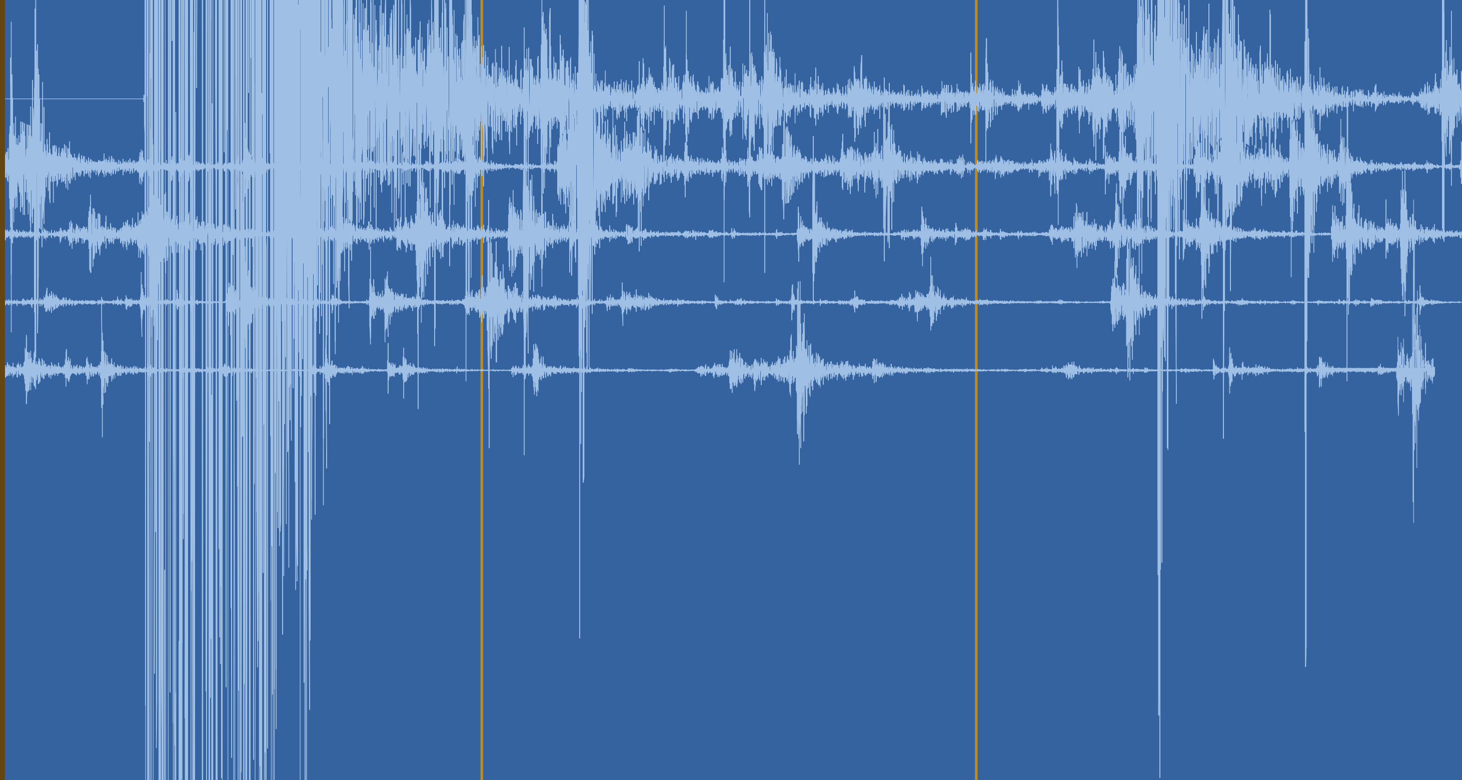


2003 ANNUAL REPORT

INCORPORATED RESEARCH INSTITUTIONS FOR SEISMOLOGY

IRIS

2003 ANNUAL REPORT

IRIS is a university research consortium 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 the international verification regime for the Comprehensive Nuclear Test-Ban Treaty. 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, 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.

Cover Photo: 1st place winner of the 2003 IRIS Annual Photo Contest taken by Chris Hayward, Southern Methodist University


Photo by: Chris Hayward, Southern Methodist University

The Year in Review and a Look Ahead

Göran Ekström, Chair, IRIS Board of Directors

It has started. In September of 2003, the cooperative agreements between the NSF and IRIS, UNAVCO, and Stanford University were signed, providing funding over the coming five years for the construction of EarthScope. Years of discussions, planning, and waiting have given way to a period of accelerating action, with the hiring of personnel, ordering of equipment, and renting of office space. The successful outcome of our organized efforts to secure funds for a new style of seismological observatory as part of EarthScope is a great achievement for the IRIS community. For the IRIS corporation, being entrusted by NSF with the construction and operation of USArray is an additional success.

With the successful launch of EarthScope, and with IRIS's role in building the USArray component of this new facility, come new responsibilities. In terms of funding, the USArray construction and operation will double the existing IRIS programs -- GSN, PASSCAL, DMS, and E&O. The continued success of IRIS depends on the vigor of our programs, and a challenge for the years ahead will be to achieve a comfortable balance between the significant and sustained efforts that will be needed to build and operate USArray, and the equally demanding work of maintaining the high quality and high level of efficiency associated with the operation of our existing programs. We also need to make sure that the existing programs continue to evolve to meet the expectation of the community, and that the level of excitement in our programs remains high.

Reviews are useful tools for critical examination of our programs, and for identifying potential problems and emerging opportunities. Earlier this year the GSN program underwent review by an external international committee. The committee visited the main facilities of the GSN and presented the Executive Committee with a report. The main conclusion of the review was that the GSN is an extraordinarily successful program. It notes that the program has been very adept at utilizing new technologies and at developing beneficial cooperative agreements with international partners. The committee also indicated that it saw additional opportunities for partnerships and the international cooperations in the GSN. The report, together with responses from the IRIS Executive Committee were forwarded to the NSF. In addition to the GSN review, the DMS has recently completed a Strategic Plan that emerged out of a self study and community review, and a review of IRIS management is getting under way.

A recurring theme in the long-range planning for IRIS, echoed also in the GSN report, is the establishment and nurturing of partnerships. Out of IRIS's many partnerships, none is more extensive or important than the one with the US Geological Survey. Over the past year, we have extended our cooperations in formal and informal ways. The USGS and NSF have signed a memorandum of understanding covering the establishment and operation of EarthScope facilities, and a joint IRIS-USGS committee has been created to oversee the establishment of the ANSS Backbone Network. This network will consist of the USArray permanent stations, the existing NSN and GSN stations, and additional ANSS permanent stations. A second very productive partnership is evolving with UNAVCO, encouraged not only by the many practical benefits that come from cooperation in the establishment of the geodetic and seismological components of EarthScope, but perhaps more significantly as a natural result of the disciplinary and intellectual proximity (and overlap) of our memberships.

We are entering our 20th year as a consortium and this may be a good time to reflect on our roots, and on what it is that has made the organization so successful. The strength of IRIS derives in large part from the active involvement of the community that it serves -- not only its 101 university members, but increasingly a much broader community of seismologists and Earth scientists in a wide range of organizations, both in the US and abroad. The active participation of the community in all levels of governance as well as the direct involvement of many individuals in the execution of IRIS programs lends the IRIS facility a distinct character when compared with many other science facilities. As the scope of IRIS's activities grows over the coming years as a consequence of USArray and the continued evolution of our existing programs, it will be important to find additional ways to engage an even larger proportion of the community in the activities of the consortium.

Executive Committee and Officers

Göran Ekström (Chair)	Harvard University
Thomas Owens (Vice Chair)	University of South Carolina
Andrew Nyblade (Secretary)	Pennsylvania State University
Susan Beck	University of Arizona
Arthur Lerner-Lam	Columbia University
Kate Miller	University of Texas, El Paso
Gary Pavlis	Indiana University
Robert van der Hilst	Massachusetts Institute of Technology
Candy Shin	IRIS Treasurer
David W. Simpson	IRIS President

Planning Committee

Adam Dziewonski (Chair)	Harvard University
Göran Ekström	Harvard University
Thomas Jordan	University of Southern California
Arthur Lerner-Lam	Columbia University
Alan Levander	Rice University
Anne Meltzer	Lehigh University
Michael Wysession	Washington University, St Louis
David W. Simpson	IRIS President
Gregory van der Vink	IRIS Director of Planning

Coordination Committee

Thomas Owens (Chair)	University of South Carolina, ExCom
Rick Aster	New Mexico Tech, E&O
David James	Carnegie Institution of Washington, PASSCAL
Thorne Lay	University of California, Santa Cruz, GSN
Guust Nolet	Princeton University, DMS
Gary Pavlis	Indiana University, ExCom
Timothy Ahern	IRIS DMS
Rhett Butler	IRIS GSN
James Fowler	IRIS PASSCAL
Shane Ingate	IRIS Director of Operations
Candy Shin	IRIS Treasurer
David Simpson	IRIS President
John Taber	IRIS E&O

Consortium

The IRIS management structure is an interface between the scientific community, funding agencies, and the programs of IRIS. The structure is designed to focus scientific talent on common objectives, to encourage broad participation, and to efficiently manage IRIS programs.

IRIS is governed by a Board of Directors consisting of representatives from each member institution. Operational policies are set by an Executive Committee elected by the Board of Directors. The Executive Committee, in turn, appoints members to the Planning Committee, the Program Coordination Committee, and the four Standing Committees that provide oversight of the Global Seismographic Network (GSN), the Program of Array Seismic Studies of the Continental Lithosphere (PASSCAL), the Data Management System (DMS), and the Education and Outreach Program (E&O). In addition, special advisory committees and ad hoc working groups are convened for special tasks. It is the role of the Standing Committees and the advisory subcommittees to develop recommendations for the Executive Committee which evaluates and approves such recommendations on behalf of the Board of Directors.

IRIS MEMBER INSTITUTIONS

University
Board Member • Alternate

University of Alabama
Dennis L. Harry

University of Alaska
Douglas H. Christensen • Roger Hansen

University of Arizona
Susan Beck • George Zandt

Arizona State University
Matthew J. Fouch • Ed J. Garnero

University of Arkansas at Little Rock
Haydar J. Al-Shukri • Jeffery B. Connelly

Auburn University
Lorraine W. Wolf

Boise State University
Lee M. Liberty • James P. McNamara

Boston College
John Ebel • Alan Kafka

Boston University
Geoffrey Abers • Rachel E. Abercrombie

Brown University
Karen Fischer • Donald Forsyth

California Institute of Technology
Donald Helmberger • Thomas Heaton

University of California, Berkeley
Barbara Romanowicz • Lane Johnson

University of California, Los Angeles
John Vidale • Paul Davis

University of California, Riverside
Stephen K. Park • David D. Oglesby

University of California, San Diego
Peter Shearer • Jon Berger

University of California, Santa Barbara
Craig Nicholson • Ralph Archuleta

University of California, Santa Cruz
Thorne Lay • Susan Schwartz

Carnegie Institution of Washington
Paul Silver • Selwyn Sacks

Central Washington University
Timothy Melbourne • Charles Rubin

University of Colorado, Boulder
Mike Ritzwoller • Anne Sheehan

Colorado School of Mines
Roel Snieder • Thomas Boyd

Columbia University
Paul G. Richards • Arthur Lerner-Lam

University of Connecticut
Vernon F. Cormier • Lanbo Liu

Cornell University
Muawia Barazangi • Dogan Seber

University of Delaware
Susan McGeary

Duke University
Peter Malin • Eylon Shalev

Florida International University
Dean Whitman

University of Georgia
Robert Hawman • James Whitney

Georgia Institute of Technology
Leland T. Long • James Gaherty

Harvard University
Göran Ekström • Adam Dziewonski

University of Hawaii at Manoa
Gerard Fryer • Charles Helsley

IGPP/Lawrence Livermore National Laboratory
William Walter • Peter Goldstein

IGPP/Los Alamos National Laboratory
Hans Hartse • Leigh House

Idaho State University
Joseph M. Kruger

University of Illinois at Urbana Champaign
Wang-Ping Chen • Xiaodong Song

Indiana University
Gary L. Pavlis • Michael Hamburger

Indiana University/Purdue University at Fort Wayne
Dipak Chowdhury

Kansas State University
Stephen Gao • Charles Oviatt

University of Kansas
Ross A. Black

University of Kentucky
Edward W. Wollery • Zhenming Wang

Lawrence Berkeley National Laboratory
D.W. Vasco • E.L. Majer

Lehigh University
Anne Meltzer

Louisiana State University
Juan Lorenzo • Roy Dokka

Macalester College
John P. Craddock • Karl R. Wirth

Massachusetts Institute of Technology
Robert Dirk van der Hilst • Bradford H. Hager

University of Miami
Tim Dixon • Falk Amelung

The University of Memphis
Jer-Ming Chiu • Arch Johnston

University of Michigan
Larry Ruff

Michigan State University
Kazuya Fujita • David W. Hyndman

Michigan Technological University
Wayne D. Pennington • Jimmy F. Diehl

University of Minnesota

University of Missouri
Eric Sandvol • Mian Liu

University of Montana
Michael Stickney • Marvin Speece

University of Nevada, Las Vegas
Catherine Snelson • Jim O'Donnell

University of Nevada, Reno
Glenn Biasi • Steve Jaume

University of New Orleans
Abu K.M. Sarwar

New Mexico Institute of Mining & Technology
Richard C.Aster • Harold Tobin

New Mexico State University
James Ni • Thomas Hearn

State University of New York at Binghamton
Francis T. Wu • Jeff Barker

State University of New York at Stony Brook
William Holt • Daniel Davis

University of North Carolina, Chapel Hill
Jonathan Lees • Jose Rial

Northern Illinois University
Paul Stoddard • Philip Carpenter

Northwestern University
Ray Russo • Seth Stein

The University of Oklahoma
Roger Young • Judson Ahern

University of Oregon
Eugene Humphreys • Doug Toomey

Oregon State University
John Nabelek • Anne Trehu

Pennsylvania State University
Shelton S. Alexander

Princeton University
Guust Nolet • Robert Phinney

University of Puerto Rico, Mayagüez
Christa von Hillebrandt • Eugenio Asencio

Purdue University
Lawrence W. Braile • Scott King

Rensselaer Polytechnic Institute
Steven Roecker • Robert McCaffrey

Rutgers University
Vadim Levin • Michael J. Carr

Rice University
Alan R. Levander • Dale Sawyer

Saint Louis University
Brian J. Mitchell • Keith Koper

San Diego State University
Robert Mellors • Steven Day

San Jose State University
Donald L. Reed • Richard Sedlock

Southeast Missouri State University
Nicholas H. Tibbs

University of South Carolina
Tom Owens • Pradeep Talwani

University of Southern California
Thomas H. Jordon • Ta-Liang Teng

Southern Methodist University
Eugene T. Herrin

Stanford University
Gregory C. Beroza • Simon Klemperer

Syracuse University
Douglas K. Nelson

University of Tennessee
Richard T. Williams

Texas A&M University
Richard Gibson • Philip D. Rabinowitz

Texas Tech University
Harold Gurrola • Calvin Barnes

University of Texas at Austin
Clifford A. Frohlich • Stephen P. Grand

University of Texas at Dallas
George McMechan • John Ferguson

University of Texas at El Paso
Kate Miller • Randy Keller

University of Tulsa
Christopher L. Liner • Bryan Tapp

University of UtahR
obert B. Smith • Gerald T. Schuster

Virginia Polytechnic Institute
J. Arthur Snoke • John Hole

University of Washington
Steve Malone • Kenneth Creager

Washington University, St. Louis
Douglas Wiens • Michael Wysession

West Virginia University
Thomas H. Wilson • Robert Behling

University of Wisconsin, Madison
Clifford Thurber • William J. Lutter

University of Wisconsin, Milwaukee
Keith A. Sverdrup • Brett Ketter

University of Wisconsin, Oshkosh
Timothy Paulsen

Woods Hole Oceanographic Institution
Ralph Stephen • Alan Chave

Wright State University
Ernest C. Hauser • Paul J. Wolfe

University of Wyoming
Scott B. Smithson

Yale University
Jeffrey J. Park

U.S. AFFILIATE MEMBER INSTITUTIONS

Naval Air Weapons Station, Geothermal Program Office
Francis Monastero

Maryland Geological Survey
Gerald R. Baum

EDUCATIONAL AFFILIATES

Arizona Western College
Michael Conway

Diné College

Eckerd College
Laura Reiser Wetzel

Trinity University
Glenn C. Kroeger

FOREIGN AFFILIATE MEMBER INSTITUTIONS

Academy of Sciences, Seismological Center, Albania
Betim Muco

Australian National University, Australia
Brian Kennett

The University of Queensland, Australia
Peter Mora

Observatório Nacional, Brazil
Jorge Luis de Souza

Universidade de Brasilia, Brazil
Joao Willy Rosa

Universidade de São Paulo, Brazil
Marcelo Assumpção

Ecole Polytechnique, Canada
Marianne Mareschal

Geological Survey of Canada, Continental Geoscience Division
Isa Asudeh

University of British Columbia, Canada
Michael G. Bostock

University of Toronto, Canada
Kin-Yip Chun

Universidad Nacional, Costa Rica
Federico Güendel

Geophysical Institute, Czech Republic
Axel Plesinger

Masaryk University, Czech Republic
Petr Firbas

National Research Institute of Astronomy and Geophysics, Egypt
Amin Ibrahim Hussein

