siple Dome Station (at 81°S, 149°W; about 150km north of Whillans Ice Stream and about 50 km south of Bindschadler Ice Stream) where a groomed skiway is maintained to receive LC-130 aircraft. This plane (operated by NYANG) can deliver thousands of kilograms of cargo, using pallets that slide out the back ramp. We used Siple Dome as a base station for the Twin Otter aircraft (ably piloted by crews from Calgary-based Kenn Borek Air) to deploy the GPS backbone array and to field our team of students, principal investigators, and collaborators, into a camp on Whillans.

Once at Whillans, we used snowmobiles to travel over the surface of the ice stream to install seismic stations, to perform ice-penetrating radar studies, to perform reflection seismic studies, to install additional GPS strain grids, and to perform glaciological studies such as surface firn properties.

For such a dynamic and fast-flowing mass of ice, Whillans is a surprisingly uncrevassed ice stream in this zone (within a few hundred kilometers of the grounding line). So long as we avoided the heavily crevassed marginal shear zone, we could travel in safety over the surface. With the help of colleagues at NASA, we had high-quality satellite imagery to identify possible trouble spots before going into the field. This allowed us to design our field experiments to operate safely and efficiently.

ONWARDS...

Our work was conducted in the austral summer of 2004–2005 (November 2004 to January 2005) and we are continuing to analyze the data. We will return to the Siple Coast of West Antarctica this austral summer (2005–2006) to deploy instruments to measure the response of Bindschadler Ice Stream to tidal forcing. We will deploy GPS, active-seismic arrays, and passive seismic arrays on the ice stream so that we can compare these two outwardly similar, but quite different, glaciers. From our preliminary processing, some clear results have emerged: Whillans Ice Stream shows tidal modulation effects far from the grounding line, thus the forces induced by the ocean tides travel up the ice stream. We are analyzing the measurements to determine the properties of the base of the ice stream. We are measuring a long-term slowdown in the flow speed of Whillans [*Joughin et al*., 2005], suggesting that the ice stream is continuing to change. Basal seismicity is linked to the slip-events, with large numbers of small thrust events at the base of the ice stream occuring within minutes of each slip.

In conclusion, we are beginning to understand the role of the basal boundary in controlling the flow-behavior of ice streams. There are striking parallels to fault-zones in rocks, with the ice stream forming one side of the fault, and the basal sedimentary till playing the role of fault gouge. Unlike faults in the lithosphere, this "cryospheric fault" slips on a regular timetable and has much to tell us about the future of the ice stream and the ice sheet. ■

Hercules LC-130 aircraft at Siple Dome.

ACKNOWLEDGEMENTS

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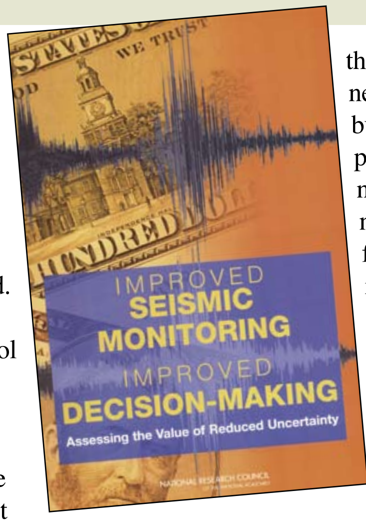
What is the Economic Value of Seismic Monitoring Information?