University of Bristol, England
George Hellfrich

University of Cambridge, England
Keith Priestley

The University of Leeds, England
Roger Clark

University of Leicester, United Kingdom
Peter Maguire

International Institute of Earthquake Engineering and Seismology, Iran
Manouchehr Bahavar

Centro de Investigacion Cientifica y de Educacion Superior de Ensenada, Mexico
Cecilio J. Rebollar

Utrecht University, The Netherlands
Roel Snieder

Institute of Geological & Nuclear Sciences, New Zealand
Mark Peter Chadwick

University of Otago, New Zealand
Helen Anderson

Victoria University, Institute of Geophysics, New Zealand
Martha Kane Savage

University of Bergen, Norway
Eystein S. Husebye

Instituto Geofisico Del Peru, Peru
Edmundo Norabuena

Chinese Academy of Sciences, China
Ai Yinshuang

Institute of Geology, SSB, Beijing, PRC
Qiyuan Liu

Institute of Geophysics, Beijing, PRC
Gongwei Zhou

Peking University,PRC
Shao Xian Zang

University of Hong Kong, PRC
Lung Sang Chan

Institute of Geophysics, Polish Academy of Sciences, Poland
Pawel Wiejacz

Instituto Superior Técnico, Portugal
Joao F.B.D. Fonseca

Universidade do Porto, Faculdade de Engenharia, Portugal
Rui Carneiro-Barros

National Institute for Earth Physics, Romania
Andrei Bala

Kuban State University, Russia
Vladimir Babeshko

Russian Academy of Sciences, Russia
Vitaly V. Adushkin

Hanyang University, Republic of Korea
So Gu Kim

Institute of Geophysics, Switzerland
Domenico Giardini

Academia Sinica, Institute of Earth Sciences, Taiwan
Bor-Shouh Huang

National Central University, Taiwan
Kuo-Gong Ma

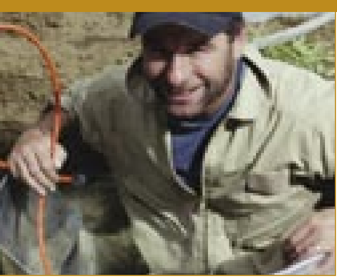
Istanbul Technical University, Turkey
Tuncay Taymaz

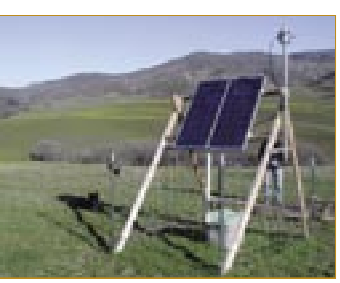
Kandilli Observatory, Bogazici University, Turkey
Nurcon Ozel

Tubitak-Marmara Research Centre, Turkey
M. Namik Yalcin

PASSCAL

The Program for the Array Seismic Studies of the Continental Lithosphere (PASSCAL) is a program of portable instruments for use by individual scientists for high-resolution experiments in areas of special interest.



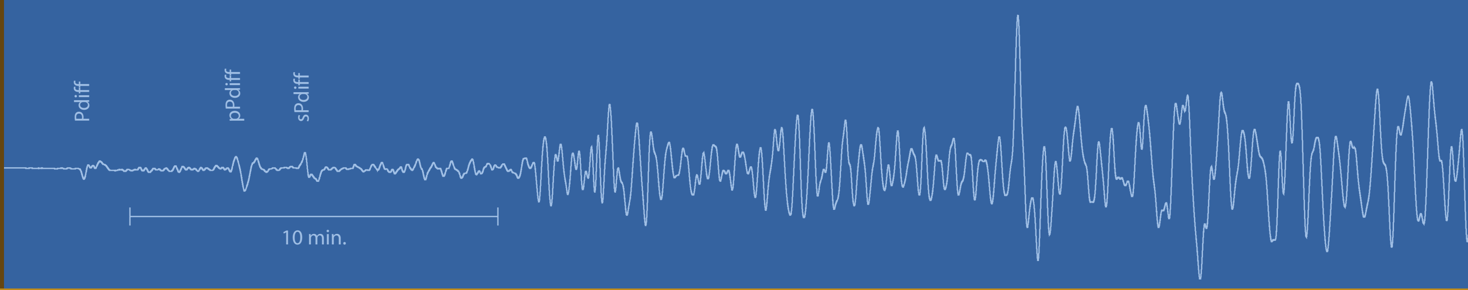


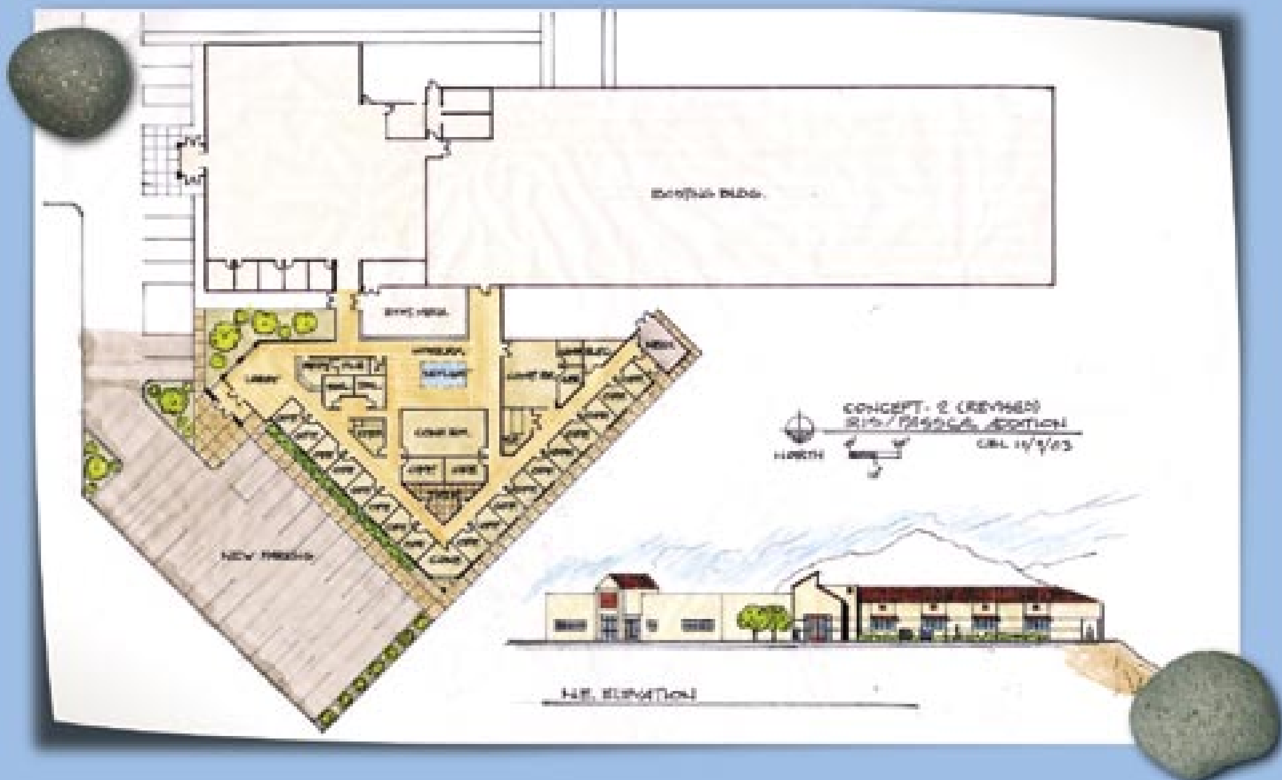
PASSCAL has provided equipment and support to over 50 experiments this year. The broadband instrument pool has grown to over 300 instruments, but the waiting time for experiments continues to be around two years. The limitations on broadband instrumentation continue to be the broadband sensors, of which there is a chronic shortage. PASSCAL has continued an aggressive policy of broadband sensor acquisition, but the demand continues to outrun availability. Thus, even though the number of broadband experiments has continued to decline, the total number of instruments requested has increased, and we expect this trend to continue. The active-source instrument pool of single channel “Texan” instruments contains over 800 instruments. The instruments continue to be popular because of their light weight and ease of use. Usage of the instruments is quite heavy in the summer field months with both domestic and foreign experiments. Delays in acquiring the PASSCAL target of 1200 instruments has put additional pressure on the useage of the current pool of 800 instruments.

To help address the problems of increasing instrument demand and the effects of aging on the current instrument pool, Congress appropriated $6,500,000 for the PASSCAL program spread over the last three fiscal years. The funding, provided through DOE’s Nonproliferation and National Security research and development account, has not only allowed for the replacement of some of the older instruments in the pool but also for the development of a new generation telemetered array that will consist of 25 broadband stations. This telemetered array will augment the two 32 station arrays currently available and are part of a larger effort to increase the use of telecommunications technology, including satellite, for use by broadband stations in remote deployments of increasingly large numbers of stations. The money in the FY02 and FY03 budgets has already been spent or is in the process of being spent to replace the older data recorders in the pool that can no longer be easily repaired. All experiments now going into the field are being equipped with new generation dataloggers. Older dataloggers that are scheduled for retirement from service continue to find considerable use on a “loan” basis to a wide variety of experiments that otherwise could not have been fielded.

PASSCAL took delivery of the first of the new prototype instruments from Quanterra and Refraction Technology in December of 2001. The instruments were tested in a series of local deployment and then sent to the field with regular scheduled experiments in late 2002 and 2003. As of the fall of 2003 we have over 150 of these new generation instruments in the field. The current funds allow us to purchase another 150 to 200 instruments that will make a significant pool of new instruments. Apart from the usual new instrument glitches, the new dataloggers function extremely well and represent a very significant advance in capability, particularly recording and networking capability, over the older generation instruments.

Development of field software has continued with the goal of making it easier for investigators





to quality control field data, convert it to a useful processing format and archive it at the Data Management Center. Over the last year, the development efforts have centered on integrating the data from the new instruments into the existing data flow. The development efforts are not only aimed at improving the software associated with the broadband stations, but also with the Texan instruments. The fact that up to 800 of these instruments are deployed at one time, sampling at relative high sample rates (100-200 sps) means that large volumes of data can be collected very quickly. The current development is aimed at making it possible to reformat and view the data with the minimum number of processing steps. The new Texan software is now being use in the field on a regular basis.

In addition to the software developments, there are also hardware modifications that will be incorporated in the next purchase of Texan instruments. This new generation of hardware will have a minimum of 256 Mbytes of memory as opposed to the 32 Mbytes in the original instrument. The new instruments will have a data upload capacity of more than 100 Mbytes per second as well as a more rugged carrying case. All of these changes are designed to increase the flexibility of the use of the instruments as well as speed the data upload and processing of the data.

Construction will begin shortly on the new wing of the PASSCAL Instrument Center at New Mexico Tech for housing the Array Operations Facility of USArray. This 11,000 square foot addition, which will more than double the engineering and laboratory space of the current facility, is being constructed with funds provided by the State of New Mexico through New Mexico Tech. Completion is anticipated in late 2004. While the two operations are separate from one another, there will be considerable overlap of function and some integration and intermingling of technical staff is certain to occur. We consider this advantageous to both operations.

Standing Committee

David James (Chair)	Carnegie Institution of Washington
John Collins	Woods Hole Oceanographic Institution
Joan Gomberg	USGS, Memphis
John Hole	Virginia Polytechnic Institute
John Louis	University of Nevada, Reno
Steven Roecker	Rensselaer Polytechnic Institute
Anne Sheehan	University of Colorado
William Walter	Lawrence Livermore National Laboratory
Colin Zelt	Rice University
James Fowler	PASSCAL Program Manager


Photo by: Chris Hayward, Southern Methodist University

New PASSCAL Instruments in the Huailai Basin, China

Yun-Tai Chen, Zhi-Xian Yang • Institute of Geophysics, China Seismological Bureau

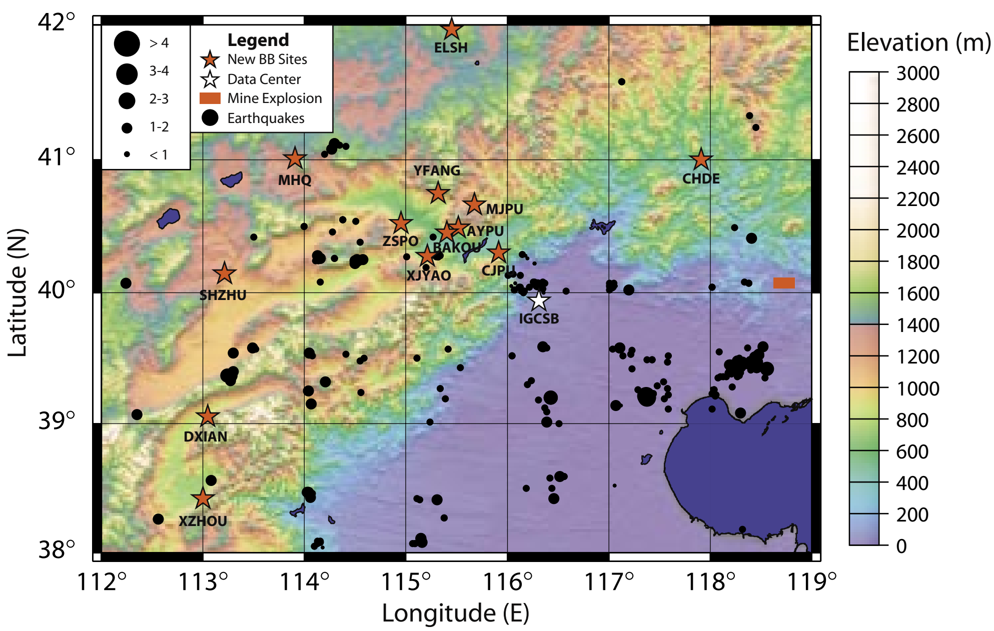
Brian Stump, Rong-Mao Zhou, Christopher Hayward • Southern Methodist University

In late November 2002, the PASSCAL Instrument Center assisted Southern Methodist University and the Institute of Geophysics, China Seismological Bureau (IGCSB) with the installation of the first five of an eventual 13 PASSCAL broadband stations in the Huailai Basin area. This was the first PASSCAL experiment to use the new Quanterra Q330 digitizers, which are part of the new set of instruments acquired with funds provided through the Department of Energy to replenish the PASSCAL pool.

Each site was installed in a pair of vaults, one vault for the seismometer and a second for the Q330 digitizer, power systems, and disk recorder (the Quanterra Baler). Each vault was approximately one meter on a side, one meter deep, and had been hand drilled in solid unfractured rock, a task that took a five man-team of drillers about one week per site.

The China-US teams installed the first two sites together during an initial two-week visit. The IGCSB team then successfully installed the next eleven sites.

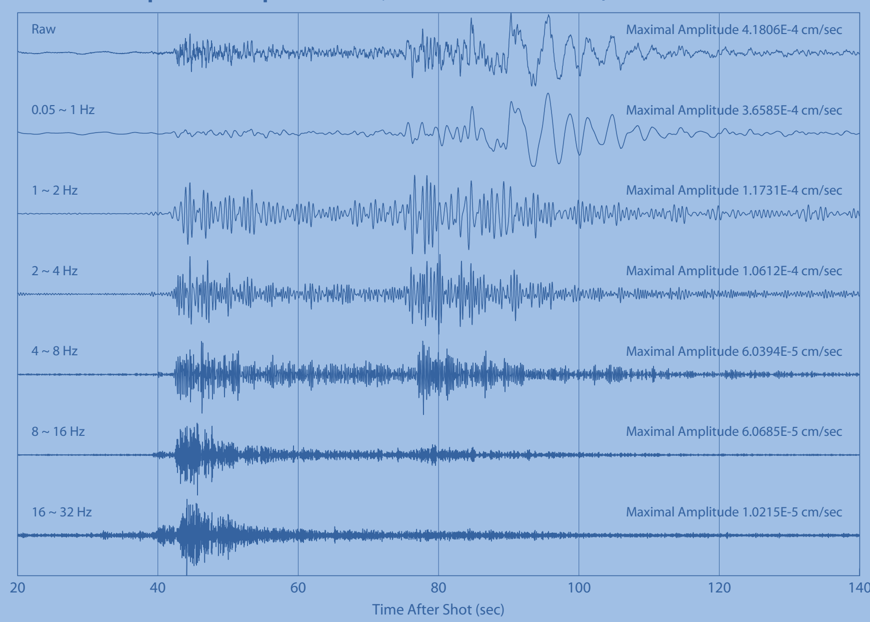
For this experiment, data are recorded locally on the Quanterra Baler, a small disk recorder with about one year of recording capacity at the 100 SPS recording rates used for the high frequency data stream. After the initial installation, it was planned to visit sites every few weeks to insure the new equipment was recording and to avoid downloading gigabytes of data in the field. However, the extended capacity was



proven fortunate when shortly after installation, the SARS outbreak curtailed field operations and instruments were left unattended for several months. Upon resumption of field operation, most of the recorders had continued recording during the field suspension.

The geographic focus of this investigation is the Yanqing-Huailai basin around Beijing. Within the Yanqing-Huailai Basin, earthquake risk and propagation path assessment are important because of the high historical seismicity in the Basin and Beijing's large population. Numerous underground mines regularly experience rock bursts and collapses resulting in disruption of mining operations, injury and occasionally death.

Spectral Composition of QianAn Event on Dec. 29, 2002 at AYPU



Existing broadband regional data are being gathered and combined with local network data to provide an initial assessment of the earthquake and mine-induced seismicity in the region. The key to this study is the separation of propagation and source effects for these events and will be addressed with an active experimental program once the background activity is quantified and understood. The utility of moment tensor inversions for extracting source parameters from broadband regional recordings of moderate earthquakes has been well illustrated by numerous researchers. This approach will be applied initially. In an attempt to expand this investigation to a wider frequency band and to improve the separation of source and propagation path effects, an active characterization of the sources will be done using close-in portable instrumentation. This active component will provide insight into the details of faulting parameters including accurate locations for aftershock sequences and allow the comparison of close-in to regional source characterization. In the case of mine-induced events the close-in measurements will again provide details on location and the dynamic process associated with underground failures. We believe that such information will provide the basis for understanding and mitigating the effects of such failures.

Preliminary analysis of the data recorded by the network demonstrates the low noise characteristics of many of the sites as a result of the hard rock vaults and remote locations. The data set includes high frequency local events from earthquake and mining sources, regional events and teleseisms. One event in particular demonstrates the utility of the broadband data in characterizing both shallow sources and crustal structure at regional distances. On December 29, 2002 the largest engineering explosion in the last decade occurred 270 km SE of the Huailai Basin. The explosion in the largest open-pit iron mine in Asia used 1.3 kilotons of explosives detonated over 1.3 sec. The seismic record at one of the stations, AYPU, is included. This record and its accompanying filter section demonstrates the effects of the shallow depth with 2-10 s surface waves and the explosion source with rich high frequency P waves to 32 Hz. The intermediate period surface waves are being used to constrain crustal shear structure and the efficient P wave propagation at high frequency to make Q estimates.

Photo by: Chris Hayward, Southern Methodist University

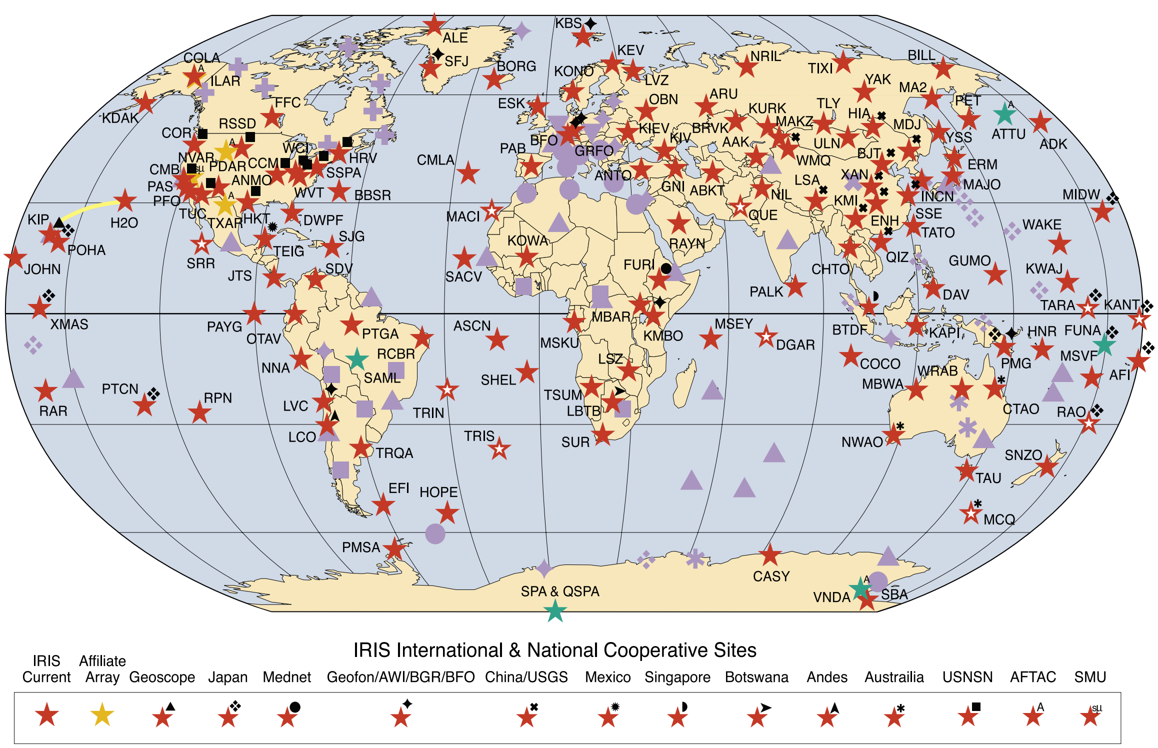
Photo by: Chris Hayward, Southern Methodist University

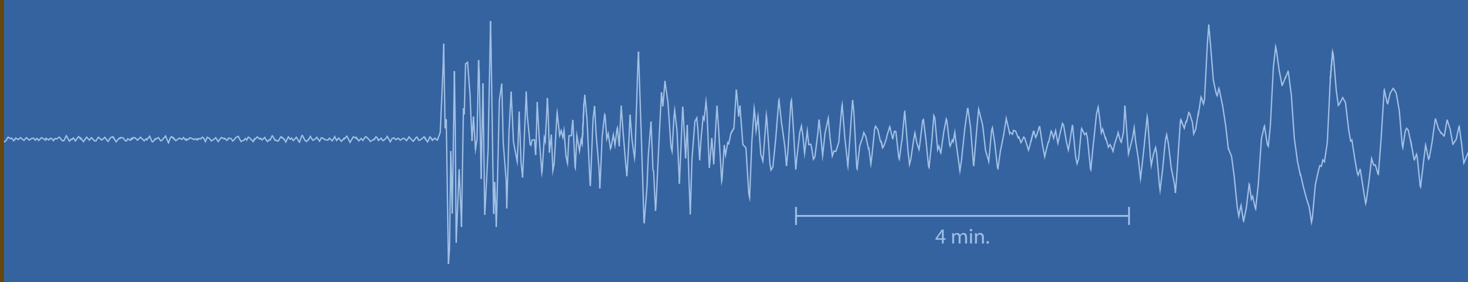
GSN

The Global Seismographic Network is a permanent network of state-of-the-art seismological and geophysical sensors connected by available telecommunications to serve the scientific research and monitoring requirements of our national and international community.

Installed to provide broad, uniform global coverage of the Earth, 135 GSN stations are now sited from the South Pole to Siberia and from the Amazon basin to the seafloor of the Northeast Pacific Ocean, in cooperation with over 100 host organizations and seismic networks in 59 countries worldwide. All GSN data are freely and openly available to anyone via the Internet.

The GSN grew by nine stations in 2003. New borehole stations were installed in western Brazil and at the South Pole, and a vault installation was completed on Funafuti island in the South Pacific as a joint station with Japan's Pacific 21 network. The new GSN station, QSPA, in the quiet sector 8 km toward Australia from the South Pole has set a new world's record for quiet conditions at frequencies above 1 Hz. Two new affiliate stations in Alaska and Antarctica , and three newly affiliate arrays in Texas, Wyoming, and Alaska were added through cooperation with the Air Force Technical Applications



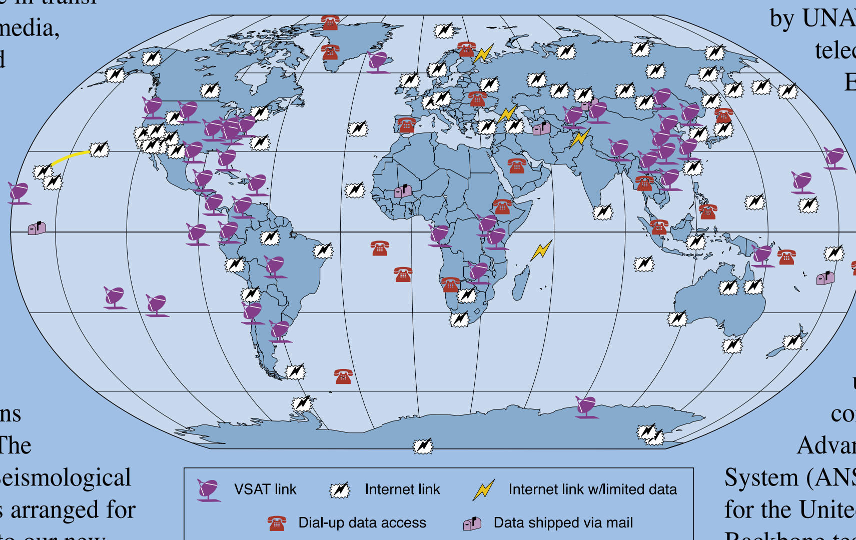


Center (AFTAC). In cooperation with Southerm Methodist University an array in Nevada joined as a GSN affiliate site. These four affiliated arrays add a new dimension to the GSN, and provide state-of-the-art array processing capabilities for the scientific community for Earth and earthquake studies.

Continuous, real-time telemetry of all GSN data is a fundamental goal. The GSN continues to create opportunities to extend new telecommunications capabilities to our stations. We are in transition from air-mailed media, dial-up telephone, and slow-speed Internet access to broadband VSAT satellite links and high-speed Internet. In 2003, 82% of the GSN is now on-line via Internet and VSAT links. Real-time access is available to all GSN stations in the United States. The USGS Albuquerque Seismological Laboratory (ASL) has arranged for Internet connectivity to our new GSN station on Funafuti. Working with the NSF Polar Programs, the GSN and the University of California at San Diego IRIS/IDA group has arranged for Irridium access to our station in northernmost Canada. Working with Geosciences Australia and Australian National University, respectively, ASL and IRIS/IDA have linked GSN stations in Antarctica and central Australia to their national satellite network and the Internet. The IRIS DMS has arranged telemetry access to the Grafenburg GSN station in Germany.

The GSN is working closely with the International Monitoring System (IMS) for the Comprehensive Nuclear Test Ban Treaty Organization (CTBTO) to share data from more than 50 GSN sites designated for participation in the IMS. Twelve GSN sites are now linked directly to the CTBTO International Data Centre via their global communication infrastructure (GCI) being established for secure communication. This satellite infrastructure is shared with the GSN, enabling remote operations, maintenance, and quality control for the IMS, and providing real-time GSN data access for the scientific community. Seven new shared VSAT links have been established this year, opening real-time access to GSN sites in Mexico, Costa Rica, Venezuela, Papua New Guinea, the Cook Islands, Iceland, and Chile.

GSN Communications



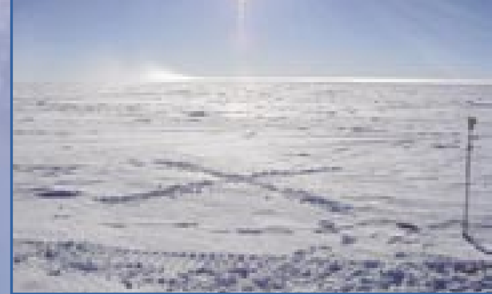
In the Pacific, the GSN is coordinating directly with the National Weather Service (NWS) to bring GSN data directly to the Oahu hub at the Pacific Tsunami Warning Center, where it is then forwarded to the Internet. A new VSAT system has been installed by ASL on Johnston Atoll, which augments existing Pacific coverage at Midway, Wake, Easter, and Pitcairn Islands. NWS is funding the satellite space segment costs for GSN data access. The Oahu hub is also being cooperatively used by UNAVCO/NASA for GPS telecommunication from Easter Island, and by the Pitcairn Islanders for their Internet access.

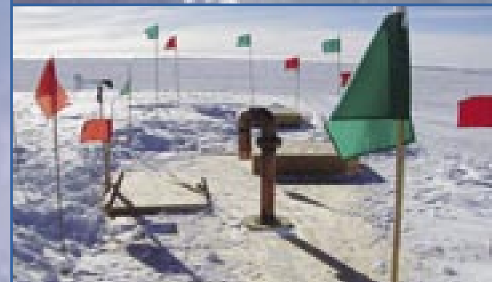
Four of the new GSN affiliate stations in Nevada, Wyoming, Texas, and Alaska became the first new sites under the USArray component of the Advanced National Seismic System (ANSS) Backbone Network for the United States. The USArray Backbone team at ASL completed seismometer upgrades at four US National Seismic Network (USNSN) stations in Georgia, Arkansas, Texas, and Virgina to further enhance the Backbone this year. Site preparations under joint USNSN and GSN funding for Backbone stations in Pensylvania and east and west Texas were completed.

Standing Committee

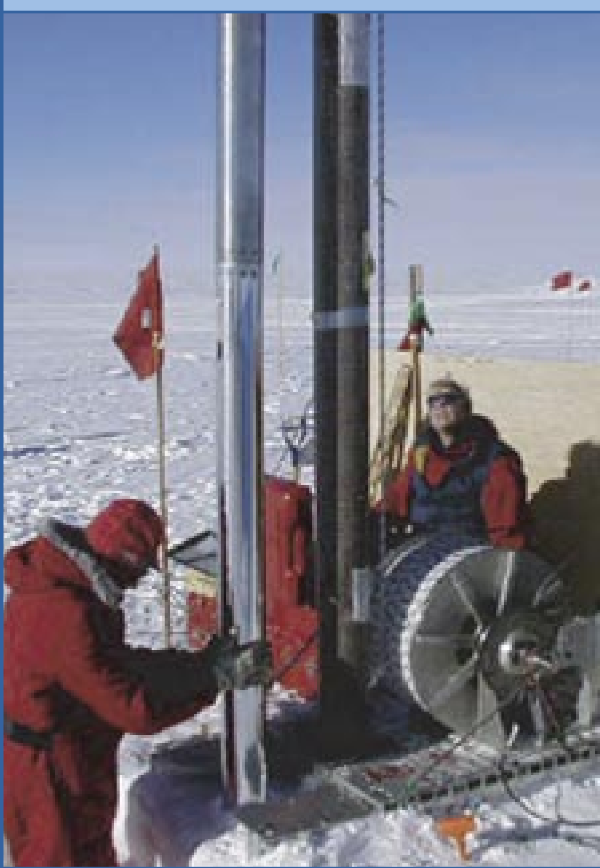
Thorne Lay (Chair)	University of California, Santa Cruz
Kenneth Creager	University of Washington
Paul Earle	NEIC, US Geological Survey, Golden
Bill Leith	US Geological Survey, Reston
James Gaherty	Georgia Institute of Technology
Gabi Laske	University of California, San Diego
Jeffrey Park	Yale University
Jeroen Tromp	California Institute of Technology
Lianxing Wen	State University of New York, Stony Brook
Rhett Butler	GSN Program Manager

SPRESSO





Seismology was the first scientific experiment at the South Pole during the International Geophysical Year 1957, and continues as the longest running observational science at the Pole. The Global Seismographic Network (GSN) instrumentation—the sixth generation since IGY—was upgraded last year as the new South Pole Remote Earth Science and Seismological Observatory (SPRESSO) was reaching completion, achieving the quietest noise levels anywhere on the planet. Seismology is inherently a global science. A world wide cooperative effort is required to monitor the Earth's seismicity. The seismic station at the South Pole is a key site in the GSN, funded by the U.S. National Science Foundation through the Incorporated Research Institution for Seismology (IRIS), and operated in partnership with the U.S. Geological Survey (USGS) through the Albuquerque Seismological Laboratory. This GSN station also serves as a United States contribution to the International Monitoring System for the Comprehensive Nuclear Test Ban Treaty.