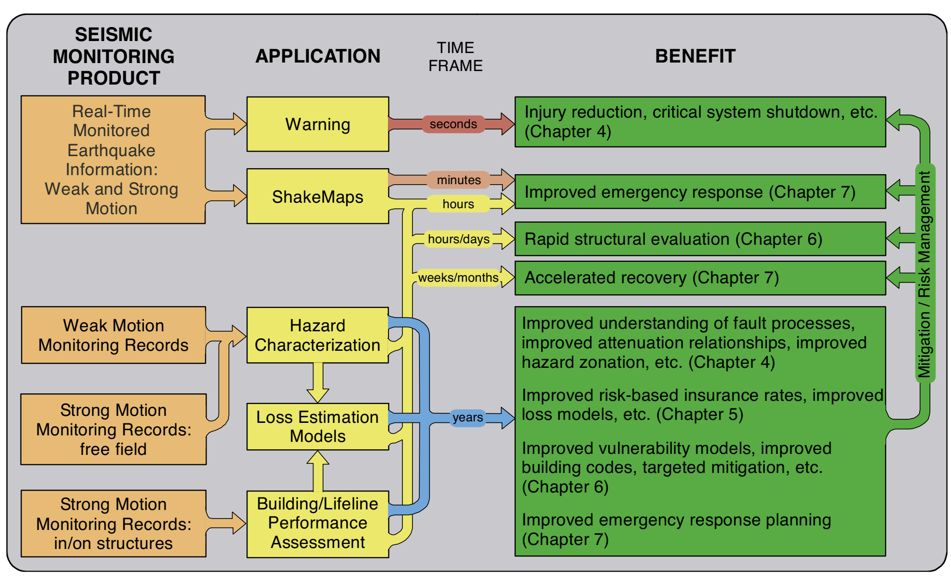
David Feary • National Research Council



For those who visit and assess areas devastated by earthquakes and have responsibility for ensuring that the damaging effects of earthquakes are minimized, the value of seismic monitoring as an essential tool is absolutely clear and unchallenged. However, providing an economic assessment of the value of this tool is a different and difficult issue, and one that has long challenged the nation's scientists and engineers. This situation prompted the U.S. Geological Survey to request that the *National Research Council* undertake a study specifically aimed at assessing the economic benefits of modernizing and expanding seismic monitoring activities in the United States—with a focus on the Advanced National Seismic System—so that the value derived from monitoring data can be compared to other activities competing for the same resources. The NRC, recognizing the multidisciplinary nature of this issue, populated the study committee with representatives from the range of professions involved with seismology, emergency management, and earthquake engineering issues, together with expert economists to ensure that the benefit analysis was undertaken with appropriate rigor.

The NRC committee determined that although it was possible to describe the numerous potential benefits provided by seismic monitoring data, at present it is not possible to rigorously quantify these benefits because the required information either does not exist or is not routinely collected. In addition, there are some benefits that realistically can never be quantified, but which nevertheless provide valid economic benefits to the nation. The committee focused on describing the considerable range of benefits provided by improved seismic monitoring data, developed quantifiable estimates when possible, and concluded that—on an annual basis—the dollar costs for improved seismic monitoring are in the tens of millions and the potential dollar benefits are in the hundreds of millions. These benefits can be categorized as:

- Improved loss estimation models (e.g., HAZUS) that increase public knowledge, confidence, and understanding of seismic risk as well as provide improved correlation between seismic risk and building code and land use regulations.
- Improved building design, as seismic monitoring data enables better correlation between building codes and seismic risk. This provides potential benefits in the form of reduced damage during ground shaking and reduced building costs for new buildings and those undergoing rehabilitation in areas shown to have lower seismic risk. Annual savings were estimated to be $142 million (see Table), mostly related to lower construction costs for new buildings and buildings selected for rehabilitation.
- Improved emergency response and recovery—better hazard identification, more targeted and faster mobilization following an earthquake, and rapid identification of unsafe buildings—that provide benefits in the form of lives saved, property spared, and reduced human suffering. →



The report specifically calls for continued integration of USGS earthquake hazard information and HAZUS loss estimation models for improved description of seismic risk in the U.S., and for the NEHRP agencies to collect data following earthquakes and sponsor applied research so that the benefits of seismic monitoring information can be documented.

The tragedy in nations surrounding the northern Indian Ocean caused by the 2004 Sumatran earthquake and tsunami provided vivid testimony to the awesome power of forces within the Earth's crust, and the enormous potential that these forces pose for devastating loss of life and economic disruption. This event focused national and international attention on the capabilities of warning systems for mitigating natural disasters, leading to accelerated implementation of long-established plans to expand tsunami warning systems. Will it take a similarly devastating earthquake in the U.S. to accelerate long-established—but only partially funded—plans to broaden seismic monitoring programs to maximize the potential for earthquake hazard mitigation?

USArray Data Products Workshop Report

Anne Trehu • Oregon State University

How will new "knowledge" about the Earth result from the EarthScope initiative? Collecting data is but one step of many that are required to generate new knowledge. The goal of EarthScope is to go beyond the production of specialized papers published in peer-reviewed journals and facilitate integration of this information across disciplines, thus providing new insights into the processes that shape the Earth. Another goal is to more broadly disseminate this information to the scientific community and to the public.

The quantity of data expected from EarthScope is enormous, but seismologists have already addressed this issue of efficient management of very large data sets. Technical standards, centers for data collection and distribution, and a community norm of open data have been developed over the past twenty years and serve the global seismological community quite well. Adapting these facilities to handle the increased USArray data flow is straightforward.

Multidisciplinary integration of the scientific results obtained from these data to address the broader EarthScope goals is a more difficult, and controversial, problem. Tools that now facilitate seismological research, such as waveform exchange mechanisms and standardized signal processing algorithms, are likely to fall short when geodesists, petrologists and others are looking to take advantage of the full panoply of EarthScope information.