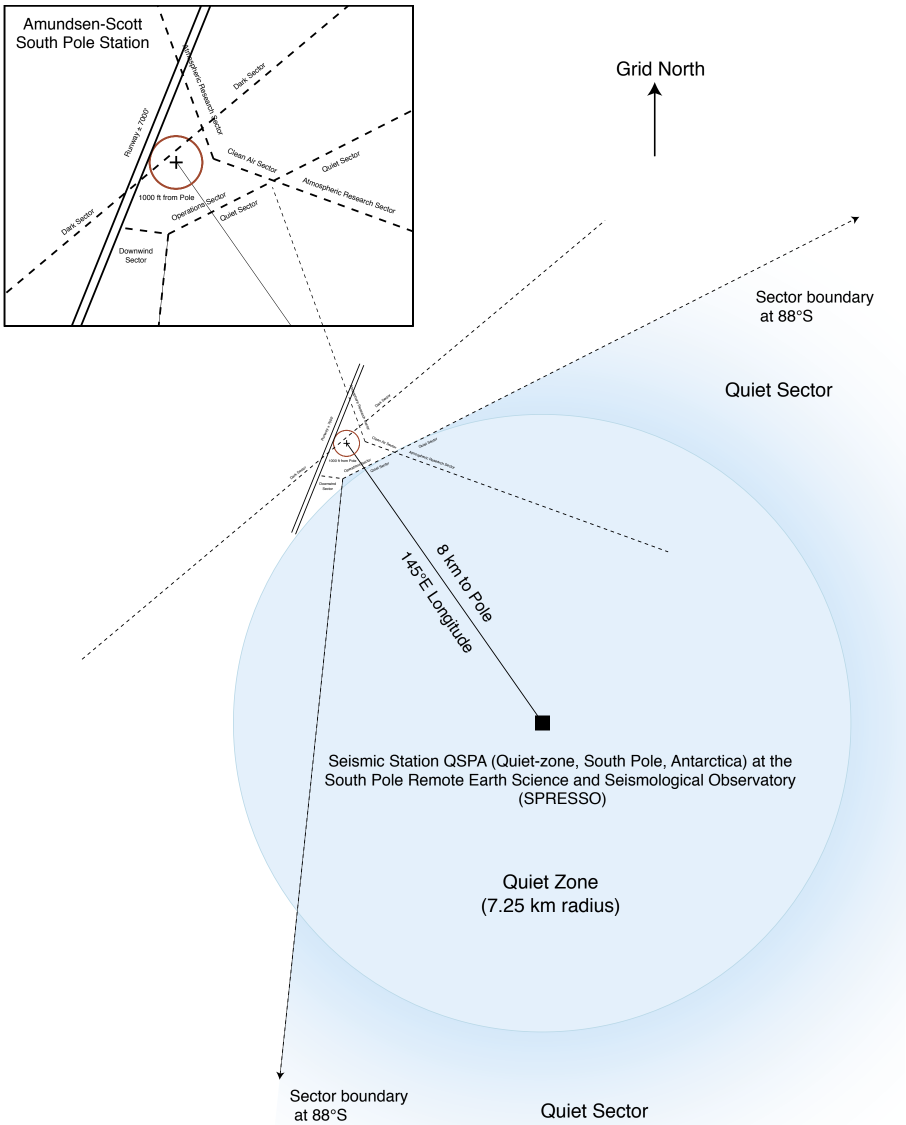
The South Pole has a unique vantage for seismology. Located on the Earth's axis of rotation, free oscillations of the Earth generated by great earthquakes and measured here are not effected by rotational forces felt elsewhere. Seismic energy felt as strong shaking at the source also travels down deep into the Earth all the way to the South Pole, where the GSN station has a window to the 'underside' of the earthquake, or a possible nuclear explosion. Seismology has discovered that the Earth's inner core—where seismic waves travel more swiftly along the rotational axis, and slower parallel to the equator—rotates slightly faster than the outer Earth. With most of the Southern hemisphere covered in ocean, the global coverage from Antarctica and the South Pole are crucial for unbiased studies of the Earth's three dimensional structure. Although Antarctica itself has few earthquakes, the South Pole station is the reference for all tectonic and structural studies of this continent and the southern oceans.

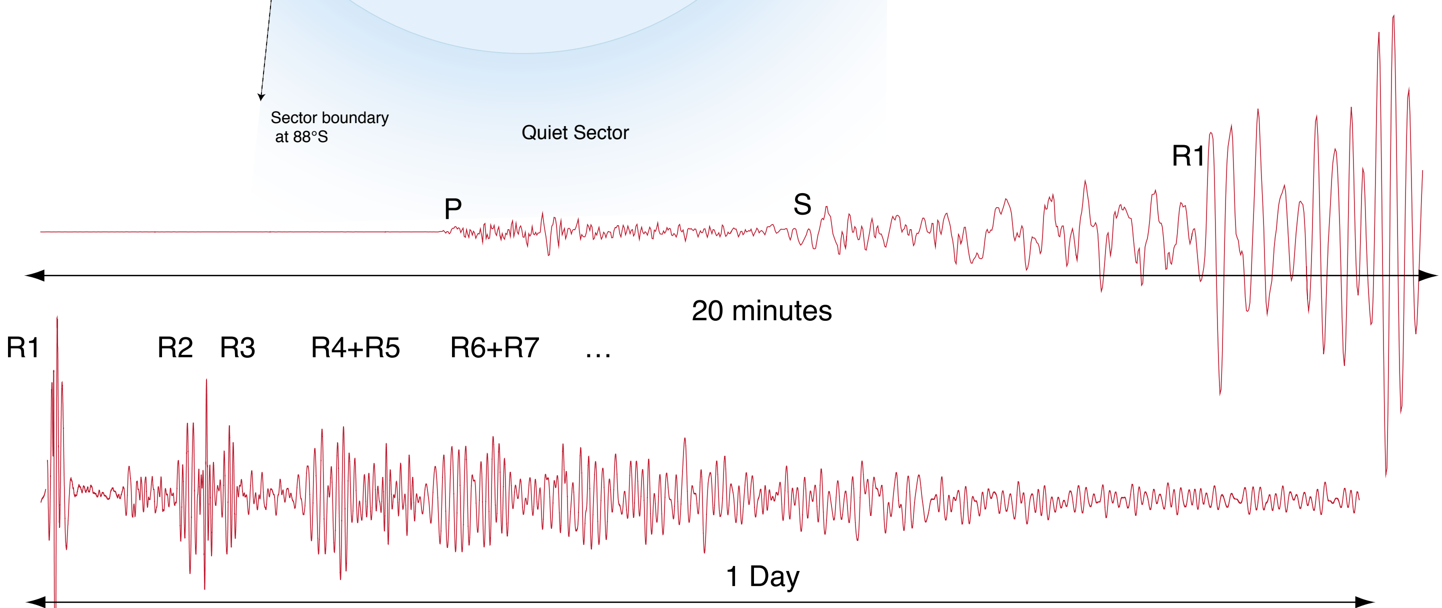
Photos by: Kent Anderson, Don Anderson, Jared Vineyard, and Rhett Butler

The Quiet Zone

The South Pole is one of the quietest places on the planet, except for wind and human activity at the Amundsen-Scott station. To achieve the true scientific potential for seismology, the seismic instrumentation is installed in the Quiet Sector away from human noise, and deployed in boreholes 300m (1,000 ft) deep in the ice to get away from the wind noise near the surface. The South Pole Remote Earth Science and Seismological Observatory (SPRESSO) is 8 km from the Pole, connected by electro-optical cable, to serve as an outpost for seismology and other experiments requiring quiet conditions.

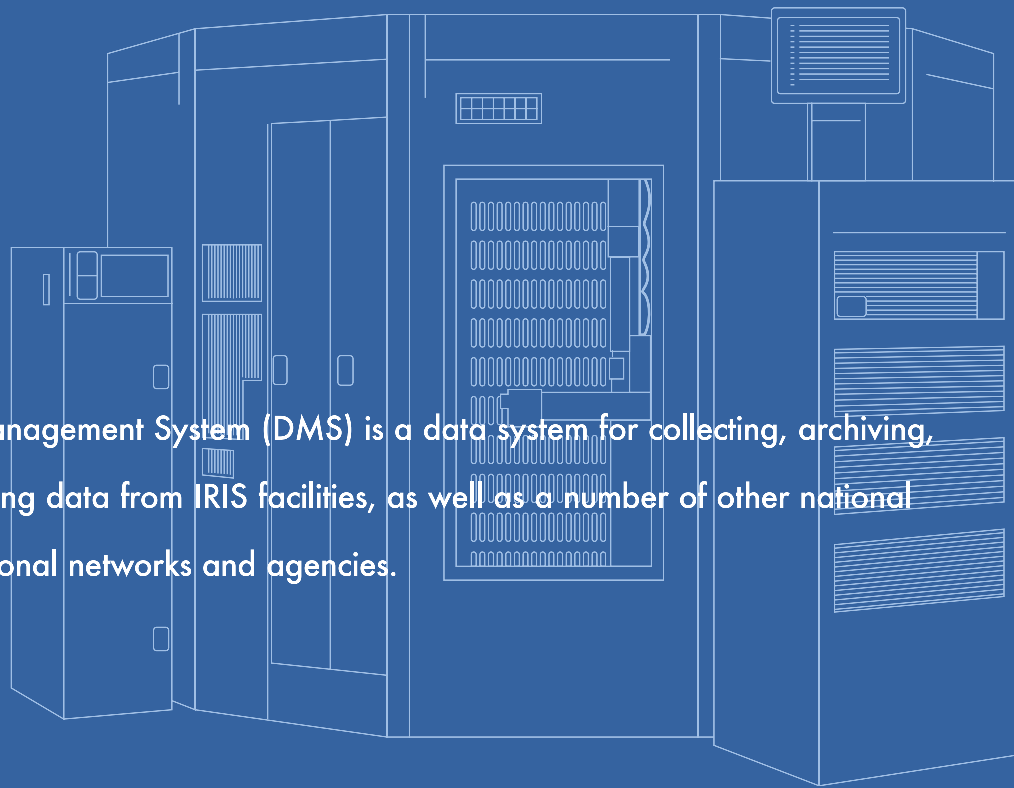
The completion of the first seismic borehole installations at QSPA in 2003 achieved the world's record for quiet conditions at frequencies above 1 Hz. A new ultra-sensitive seismometer and magnetometer will be installed this year at SPRESSO. The next phase planned will be the installation of a true three-dimensional seismic array with an aperture of 2.5 km installed as a lattice in the ice of the Quiet Zone, augmented by autonomous stations located 10-100 km out in the Quiet Sector.



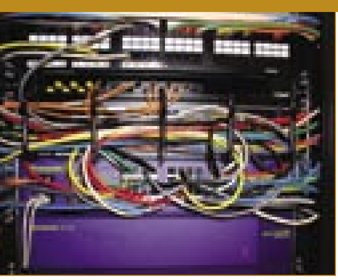


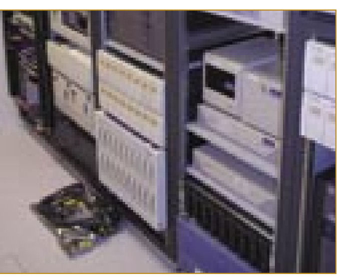
The magnitude 8.1 Balleny Island Earthquake in 1998 was one of the world's largest in the last decade and occurred 3,000 km from the South Pole toward Australia. The traces show the vertical motions at the South Pole GSN seismic station. In the upper trace, the Primary (P) compressional waves arrive within about 6 minutes after traveling over 700 km deep in the Earth. They are followed along essentially the same path by Secondary (S) waves that shake perpendicularly to their propagation direction. The difference in time (S-P) is a measure of the distance to the earthquake. These waves that travel through the body of the Earth are followed by much larger Rayleigh waves (R) that travel near the surface. In the lower trace in the day following the earthquake surface and body waves continue to vibrate around the planet. The surface wave R2 travels the long arc to the South Pole, going first north over the North Pole. After R1 passes the South Pole, it continues around the world again, returning as R3. Similarly, R2 propagates around again as R4. This continues (R5, R6, R7,…) for days as the waves spread out and merge. The seismometers at the South Pole are capable of recording the largest earthquakes with full fidelity and at the same time the smallest vibrations of about 1-billionth of a meter.

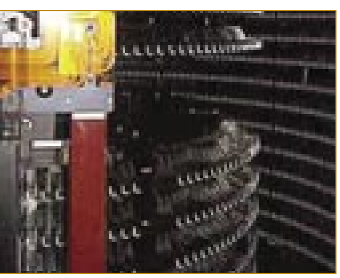
DMS

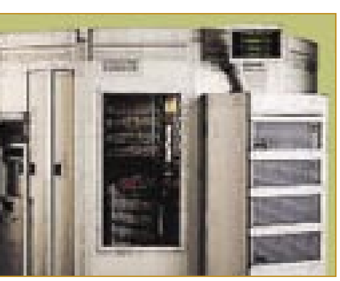


The Data Management System (DMS) is a data system for collecting, archiving, and distributing data from IRIS facilities, as well as a number of other national and international networks and agencies.









The quantity and diversity of data managed by the IRIS Data Management System continued to grow this year. As of September 29, 2003 there were 43.8 terabytes of seismological data in the archive at the Data Management Center. The DMC manages data from 48 different permanent seismic networks around the globe and has data from more than 100 temporary experiments.

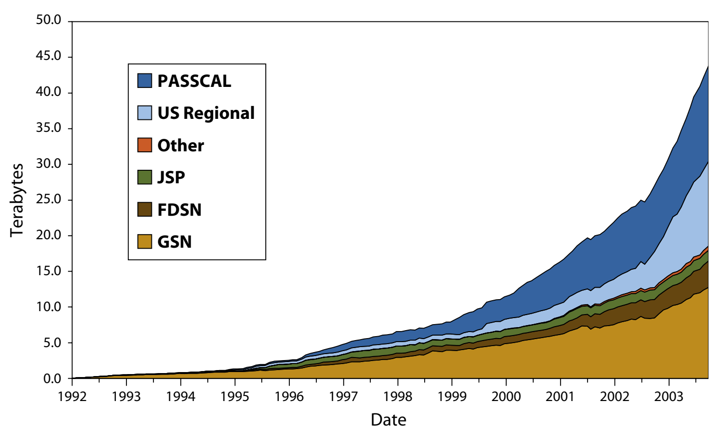
An increasing amount of data is reaching the DMC via electronic mechanisms. Thirty-five networks now contribute at least part of their data to the DMC in real time. The heart of the real time system is the Buffer of Uniform Data (BUD). Presently it can receive real time data from Antelope, Earthworm, LISS, and SEEDlink systems. Typically data from more than 700 stations are available for research use within a few tens of seconds to a few tens of minutes. Those interested in more details can refer to www.iris.washington.edu/bud_stuff/dmc/index.htm.

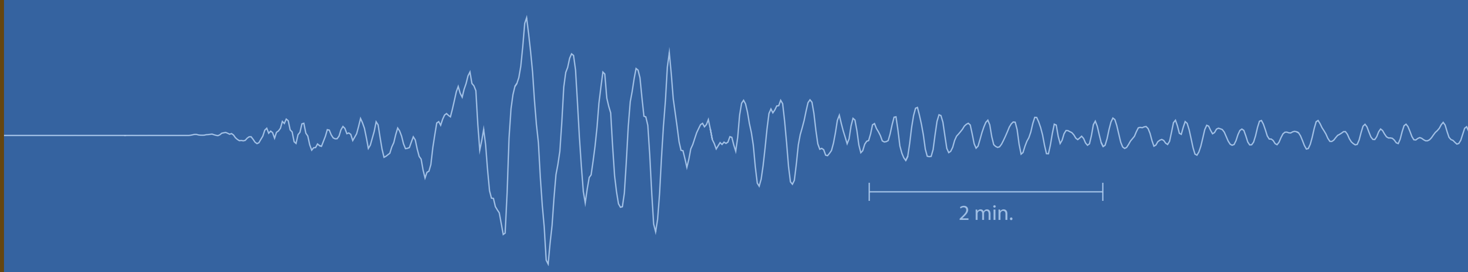
Nine networks with a total of 80 stations and 4 arrays are providing real time data that are new to the DMC this year. The contributions of the Kazakh National Data Center and AFTAC are especially interesting in that they provide data from arrays of many elements in addition to 3 component broadband stations. To help improve the delivery of complete data sets in SEED format, the DMS continues to develop tools (Portable Data Collection Center) that assist network operators in the generation and management of metadata.

The Fast Archive Recovery Method (FARM):

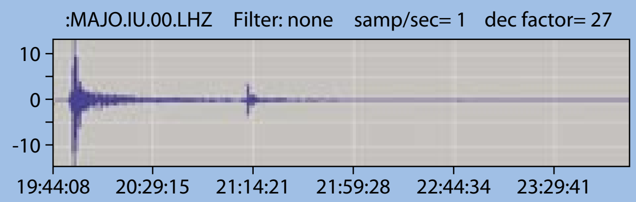
The DMC routinely preassembles data for larger events. When done from the real-time system, the volumes are called SPYDER® volumes. When produced from the quality-controlled archive, they are called FARM volumes. The historical FARM data repository is now completely populated and contains all data from larger events. This includes data from all of the networks from which the DMC has received data, unless access is temporarily restricted due to data release policies of the PASSCAL, OBSIP or SEIS-UK programs. The data are organized by event into miniSEED files, one for each network. As of October 2003 there are more than 101,000 of these files from 42 permanent networks since 1972. Additionally, hundreds of event files have been created for data from temporary networks.

Dual Sorted Archive as of 9-29-03

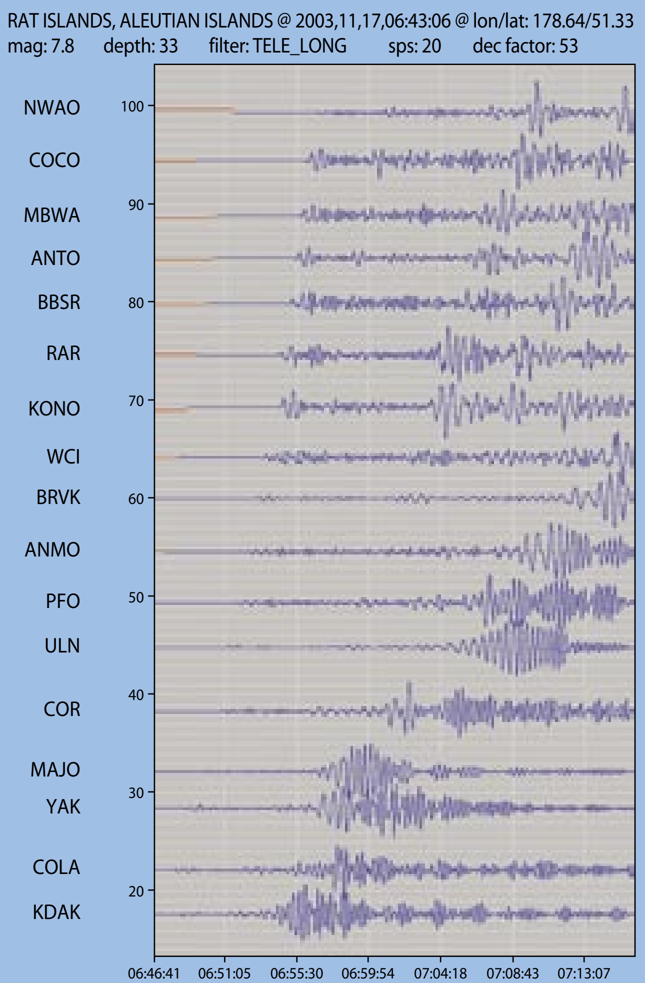




During this year, the DMC completed building the ultra-long-period UV-FARM archive. This contains all the data from the UH (1 sample every 100 seconds) and VH (1 sample every 10 seconds) channels from those stations that produce them. There are now 2,336 of the UV Farm files available. Each miniSEED file contains data for one month of UV data from each network.



Station MAJO Viewed through WILBER. A new waveform visualization tool has been developed for viewing waveforms in the FARM and SPYDER® repositories. This tool produces images in png format dynamically. This figure shows an example of the long period vertical channel from station MAJO for the September 25, 2003 Hokkaido event.



WILBER Record Section. This figure shows a record section that is now available through the WILBER interface.

Accessing FARM Volumes

Assembled data sets for large earthquakes in the FARM volumes are accessible through a variety of mechanisms:

WILBER II: A web based method that can be used to access FARM, SPYDER®, and UV-FARM products. WILBER has new methods of displaying waveforms that result in faster displays of the waveform components on a per channel basis. A record section plotting utility is being finalized for use through WILBER that supports filtering, phase marking and a variety of scaling options.

FTP: All data in the FARM and SPYDER® data repositories are also available through ftp, but only as miniSEED files. Users accessing data in this manner also need SEED metadata. Users can generate dataless SEED volumes from the IRIS web site and use RDSEED to combine the metadata with the waveforms.

WEED: The powerful request tool, WEED, can access data in the FARM and SPYDER® data repositories and can do it efficiently for hundreds of events. WEED is currently being rewritten in Java and in a way that will leverage the Data Handling Interface (DHI/FISSURES). Users will either be able to use WEED from local files containing information about events and stations or they will be able to access the event and station information directly from a data center supporting the FISSURES/DHI technology.

Access Tools

The Data Handling Interface (DHI) system of servers and client applications is now quite robust. The IRIS DMC, U. of South Carolina, and UC Berkeley now run one or more DHI servers and we anticipate adding to this list as time progresses. DHI clients are now numerous and useful and can be accessed at www.iris.washington.edu/DHI/clients.html. Several different groups have developed DHI clients including:

University of South Carolina

- *GEE (Global Earthquake Explorer) is a tool to access events and waveforms for use in the Education and Outreach communities.*

- *SOD: Standing Order for Data. This system will allow a seismologist to pre-order data with specific characteristics. While a working prototype exists today, work on a GUI is needed before general release.*

University of Washington

- *DHI2MAT is a method for MATLAB users to access network, event or waveform information directly within MATLAB.*

ISTI

- *JEvalResp and JPlotResp are DHI enabled clients that assist in evaluation of response information.*

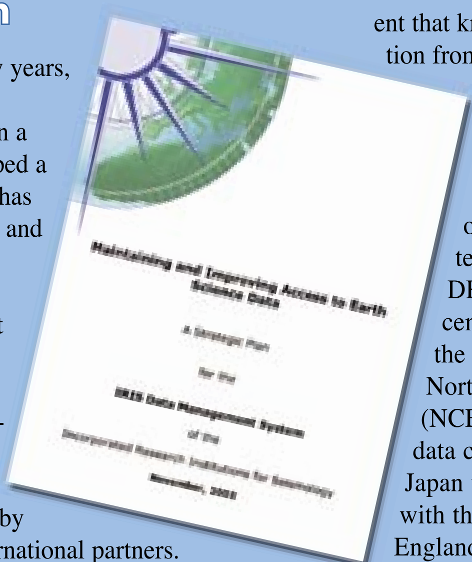
IRIS DMC

- *VASE (Visualization and Seismogram Extraction) allows access to data in the FARM, SPYDER® or BUD data repositories. VASE can be configured to have continuous waveforms or new event windowed data appear automatically on your client computer as they become available.*
- *WEED (Windows Extracted from Event Data) is a powerful tool to access data from the DMC archive, BUD, FARM or SPYDER® across multiple data centers.*

All of the DHI clients that have been developed with IRIS resources are written in Java and intended to run on Windows, SOLARIS, LINUS and Macintosh OS X operating systems.

The rich suite of data request tools that the IRIS DMC supports is intended to help users easily generate data requests. During calendar year 2003 we anticipate servicing about 49,000 customized user requests for data, an increase of 6.8% over last year's shipments.

The Data Management System Strategic Plan



Over the past few years, the Data Management System has undertaken a self-study and developed a Strategic Plan, which has recently be completed and approved by the IRIS Executive Committee. The mission statement included in that plan highlights the importance of the DMS providing access to not only IRIS data, but also to data produced by our domestic and international partners. The Strategic Plan is available for download at http://www.iris.washington.edu/about/DMC/dms.htm.

The Mission of the IRIS Data Management System

To provide reliable and efficient access to high quality seismological and related geophysical data, generated by IRIS and its domestic and international partners, and to enable all parties interested in using these data to do so in a straightforward and efficient manner.

Two DMS activities are key in meeting that mission:

- development of distributed data center access techniques and;
- acting as a data archive and distribution center for networks that have requested the DMC to act in this capacity

Distributed Data Centers NetDC: The IRIS DMC pioneered the concept of Networked Data Centers and was the primary developer of the NetDC system. This system is currently operating or has been operating at centers at GFZ in Potsdam, Germany, IPGP in Paris, France, ORFEUS in deBilt the Netherlands, University of California at Berkeley, the IRIS DMC in Seattle, ING in Rome, Italy and two centers in Japan and China. NetDC allows a user to generate and send a formatted request message to one email address and have data from all of the networked data centers returned in either a merged volume or individual volumes. Alternatively users can use a Web Form from the IRIS web site to generate a NetDC request.

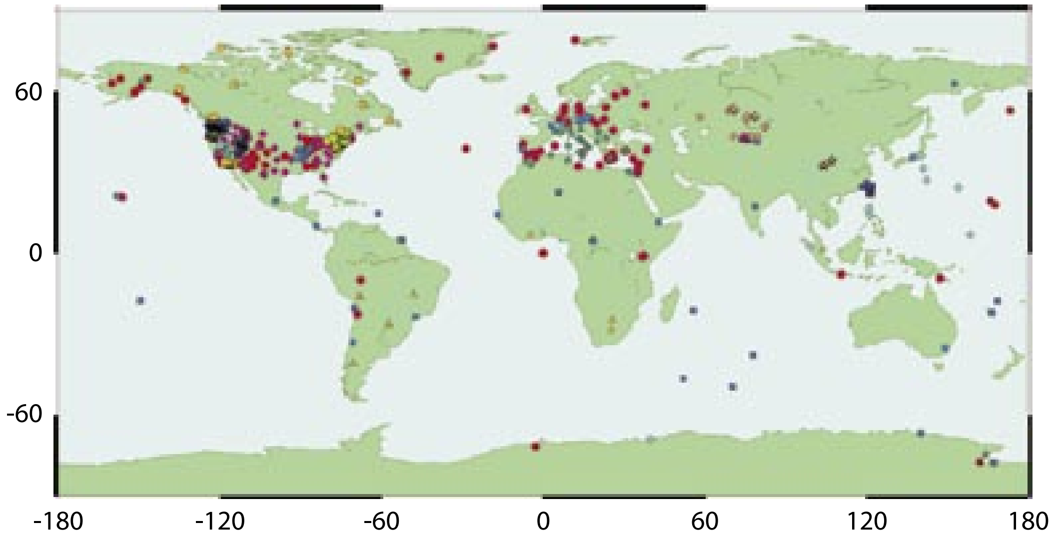
FISSURES and the Data Handling Interface

FISSURES is based upon an industry standard distributed computing architecture called CORBA. An inherent part of CORBA is the Interface Definition Language (IDL). IDL is structured in a manner that all servers must have an identical interface to the network, event and waveform services available at a DHI enabled data center. As such, a client that knows how to connect and recover information from one data center using the Data Handling Interface (DHI) knows how to connect and access information from any other DHI center.

The IRIS DMC is still in the development stages of making the DHI system one that can transparently access all DHI enabled data centers. Currently DHI centers exist at the IRIS DMC in Seattle, the University of South Carolina and at the Northern California Earthquake Data Center (NCEDC) in Berkeley. We expect that other data centers in southern California, Europe and Japan will also install DHI servers. Discussions with the International Seismological Centre in England and the NEIC in Golden, Colorado have also taken place and event servers may become available from those locations in the future.

Data from non-IRIS/NSF Sources at the IRIS DMC

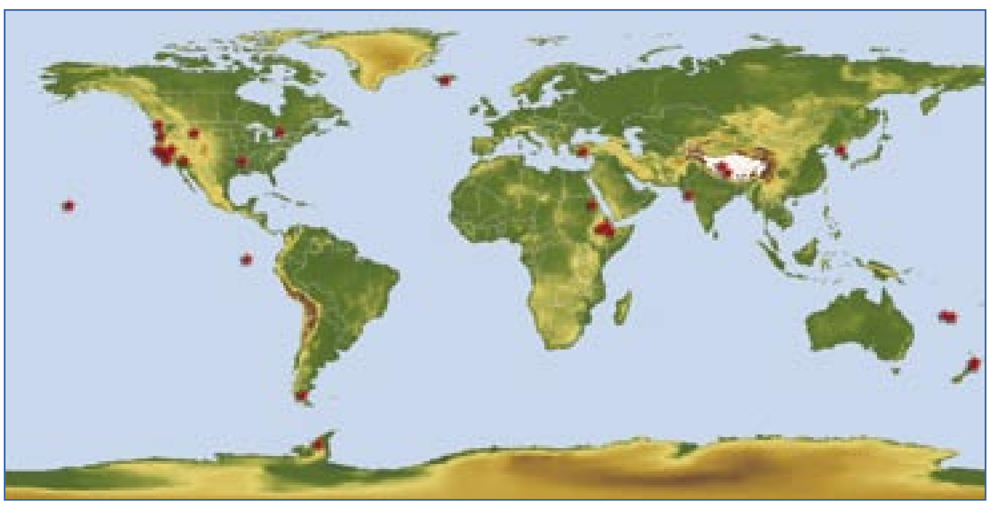
While technological solutions evolve, the DMC also plays an active role in acquiring, archiving and distributing data from other networks worldwide. Many seismological networks that exist primarily for earthquake monitoring prefer not to have a parallel data archiving project and have requested the IRIS DMC to act as an archive for their data. As the FDSN Archive for Continuous Data, the DMC routinely receives data from a total of 192 stations throughout the world (73 in real time) and these stations greatly enhance the coverage from the IRIS GSN. The DMC also receives data from four additional national networks and arrays (176 stations) that are not part of the FDSN.



Non-IRIS Permanent Stations. Locations of 1,334 stations that have contributed data to the DMC within the past two years.

The DMC now acts as the archive and distribution point for data from 19 regional networks (884 stations) within the United States. While many of these regional network stations are short-period, more and more of them are incorporating broadband sensors as part of the development of the Advanced National Seismic System (ANSS) funded by the USGS.

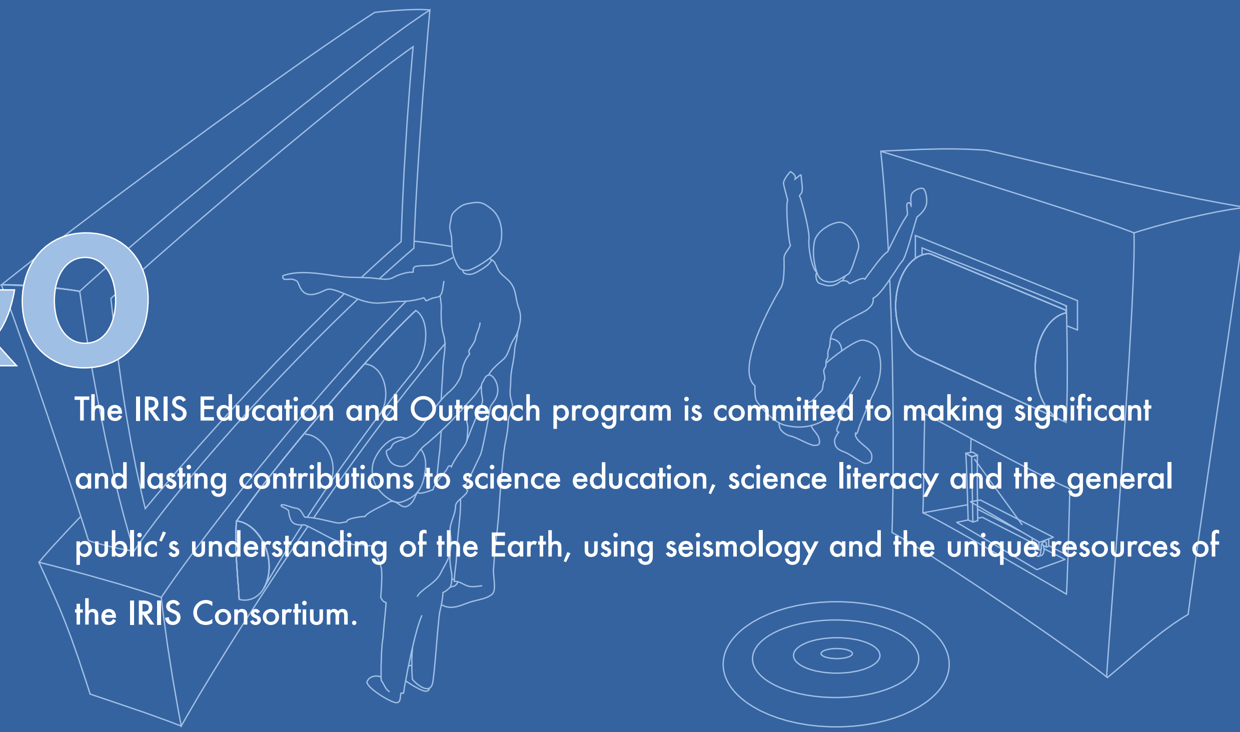
In addition to being the primary archive for data from PASSCAL experiments, the DMC is also developing linkages with other temporary networks. For instance the Ocean Bottom Seismometer Instrumentation Program (OBSIP) has selected the IRIS DMC as the archive and distribution point for data from their instruments. The SEIS-UK program in the United Kingdom also distributes their data through the IRIS DMC. We also have an assortment of data from other projects supported by the USGS, NASA and DoE.



Non-IRIS Temporary Experiments. Locations of 29 experiments that have or soon will contribute data to the IRIS DMC. These experiments come from the USGS, OBSIP, SEIS-UK, UC San Diego, or other organizations but were not part of an IRIS temporary deployment.

While the IRIS DMS views its primary role as the archive and distribution point for data from the NSF-funded GSN and PASSCAL programs, it is becoming a source for seismological data funded by a very significant number of other groups around the world. When combined with our active development of Distributed Data Center access tools, we believe we are making significant strides in improving access to seismological data from around the globe, consistent with the newly articulated DMS mission.

E&O



The IRIS Education and Outreach program is committed to making significant and lasting contributions to science education, science literacy and the general public's understanding of the Earth, using seismology and the unique resources of the IRIS Consortium.

The E&O program has continued its development of a well-rounded suite of educational activities designed to impact a spectrum of learners, ranging from 5th grade students to adults. These powerful learning experiences transpire in a variety of educational settings ranging from self-exploration in front of one's own computer, to the excitement and awe of an interactive museum exhibit hall, a major public lecture, or in-depth exploration of the Earth's interior in a formal classroom.

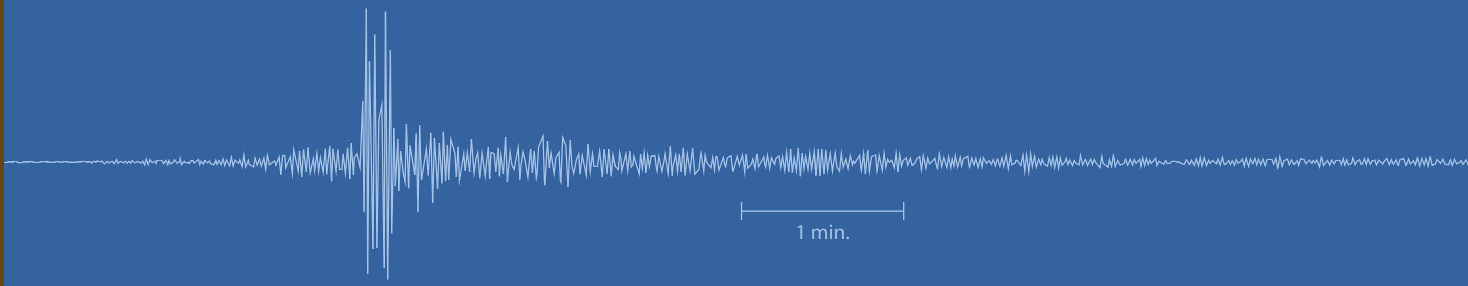
The efforts of the IRIS E&O program during the past year have been largely focused on the consolidation, refining, and enhancing of ongoing core activities, and have resulted in a dramatic expansion of their impact. The museum program highlights these efforts, as the number of individuals potentially impacted by the IRIS/USGS museum displays has doubled to 16 million people, principally as a result of the installation of a permanent exhibit in the Smithsonian Institution Museum of Natural History. An additional effort to reach the public through informal learning institutions was realized through the inaugural year of the IRIS/SSA Distinguished Lecture Series. In the first year of the series, our two speakers presented a total of nine lectures at major museums and universities throughout the country to audiences of up to 400 people.