In October 2004, the IRIS Consortium sponsored a workshop to discuss a wider range of potential data products from USArray. Anne Trehu chaired the workshops organizing committee, which also included Rick Aster, Matt Fouch, David James, Anne Meltzer and Stuart Sipkin. Nearly 40 invitees from academia, the USGS, and IRIS participated, representing a broad cross-section of seismologists and computer professionals with expertise in earthquakes, Earth structure, data archiving and distribution, and education and outreach.

The primary objectives of the workshop were to specify and prioritize a standard set of routine and higher-order USArray data products; to establish protocols and procedures for creating, reviewing and updating these products; and to propose a framework for supporting this work. Discussions focused on when and how to define protocols that would lead to automated or semi-automated techniques for analysis of data that are currently time-consuming and require considerable scientific input. In principle, these protocols could then be implemented at USArray or university-based facilities.

A report summarizing discussion and recommendations from the workshop is posted at *www.iris.edu/USArray*. The participants considered a wide range of issues, including the role of judgment and individual expertise in creating each product, the need for quality control and for updating of procedures, approaches towards presenting a product's uncertainty or non-uniqueness, and the development or research necessary to begin "routinely" preparing products.

Even with well-defined protocols, many "routine" data products would require oversight and quality control by a scientist whose research is closely tied to the product. Nevertheless, the protocols would encourage timely and complete access to products, facilitate comparison of results from different parts of USArray, and free up research time and funding for new, innovative approaches to data analysis, modeling and interpretation.

Four working groups – on waveform products, education and outreach, event characterization, and Earth structure – reached conclusions about the various low-level and high-level products that are most likely to be widely useful. Examples include tomographic velocity models, crustal thickness maps and shear wave splitting maps. Some products could be produced and distributed in the near future, while others will require significant development to be practical and serious evaluation to prove their reliability.

The workshop represents an early step in an ongoing process by which the EarthScope community will define data products. Ongoing collaboration between USArray and ANSS is essential for the success of this effort. I hope that the report will be useful to EarthScope as a source of information on the types of products that should be provided, to investigators who are preparing EarthScope-related proposals that include product preparation, and to NSF review panels evaluating EarthScope science or operations proposals.