The E&O Program continues to refine its highly effective, one-day professional development experience designed to support the background and curricular needs of formal educators. Leveraging the expertise of the consortium, IRIS delivers content such as: plate tectonics, propagation of seismic waves, seismographs, earthquake locations, and Earth's interior structure. At the core of the IRIS professional development model is the philosophy that improvements in the level of teacher use of such material can be achieved by increasing teacher comfort in the classroom. Specifically, we seek to increase teacher comfort in the classroom by providing professional development which:

- Increases an educator's knowledge of scientific content,
- Provides educators with a variety of high-quality, scientifically accurate activities to deliver content to students,
- Provides educators with inquiry-based learning experiences,
- Provides direct contact with IRIS research and E&O individuals

The development of a coordinated assessment effort during the past year has provided critical decision making data and begun to document the impact the program has on educators. Using this information as a guide, IRIS will continue to monitor and alter its curricular resources and implementation style in an effort to maximize this impact.

The Educational Affiliate Membership category and the Undergraduate Internship program have also increased IRIS' impact among their respective audiences of undergraduate faculty and students. The objective of the affiliate membership category is to cultivate a base of non-research colleges and universities committed to excellence in undergraduate geoscience education through the co-development of E&O activities designed to address their needs. Enhancements in promoting the Undergraduate Internship program this



year resulted in an increased applicant pool (20), an increased number of proposals to host students from IRIS member institutions (9), and the largest class of IRIS interns to date (9). In culmination of their summer experience, eight of this year's interns will present their research as part of the Fall AGU meeting. Through their participation in the program, these students gain experience in and exposure to the research and Earth science as potential career paths.

The web-based Seismic Monitor has been enhanced in the past year with much faster download speeds, easier access to seismic data and improved usability based on user feedback. Eight IRIS institutions are nearing completion of new educational activities related to the use and interpretation of seismic data using seed money grants awarded last year. The Global Earthquake Explorer (GEE) software and associated instructional materials, now in beta testing, have been developed in part via a subaward to the University of South Carolina. GEE will be a key to educational access to the seismic data sets that are at the heart of IRIS.

The U.S. Educational Seismology Network (USESN) is a coalition of educational seismic networks that is organizing to operate under the auspices of the IRIS E&O program.

The USESN is bringing together into a single federation a variety of seismology outreach programs (e.g. Indiana PEPP, MichSeis, OhioSeis, SCEP, NESN, IRIS Seismographs in Schools). The USESN seeks to (1) promote the installation and effective use of educational seismographs and seismic data; (2) disseminate high-quality curricular materials and educational services that promote the use of seismology in science education; and (3) provide an organizational framework for coordination and advocacy of educational seismology across the country.

Additional efforts to reach a wider audience will be realized as we continue to collaborate with other national geoscience programs such as the Digital Library for Earth System Education (DLESE). We are a partner in the Electronic Encyclopedia of Earthquakes project led by the Southern California Earthquake Center (SCEC) and will be working closely with the EarthScope Education and Outreach efforts. The success of the E&O program is directly attributable to those who have volunteered their time and energy. In particular we acknowledge the extensive contributions of the E&O committee members, and we encourage continued participation by individuals within and beyond IRIS.

Standing Committee

Richard Aster (Chair)	New Mexico Tech
Thomas Boyd	Colorado School of Mines
Michael Hamberger	Indiana University
Alan Kafka	Boston College
Susan Schwartz	University of California, Santa Cruz
Steven Semken	Arizona State University
Lisa Wald	US Geological Survey, Golden
John Taber	E&O Program Manager
Michael Hubenthal	E&O Education Specialist

Earthquakes In Museums

Christel B. Hennet, J. John Taber, Gregory E. van der Vink • IRIS Consortium

Charles R. Hutt • USGS Albuquerque Seismological Laboratory

During the past year, the IRIS Consortium and the US Geological Survey Albuquerque Seismological Laboratory (USGS/ASL) have worked with the Smithsonian Institution National Museum of Natural History to make global earthquake and ground-motion data available to the general public in real-time through a museum exhibit. The Smithsonian exhibit joins three other permanent exhibits and one traveling exhibit that have been developed in partnership with museums over the past five years. A portable version of the display has been on loan to the Franklin Institute Science Museum for use in their Powers of Nature exhibit and has traveled to 10 museums since 1998. In the next year, more than 16 million visitors will have the opportunity to view and learn from these exhibits in museums around the US. The exhibits portray earthquakes not as destructive events, but as signals of the geological forces that build our mountains and shape our landscape. The real-time aspect of the display 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. The success of the program is attributed to real-time global data streams, state-of-art electronic displays combined with traditional "three-dimensional" mechanical displays (retired drum recorders), on-going evaluations and upgrades, and strong partnerships that allow each exhibit to be sustained and customized to the specific needs of the individual host museum.

Exhibit Elements

Create-Your-Own Earthquake – The display begins with seismometers of simple design such as 1-Hz geophones or the AS-1 school seismometer. The AS-1 is popular because it intuitively illustrates the concept by which a seismometer works. By jumping on the ground in front of the display, a visitor creates an earthquake that is recorded mechanically on a large rotating drum. As the students learn the concept of a seismometer and how ground-motion is recorded, they also get to sign their own "earthquake".

Watch Ground Motion From Around the World in Real-Time – After creating their own earthquakes, the visitors notice on large mechanical triple drum recorders similar signals from natural earthquakes currently being recorded in different parts of the world and broadcast in real-time to the museum via the USGS/ASL Live Internet Seismic Server (LISS).

We have found that the mechanical drum recorders, although largely obsolete scientifically, are an essential component for attracting and maintaining interest in the exhibit.

Monitor Earthquakes – Realizing that earthquakes are happening every day, visitors can find information on recent earthquakes displayed on two large monitors. One monitor lists the time, magnitude, and geographic location of earthquakes that have occurred within the last few days. We set this monitor to update the information every ten minutes and alert the visitor when new events have been added to the list. A count-down clock displays the time remaining until the next update. The clock is popular with K-12 students who enjoy the opportunity to 'predict' the occurrence of new earthquakes.

The second monitor displays the location of recent earthquakes as color coded symbols on base maps compiled from satellite images. The visitors learn that earthquakes are always happening somewhere, and discover the relationship between seismicity and plate tectonics.

Exhibit Assessment

While the main elements of the museum display are being developed to meet the needs of all members of our museum program, each individual exhibit is designed and constructed in the style and context of the respective museum. Assessments guided by internal and external educational specialists help us ensure that each exhibit is up-to-date, clearly conveys its message, and meets the current interests of the visitors.

For example in the testing phase for the Smithsonian exhibit, the exhibit was set up in temporary space off the main exhibit floor and randomly selected visitors to the museum were asked to explore the exhibit and answer questions regarding the overall content, clarity and personal interest in the display. The Smithsonian surveys indicate that the main points of the exhibit are successfully communicated to all age groups, and that the concepts are interesting and well explained.

We monitor the long-term performance and effectiveness of the displays through formal and informal evaluations. Based on the evaluations, we then discuss possible modifications, updates, and expansions to each exhibit. Assessments of our displays consistently show that our earthquake exhibits are highly popular with visitors of all age groups. Visitors express equal interest in both the electronic and the mechanical components of the display and they are excited by the opportunity to witness earthquake activity in real-time.

A Launching Point for Further Interest in Geoscience

The museum display is designed to provoke interest in earthquakes, and to serve as a launching point for further understanding of seismology and Geoscience. In fact, the educational content of the display can be "carried away" with the visitor. One-page handouts provide succinct, hard copy explanations of basic seismological concepts. The electronic portions of the exhibit are accessible through the IRIS Seismic Monitor web page which allows individuals or classes to continue to monitor global seismicity at school and at home. The website display is interactive and allows viewers to find out more information about individual earthquakes, to access seismograms, and to electronically visit individual seismic stations around the world.

Activities and Publications

In addition to program oversight and administration, the Consortium also serves the role of an on-going forum for exchanging ideas, setting community priorities, and fostering cooperation. To enhance this role, IRIS engages the broader community through the use of publications and workshops. Our publications, which are widely distributed without charge, are organized around topical issues that highlight emerging opportunities for seismology. The annual workshop is used to assess the state of the science, introduce programs, and provide training. Through a student grant program, young scientists attend the workshop at little or no cost, and become introduced to the programs and services of the Consortium. As a Consortium, IRIS also serves as a representative for the Geoscience community. IRIS staff and Committee members serve on White House Committees, State Department Advisory Boards, US Geological Survey panels, and testify before Congress. Such broad interactions raise the profile of Geosciences and provide a direct societal return from the federal investment in IRIS.

Meetings and Publications Subcommittee

Gary Pavlis (Chair)	Indiana University
Richard Aster	New Mexico Tech
David James	Carnegie Institution of Washington
Thorne Lay	University of California, Santa Cruz
Guust Nolet	Princeton University
Gregory van der Vink	IRIS Director of Planning

Joint IRIS-UNAVCO Workshop June 18-22, 2003

The 15th Annual IRIS Workshop was a return to rustic Tanaya Lodge just outside of spectacular Yosemite Park, California, where more than 200 participants gathered for the first joint Workshop for IRIS and the newly re-organized UNAVCO Inc.

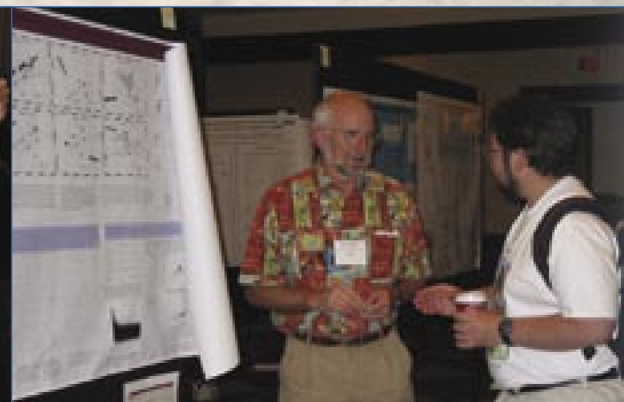
EarthScope was a prevailing theme throughout the Workshop. The recent announcement of the National Science Board's approval of EarthScope provided an opportunity for celebration and planning for IRIS, UNAVCO and members of the SAFOD team. Science sessions focused on EarthScope-related themes, including *Plate Boundary Processes*, *The Earthquake Problem* and *Sampling Across the Frequency Spectrum: Techniques Integration*. A prototype of a joint USArray/PBO station was installed

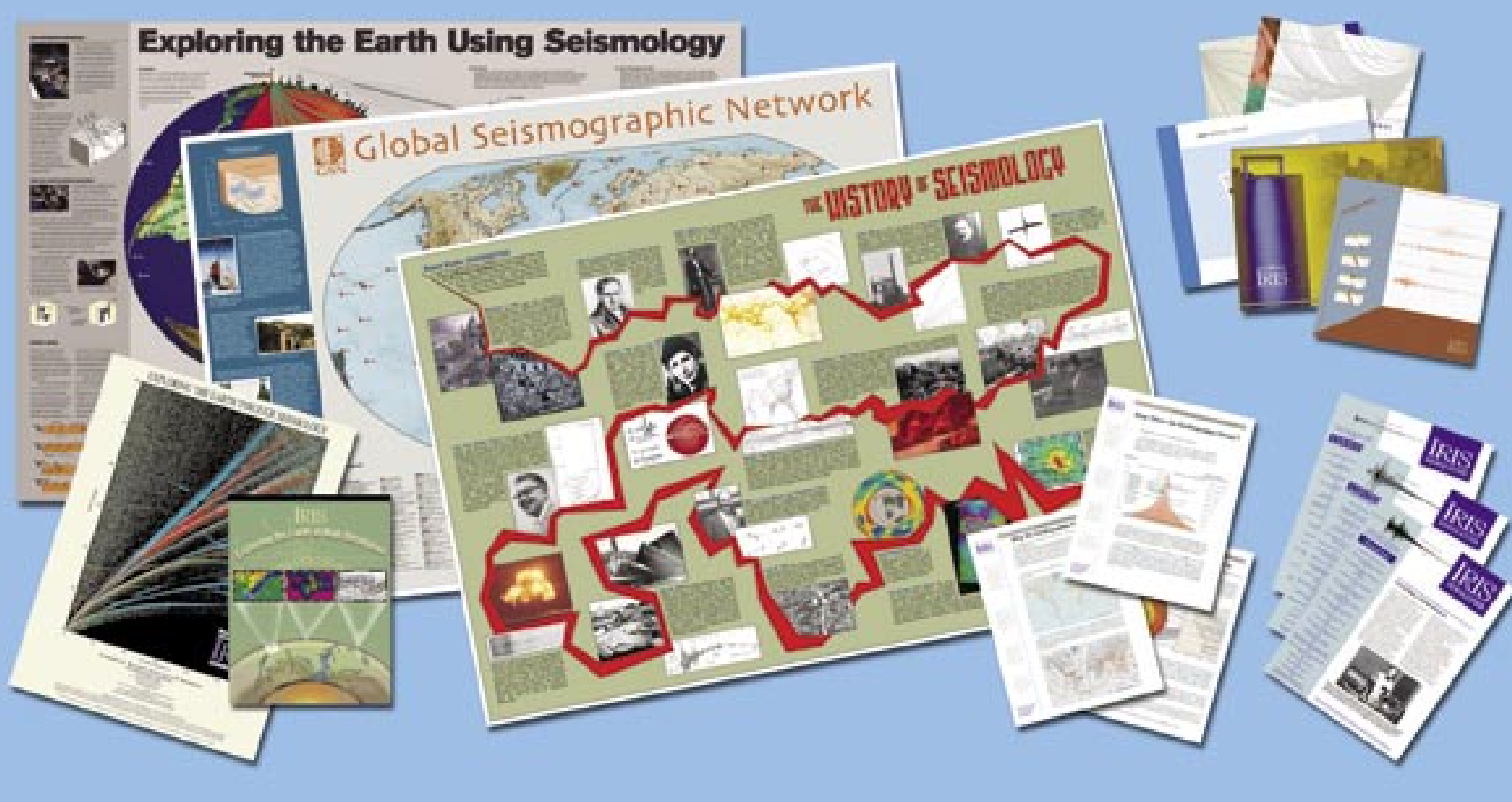
on the lawn outside the Lodge. Poster sessions, working groups and program forums provided reviews of current and developing IRIS and UNAVCO programs.

Workshop participants were provided with a flavor of IRIS outreach efforts when Walter Mooney, one of this year's IRIS/SSA Distinguished Lecturers, presented his talk on *The Discovery of the Earth: The Quest to Understand the Interior of our Planet*. [Many had heard Roger Bilham, this year's other IRIS/SSA lecturer, present *Death and Construction*: *Earthquakes on an Urban Planet*, at the SSA meeting in Puerto Rico earlier in the year.]

The workshop also featured the first (hopefully annual) IRIS Photo Competition, which encouraged submission of pictures related to some aspect of the development or use of IRIS facilities. This year's winning entry, from Chris Hayward of SMU, is featured on the cover of this report.

Many thanks to Susan Beck, Meghan Miller, Gary Pavlis, Paul Silver and Rob van der Hilst for their work with Greg van der Vink in organizing the workshop





Through the Education and Outreach Program, IRIS develops and distributes posters about seismology. The posters are featured at various scientific and educational meetings, and can be found on classroom walls around the world. IRIS has developed a series of "one-pagers" to attract the attention of students, educators, decision makers, and the general public. The one-pagers provide succinct explanations of basic seismological concepts, and are available in hard-copy and on the web in both English and Spanish.

Financial Overview

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

GSN

The Global Seismographic Network is operated in partnership with the US Geological Survey. Funding from NSF for the GSN supports the installation and upgrade of new stations, and the operation and maintenance of stations of the IDA Network at University of California, San Diego and other stations not funded directly within the budget of the USGS. Operation and maintenance of USGS/GSN stations is funded directly through the USGS budget. Subawards include the University of California, San Diego, the University of California, Berkeley, the California Institute of Technology, Columbia University, University of Hawaii, Albuquerque Seismological Laboratory, Synapse Science Center, Moscow, Woods Hole Oceanographic Institution, Montana Tech, University of Texas at Austin, and Texas Tech University.

PASSCAL

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

DMS

Funding for the Data Management System supports data collection, data archiving, data distribution, communication links, software development, data evaluation, and web interface systems. Subawards include the University of Washington, Harvard University, the University of California, San Diego, Columbia University, Synapse Science Center, Moscow, University of South Carolina, and Institute for Geophysical Research, Kazakstan.

Education and Outreach

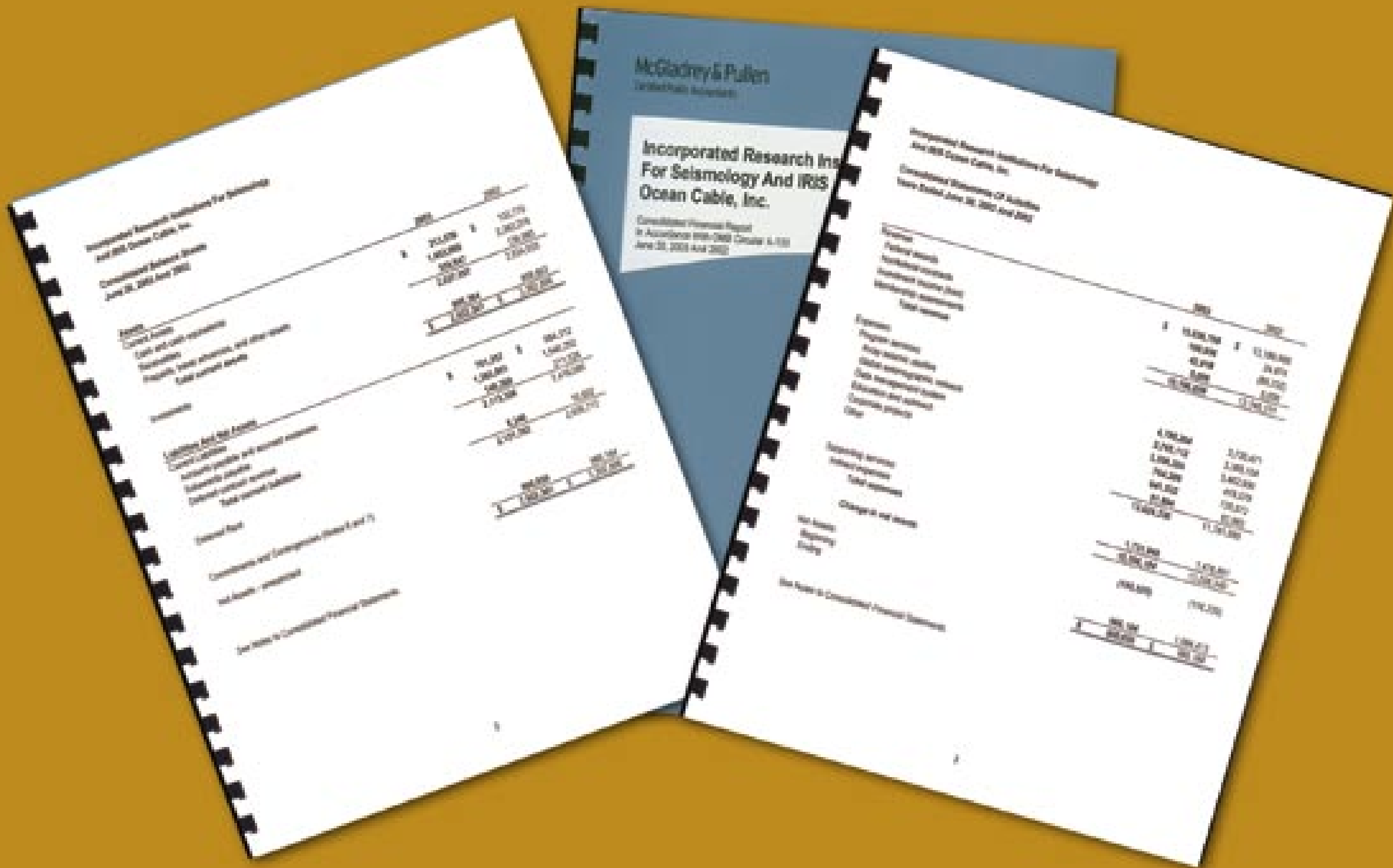
Funding for the Education and Outreach program is used to support teacher and faculty workshops, undergraduate internships, the production of hard-copy, video and web-based educational materials, a distinguished lecturer series, educational seismographs, and the development of museum displays. Subawards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

Indirect Expenses

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

Other Activities

Other activities include IRIS workshops, publications and special projects such as KNET.



IRIS Budgets

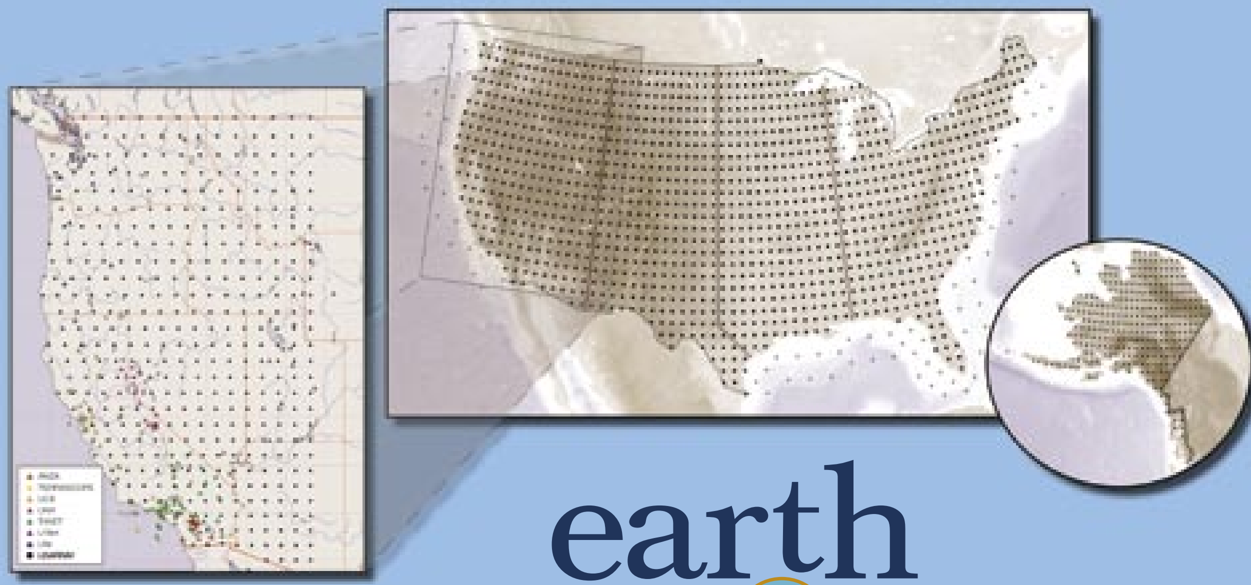
Core program budgets*		Earthscope awards**	
	FY2004		
GSN	3,402,215	Permanent backbone	3,564,469
PASSCAL	3,834,580	Transportable/Flexible Arrays	7,648,005
DMS	3,451,855	Data management	1,447,663
E&O	612,380	E&O	69,175
Other	644,454	Other	26,000
		Earthscope Office	559,162
Indirect Costs	1,242,652	Indirect Costs	1,772,002
Total	***13,188,136***	***Total***	***15,086,476***

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

** Includes budgets for USArray MRE & O&M, and the Earthscope Office Cooperative Agreements.

The consolidated financial statements of IRIS and IRIS Ocean Cable, Incorporated, and the Auditor's Report are available from the IRIS business office upon request.

Budget and Finance Subcommittee	
Susan Beck (Chair)	University of Arizona
Robert van der Hilst	Massachusetts Institute of Technology
Arthur Lerner-Lam	Columbia University
Candy Shin	Director of Finance & Administration



IRIS is a part of a group that submitted a proposal to the National Science Foundation (NSF) to construct the EarthScope Observatory, a facility that will apply modern observational, analytical and telecommunications technologies to investigate the three-dimensional structure and evolution of the North American continent and the physical processes controlling earthquakes and volcanic eruptions.

The overall EarthScope project has been developed jointly by the scientific community and NSF, in partnership with other science and mission-oriented agencies including the U.S. Geological Survey (USGS), and with strong links to existing regional networks and state-based agencies. The EarthScope Observatory project funded by NSF's Major Research Equipment and Facilities Construction (MREFC) program is for the acquisition and installation of EarthScope's three elements: USArray, SAFOD, and PBO:

USArray (United States Seismic Array): Continental scale, portable seismic arrays will map the structure and composition of the continent and the underlying crust and mantle at high resolution,

SAFOD (San Andreas Fault Observatory at Depth): A geophysical observatory within the active San Andreas Fault will measure subsurface conditions that give rise to earthquakes and deformation in the crust.

PBO (Plate Boundary Observatory): A fixed array of GPS receivers and strainmeters will map ongoing deformation of the western half of the continent with a resolution of one millimeter or better.

It is anticipated that construction of the EarthScope Observatory will take 5 years to complete. Operations and maintenance of the facility will extend at least another 5 years.

IRIS is responsible for implementing the USArray component of EarthScope. USArray consists of three major elements: (1) a Transportable Array, (2) a Flexible Array, and (3) the ANSS Backbone network of permanent stations.

Photo by: Marcos Alvaarez, New Mexico Tech

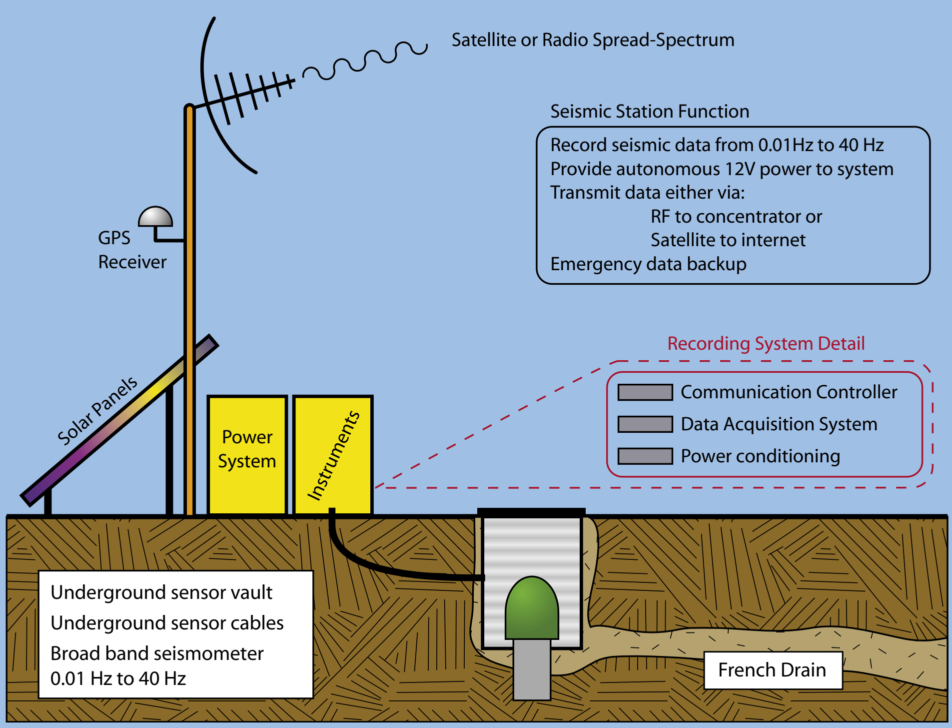
The core of USArray is the Transportable Array, a telemetered array of 400 broadband seismometers, deployed in the United States. The array is designed to provide real-time data from a regular grid with dense and uniform station spacing of ~70 km and an aperture of ~1400 km. The Transportable Array will record local, regional, and teleseismic earthquakes to produce significant new insights into the earthquake process, provide resolution of crustal and upper mantle structure on the order of tens of kilometers, and increase the resolution of structures in the lower mantle and at the core-mantle boundary. The Transportable Array will roll across the country with 18-24 month deployments at each site. Multiple deployments will cover the entire continental United States and Alaska over a period of 10-12 years. When completed, the array will provide unprecedented coverage for 3-D imaging from ~2000 seismograph stations. Site selection, permitting and installation of the first 400 sites in the western states will take four years to complete. In Year 5 the array will begin to roll, with around 200 stations being redeployed toward the east each year, until reaching the east coast around Year 9. All hardware will be purchased and owned by NSF/IRIS, but the field work will be carried out by contractors.

As a complement to the Transportable Array, USArray's Flexible Array will include a pool of ~2400 portable instruments (a mix of broadband, short-period, and high-frequency sensors) that can be deployed using flexible source-receiver geometries. These instruments will permit high-density, shorter-term observations, using both natural and explosive sources, of key geological targets within the footprint of the larger Transportable Array. This component of USArray will operate differently from the Transportable Array, with all field activities funded by individual investigators.

A third element of USArray is the development of the ANSS Backbone. Relatively dense, high-quality observations from a continental network with uniform spacing of 300-350 km are important for tomographic imaging of deep Earth structure, providing a platform for continuous long-term observations, and establishing fixed reference points for calibration of the Transportable Array. Sixteen stations of the ANSS Backbone will also be equipped with continuous geodetic-quality GPS receivers. This permanent component of USArray will be coordinated with the USGS and complements the initiative underway at the USGS to install an Advanced National Seismic System (ANSS). Because of the importance of using this network to calibrate the Transportable Array, equipment procurement, site selection and installation of 39 high-quality stations will take three years.

All data from the Transportable Array and ANSS Backbone will be transmitted in real time and archived and distributed to the user-community by the IRIS Data Management Center.

Telemetered USArray Broad-Band Seismic Station



Glacial Earthquakes

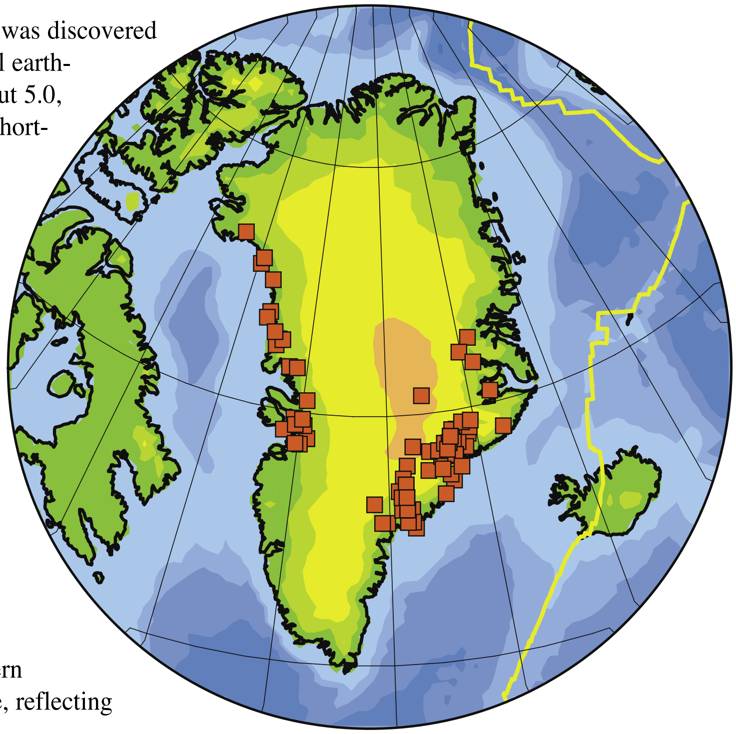
Göran Ekström • Harvard University

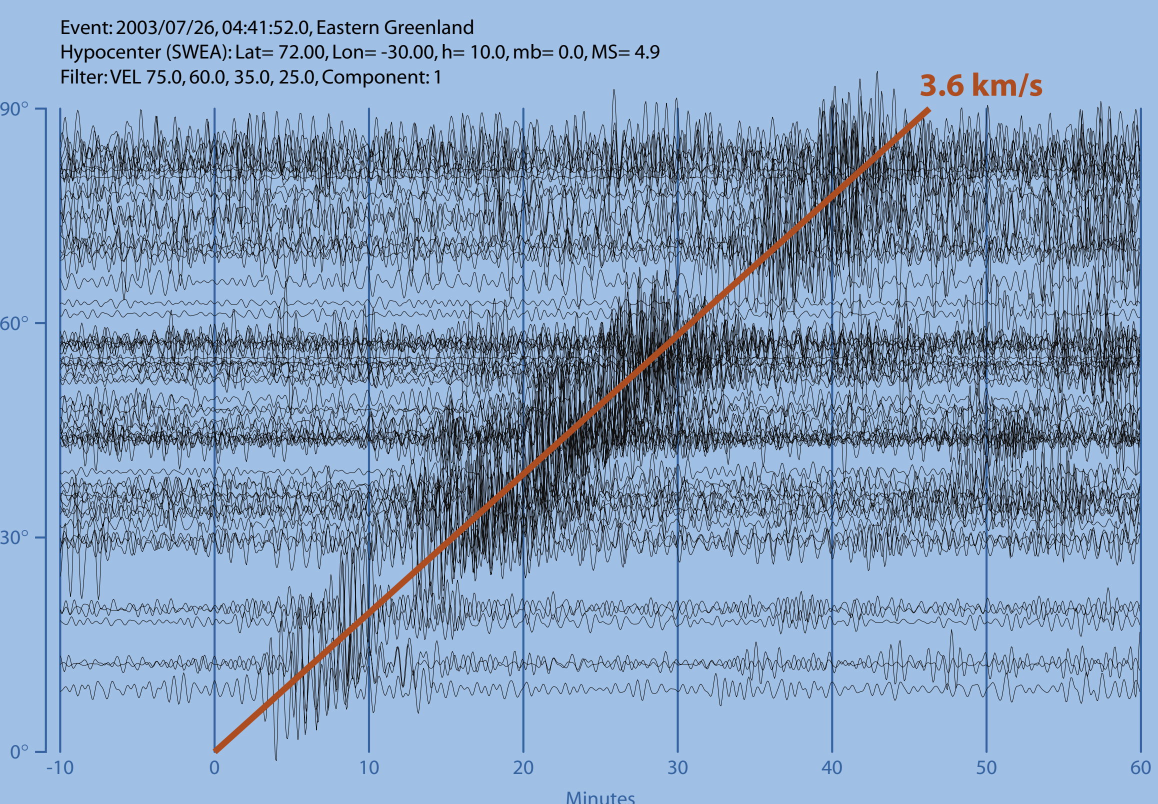
A new class of earthquakes associated with glaciers was discovered in 2003 using IRIS GSN and PASSCAL data. The glacial earthquakes, which all have a surface-wave magnitude of about 5.0, are very slow and do not radiate significant amounts of short-period waves.