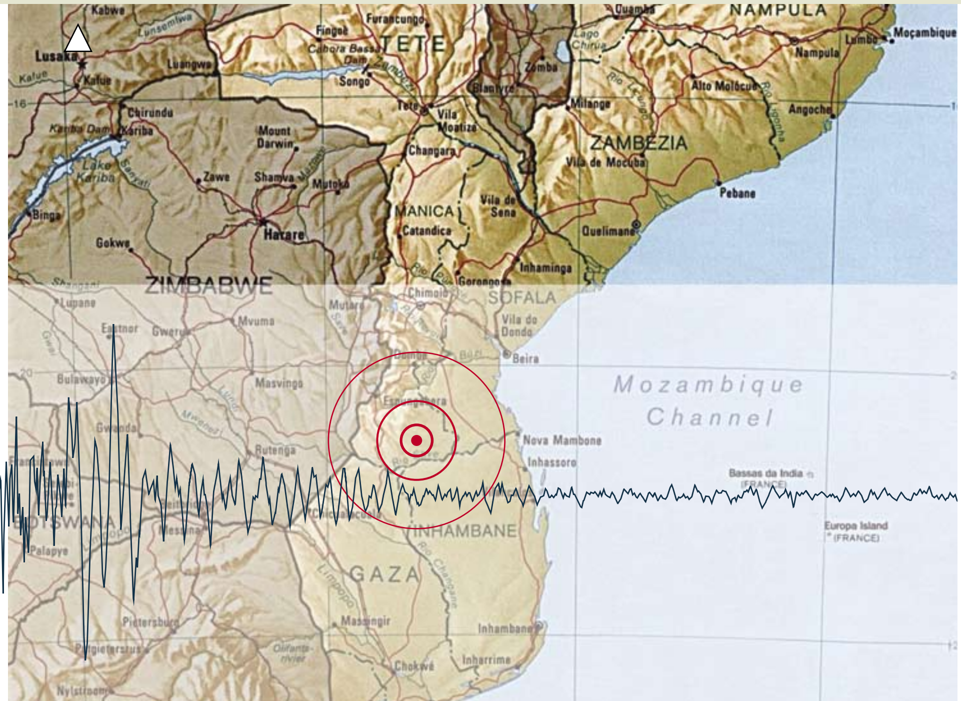
Staff News

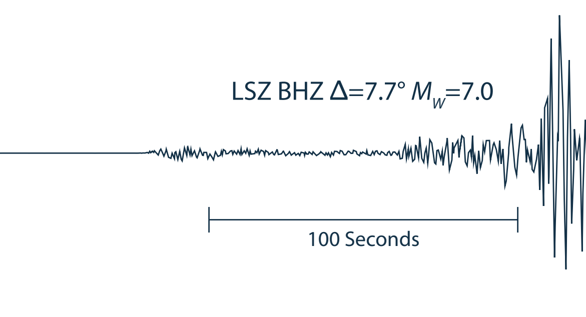
IRIS employs a total of 48 people at the Data Management Center in Seattle, WA, the PASSCAL Instrument Center in Socorro, NM, and IRIS Headquarters in Washington DC. IRIS Headquarters includes staff members for the President's Office, the Business Office, the Education and Outreach Program, the Global Seismographic Network and USArray. A complete list of staff members and their contact information is posted at www.iris.edu. Through subawards from IRIS, employees of the New Mexico Institute of Mining and Technology staff the PASSCAL Instrument Center and employees of the University of California, San Diego operate the IDA stations of the GSN. In cooperation with IRIS, the staff of the Albuquerque Seismological Laboratory operates the USGS stations of the GSN.

This Issue's Bannergram

M_w 7.0 in Mozambique on February 22, 2006

The M_W 7.0 earthquake on February 22, 2006, occurred near the southern end of a zone of seismicity extending southward from the Malawi rift through central and southern Mozambique. This zone of seismicity marks the southern terminus of the East African rift system, straddling the boundary between the Nubia and Somalia plates. How this plate boundary connects in southern Mozambique across the continent-ocean transition to the mid-ocean ridge system in the Indian Ocean is uncertain.





This event is one of the largest earthquakes in eastern Africa to have been digitally recorded; the only known M>6 event within 1000 km of this epicenter is a 1989 M_S 6.2 earthquake 840 km to the north. As would be expected, the earthquake was shallow and had an extensional source mechanism on a north-south striking fault plane.

Although ground shaking was felt throughout southeastern Africa, losses from the earthquake (including 5 deaths and 28 injuries) were limited because of its location in a sparsely populated region of Mozambique, 200 kilometers from the nearest large town of Beira and 500 kilometers from the capital city of Maputo.

Among stations transmitting data to the DMC in near real time, USGS/GSN station LSZ (Lusaka, Zambia) at a distance of 7.7° was closest. In the unfiltered broadband vertical displacement record shown here (and on page 1), the P and S body wave arrivals are visible but dwarfed in amplitude by the crustal phases and surface waves that arrive later. ■

IRIS Newsletter

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The Incorporated Research Institutions for Seismology (IRIS) is a university consortium of over 100 research institutions dedicated to monitoring the Earth and exploring its interior through the collection and distribution of geophysical data. IRIS programs contribute to scholarly research, education, earthquake hazard mitigation, and monitoring underground nuclear explosions. IRIS operates through a Cooperative Agreement with the National Science Foundation under the Division of Earth Science's Instrumentation and Facilities Program. Funding is provided by the National Science Foundation, the Department of Energy, other federal agencies, universities, and private foundations. All IRIS programs are carried out in close coordination with the US Geological Survey and many international partners.

The IRIS Newsletter welcomes contributed articles. Please contact one of the editors.

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2006 IRIS Workshop

WESTWARD LOOK RESORT • TUCSON, AZ • JUNE 8-10, 2006

– REGISTER AT WWW.IRIS.EDU

– REGISTRATION DEADLINE – APRIL 25

– HOTEL RESERVATION DEADLINE – MAY 6

– ABSTRACT DEADLINE – MAY 7

IRIS will be returning to the Westward Look Resort in Tucson, Arizona for the 17th Annual IRIS Workshop.

The Workshop will open on Thursday with "USArray Today" – a full day of talks, posters and meetings of special interest groups about USArray and the exciting first results from Flexible Array experiments and the Transportable Array. Friday will begin with a morning field trip to the Santa Catalina metamorphic core complex led by Jon Spencer of the Arizona Geological Survey, and in the afternoon there will be talks and posters on "Interpreting Velocity and Attenuation: Temperature, Composition or State?" including perspectives from rock mechanics and geochemistry. The workshop will conclude Saturday with sessions on international seismology – including interesting talks in the morning from international development experts on how seismology fits into their world, followed by talks and posters in the afternoon from seismologists whose overseas research has intersected with development issues. Meeting registration and abstract submission are now posted on the IRIS website.

MAY 23-26, 2006

AGU Joint Assembly
Baltimore, MD
www.agu.org

JULY 10-14, 2006

Workshop on Managing Waveform Data and Related Metadata for Seismic Networks
Sao Paulo, Brazil
www.iris.edu

JULY 24-27, 2006

Western Pacific Geophysics Meeting
Beijing, China
www.agu.org

AUGUST 27 - SEPTEMBER 1, 2006

International Disaster Reduction Conference
Davos, Switzerland
www.davos2006.ch

SEPTEMBER 3-8, 2006

European Conference on Earthquake Engineering and Seismology, Geneva, Switzerland
www.ecees.org

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