The glacial earthquakes were detected using a computer algorithm that continuously analyzes thousands of points on the surface of the Earth as potential sources for long-period surface waves recorded on the GSN.

Most of the glacial earthquakes occur along the coasts of Greenland. One hundred events have been located on Greenland by systematic processing of GSN data since 1995. The events are thought to be caused by sudden down-hill sliding of several cubic kilometers of ice by several meters. The observation that there are fewer events during the coldest part of the year suggests that hydrological effects associated with summer melting may be the trigger for the sliding.

The record sections for glacial earthquakes, such as the one here for an earthquake on July 26, 2003 on Eastern Greenland, show prominent surface waves, and little else, reflecting the long-period character of the seismic source.



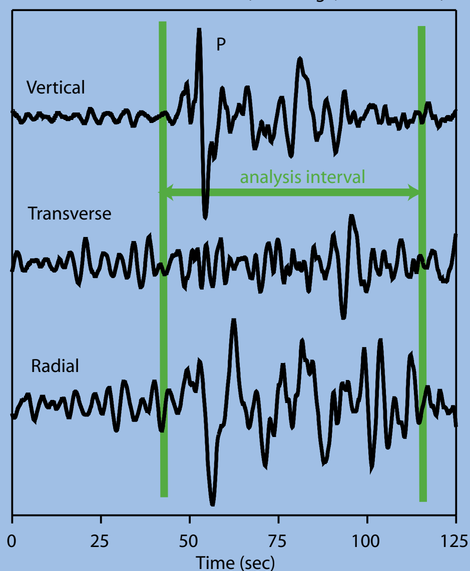


Receiver Functions at Rarotonga, Cook Islands

Garrett Leahy and Jeffrey Park • Yale University

Conventional wisdom tells us that seismic data from ocean island GSN stations are noisy and must be used with great caution. Nevertheless, surprising signals can be extracted from ocean-island stations with careful data processing. We demonstrate this with a receiver function computed with multiple-taper cross-correlation (Park and Levin, 2000) for a single P wave observed at RAR (Rarotonga, Cook Islands) from a 26 May 2003 event off Japan (Ms=7.0, Δ=81.1°). The multiple-taper RF operates in the frequency domain, allowing practical application at higher frequencies than typical time-domain deconvolution algorithms. This helps greatly for ocean-island data, where frequencies well above the microseism noise band are required to resolve P-to-S converted phases from the shallow oceanic Moho.

May 26, 2003 quake off the coast of Japan (Ms = 7.0) recorded at GSN station RAR (Rarotonga, Cook Islands)

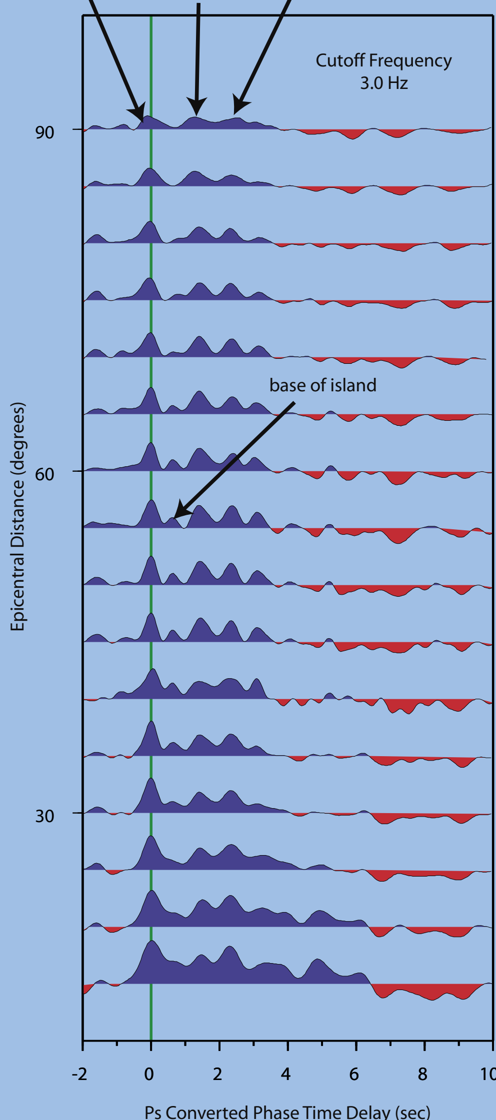


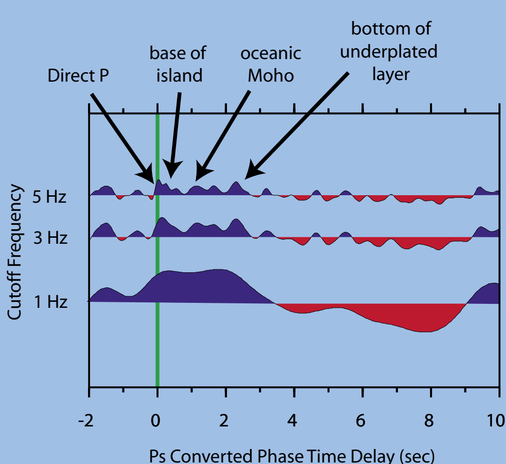
The radial component receiver functions for the P wave shown (left) were computed with frequency cutoffs of 1 Hz, 3 Hz and 5 Hz from a time window of 75 seconds (lower left). The positive pulses can be interpreted as Ps converted phases associated with a set of horizontal discontinuities in seismic wavespeed and/or anisotropy. The depths of these interfaces increases with the Ps time delay. (The rule-of-thumb is 8 km of depth for each second of Ps delay.) Several pulses are evident in the single-record receiver function, and have been confirmed as reliable in an epicentral sweep of receiver functions from 167 teleseismic P coda recorded at RAR over the past decade (right).

We find that the crust and upper mantle under RAR is more complex than a simple oceanic lithosphere model predicts. We observe Ps conversions arriving at 0.5-s delay that we attribute to conversions from the base of the volcano. We also see three conversions arriving at roughly 1, 2, and 3 seconds delay. We attempt to model the crust under RAR using the method of Zhu and Kanamori (2000), and find that the receiver functions can be fit by a layer of mafic (Vp/Vs ~ 1.8) "layer-3" lithology with a thickness of ~10 km underplating the original ~7-km thick oceanic crust

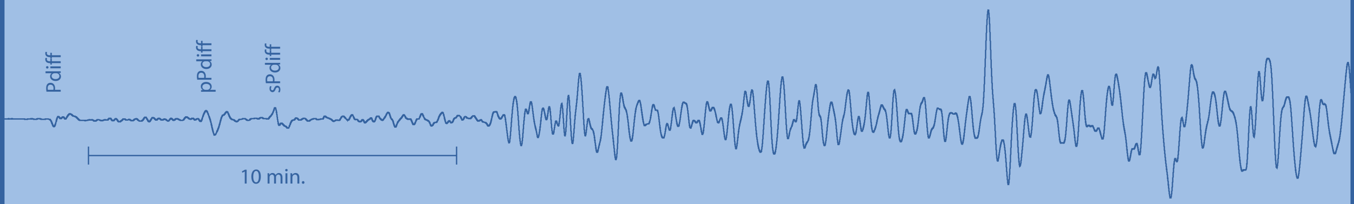
Similar structures have been seen underneath stations PPT and XMAS, but not underneath North Pacific stations POHA or WAKE, suggesting that the structure we see underneath RAR may be broadly associated with the Pacific superswell.

Bin-Averaged Receiver Functions for 265°-300° back azimuth

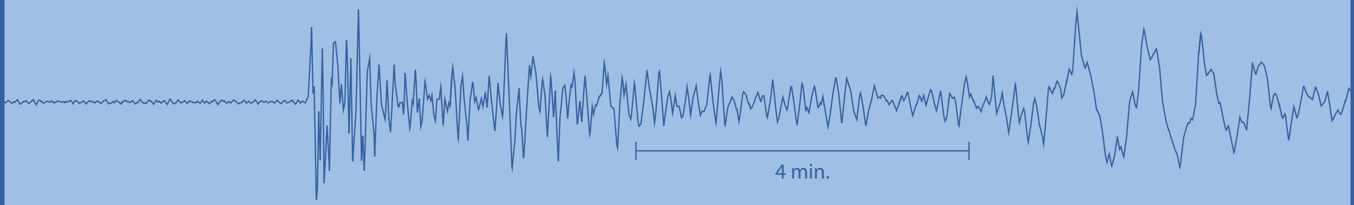




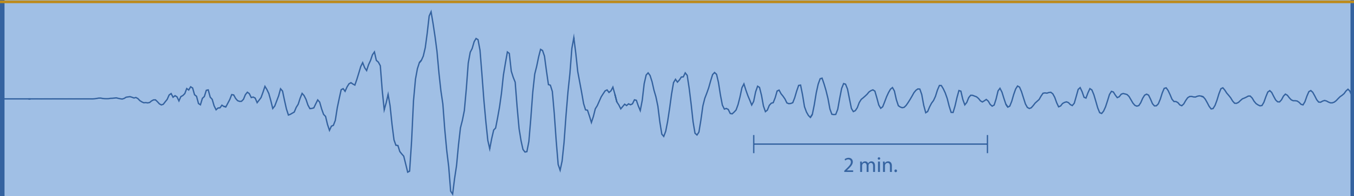
Radial receiver function for 26 May 2003 earthquake off Japan, recorded at GSN station RAR (Rarotonga, Cook Islands)



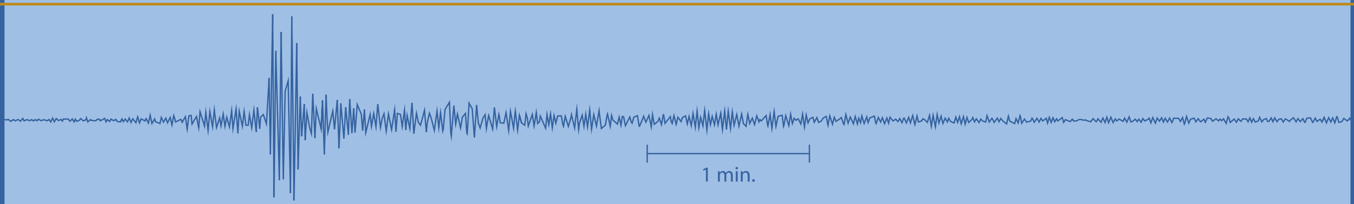
Vertical channel recording of the June 20, 2003 magnitude 7.1 earthquake 560 km deep beneath Amazonas, Brazil. The seismogram was recorded on an STS-2 seismometer with Reftek-72A digitizer installed on top of Bozdag Mountain Ranges in western Turkey during the Western Anatolia Seismic Recording Experiment. Station-event distance is 102 degrees. The experiment is designed to image crustal and upper mantle seismic structures and their relationship to crust extension processes (Lupei Zhu, Saint Louis University).



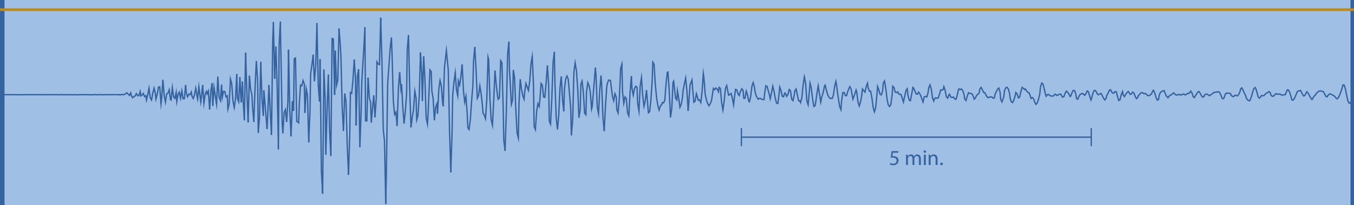
At least 2,000 people were killed and 200,000 made homeless when a magnitude 6.8 earthquake struck Northern Algeria on May 21, 2003. GSN station Kilima Mbogo (KMBO) in Kenya recorded the event at a distance of about 5500 km with strong P- and S-wave energy. The earthquake generated a tsunami with an estimated wave height of 2 meters, causing damage to boats and underwater telephone cables, and was felt as far as Monaco and southwestern Spain (Rick Benson, IRIS DMC).



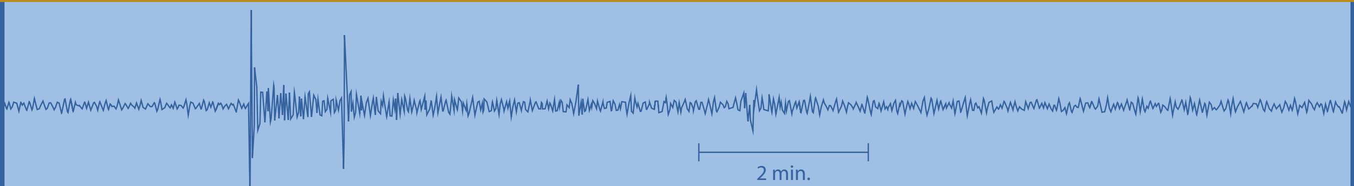
The largest earthquake of 2003 occurred on the evening of September 25th when a magnitude 8.3 earthquake struck the Hokkaido region of Japan. More than 500 people were injured. Damage estimates exceed 90 million U.S. dollars. The quake generated a tsunami with an estimated wave height of 4 meters along the southeastern coast of Hokkaido. GSN station Matsushiro (MAJO) recorded this event at a distance of 700 kilometers (Russ Welti, IRIS DMC).



As part of the IRIS E&O Seismographs in Schools program, more than 60 schools across the nation are now utilizing AS-1 instruments to record and analyze high quality data of local and regional events. AS-1 station WLIN near West Lafayette, Indiana recorded this magnitude 4.6 event on 29 April 2003 near Fort Payne, Alabama (Larry Braile, Perdue University).



This is a recording of the November 3, 2002 Denali earthquake made on the vertical channel of an FBA-23 strong motion accelerometer located at IRIS/IDA GSN station KDAK (Kodiak, Alaska) at a distance of 6.3 degrees. FBA-23s are deployed at GSN stations to ensure on-scale recording of large amplitude surface waves during very large events (Pete Davis, UCSD).



GSN station CCM near Cathedral Caves in Missouri recorded these extremely impulsive P, PcP, and ScP phases from a 580 kilometers deep earthquake in western Brazil on 27 April 2003. The seismogram trace shows unfiltered data recorded on an STS-1 surface instrument (Tyler Storm, USGS Albuquerque Seismological Laboratory).

Headquarters
Incorporated Research Institutions for Seismology
1200 New York Avenue, NW, Suite 800
Washington, DC 20005
Tel: 202.682.2220
Fax: 202.682.2444
www.iris.edu

David W. Simpson	President
Gregory E. van der Vink	Director of Planning
Shane Ingate	Director of Operations
Rhett Butler	Global Seismographic Network Program Manager
John Taber	Education & Outreach Program Manager
Candy K. Shin	Director of Finance & Administration
Robert Austin	Business Analyst
Michael Hubenthal	Education Specialist
Naim Jones	Business Analyst
Cecelia Kelton	Accounting Manager
Jason Mallett	Publications Coordinator
Maria Teresa Saavedra	Receptionist/Secretary
Susan Strain	Executive Assistant

IRIS Data Management Center
1408 NE 45th Street, Suite 201
Seattle, WA 98105
Tel: 206.547.0393
Fax: 206.547.1093

Tim Ahern	Program manager
Deborah Barnes	Information Services Coordinator / Webmaster
Leanne (Beach) Rubin	Office Manager
Rick Benson	Director of Operations
Rick Braman	UNIX Systems Administrator
Rob Casey	Software Engineer
Mary Edmunds	Data Control Technician
Stacy Fournier	Data Control Technician
Lonny Jones	USArray Systems Administrator
Linus Kamb	Software Engineer
Chris Laughbon	Senior Software Engineer
Anh Ngo	Data Control Technician
Sue Schoch	Senior Software Engineer
Sandy Stromme	Software Engineer
Bruce Weertman	Software Engineer
Russ Welti	Software Engineer

IRIS PASSCAL Instrument Center
New Mexico Tech
100 East Road
Socorro, NM 87801
Tel: 505.835.5072
Fax: 505.838.5079

James Fowler	PASSCAL Program Manager

IRIS

THE INCORPORATED RESEARCH INSTITUTIONS FOR SEISMOLOGY

IRIS Consortium
1200 New York Avenue, NW
Suite 800
Washington, D.C. 20005

ADDRESS CORRECTION REQUESTED

Non Profit Org.
U.S. Postage
PAID
Washington, DC
Permit No. 1227