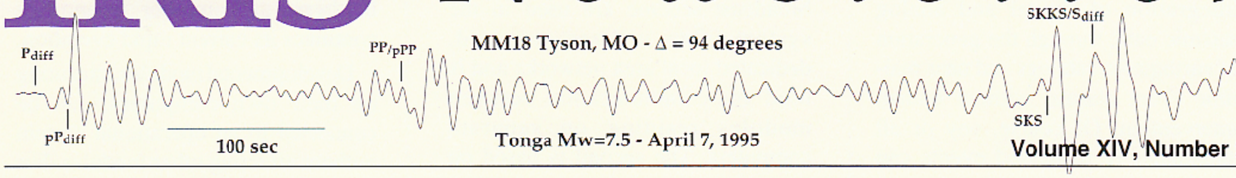
IRIS Newsletter



Volume XIV, Number 2

Earthworm : A Flexible Approach to Seismic Network Processing

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Rapid technological evolution is both a boon and a bane to regional seismic network operators. On the one hand, smaller and faster computers and dramatic improvements in communications technology fuel the development of increasingly capable network data analysis systems. On the other hand, innovative systems are soon antiquated and the cost of 'keeping up' can be prohibitive. An adaptable, scalable seismic data processing system that can evolve with technological trends is the Holy Grail of regional network operators.

In June of 1991, regional seismic network operators gathered at the Alta II conference in Utah to address common interests. Network acquisition and processing systems were identified as being a source of common problems, including: obsolescent hardware, high maintenance costs, lack of commonality between institutions, and difficulties in integrating enhancements such as digital telemetry and rapid response functions.

What emerged was a clear need for a regional network data processing system that would offer a number of features:

• *Scalability*- The system design should permit configurations to meet the requirements of the small as well as large networks. The cost of each such configuration should be proportional to the scale of its application.

• *Flexibility*- It should be possible to tailor the system to specific network requirements, including various types of digital telemetry, processing algorithms, and interfaces to ancillary systems. It should also be possible to enhance the system after it has been put into operation. This implies the ability to readily incorporate preexisting computer codes, and to support development efforts without destabilizing other functions.

• *Longevity*- The system should permit contemporary, cost-effective hardware to be incorporated as it becomes available.

• *Data Exchange*- The system should support exchange of various data in near real-time to permit adjacent regional networks to improve their coverage and accuracy.

• *Support*- Long term, committed support is required and should be tailored to complement the existing resources available at the various regional networks. Such support should range from supplying complete turn-key service to accepting suggestions and contributions.

The Seismology Branch of the USGS at Menlo Park undertook to address these issues. The Earthworm project was initiated shortly after the Alta II conference and has produced a system which attempts to meet the above requirements.

Earthworm: A Modular Network Processing System

The Earthworm system can be thought of as a toolkit of processing modules for integrating regional seismic network data processing. Individual modules provide such functionality as: acquisition of digital data, digitization of analog data, phase arrival identification, amplitude and duration measurements, event association, phase identification, hypocenter determination, event catalog generation, and earthquake alarm generation. Processing is fully automatic,

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proceeding from the collection and integration of digital and analog seismic data, through the generation of earthquake catalogs and near real-time event alarms, without human intervention. Of course, any or all automatically processed events can be reexamined by trained analysts as desired.

The basic system architecture is an object-oriented, message-passing design. Each seismic function (e.g. data acquisition, P-phase picking, phase association) is encapsulated into a software module. Modules can generate messages (e.g. pick messages), and broadcast such messages onto a common media (e.g. a dedicated local network). Modules can also listen on such media and 'tune in' to messages of interest to them (e.g. trace data messages).

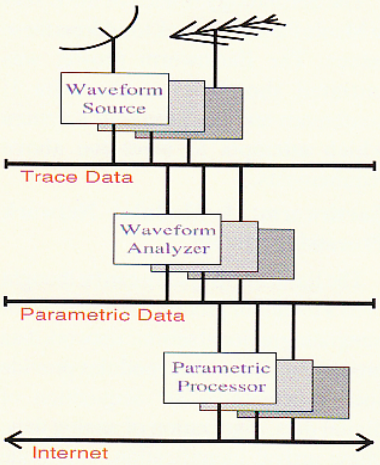


Figure 1. The basic Earthworm architecture is an object-oriented, message-passing design. Each seismic function is encapsulated into a software module which can broadcast and receive messages on common communication media. The specific configuration of modules and media can be tailored for individual installation.

Two implementations of this broadcast scheme are used in the system. One utilizes standard, dedicated local area networks and is used for communication between modules residing on separate computers. The second is based on interprocess communication mechanisms, and permits communication between modules residing within one computer. A pair of 'adapter' modules are used to move messages between the two media.

System integrity is monitored via 'heartbeat' and error messages. Any module which ceases to function or detects an error (e.g. missing or garbled message) will cause the system to issue a suitable notification. The entire system, in turn, issues a heartbeat which can be monitored by a separate computer capable of generating alarms.

This architecture offers several benefits:

• A variety of computer systems can be used and freely intermixed to create a system of desired power and features. To date, a variety of configurations using Sun (SunOs and Solaris), Intel 486 (DOS and OS/2), and Pentium (OS/2) computers have been demonstrated. This permits the Earthworm system to be based on the most suitable and cost-effective platform for each installation.

• For large networks, multiple copies of the same module may be run in parallel to achieve the requisite throughput. At Menlo Park, for example, the analog 'front end' consists of three digitizer modules feeding two P-phase picking modules.

• Modules can be easily migrated individually or collectively to more capable or more cost effective hardware as computer technology continues its current rapid evolution.

• Developmental modules, executing on their own computers, can be connected to an operational system without affecting other modules. For example, an experimental teleseismic trigger can be added without disrupting critical notification functions. New technologies, such as digital telemetry can be smoothly brought on line without disruption of existing data acquisition.

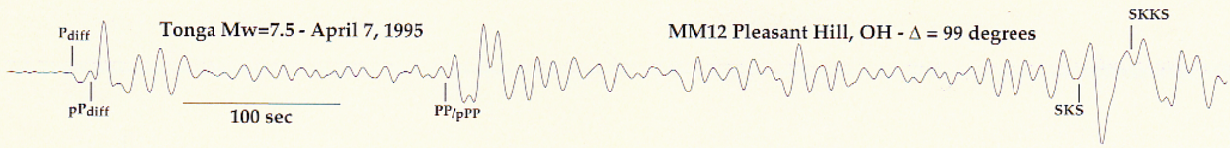
• Various types of data can be exchanged with other networks in near real-time. The system includes "Import" and "Export" modules, capable of exchanging internal messages, such as trace data, picks, or hypocentral estimates, with other systems via internet.

Key Algorithms

Currently, several existing algorithms have been integrated into Earthworm to perform the rapid notification functions: The Rex Allen P-picking scheme (Allen, 1978, 1982) is used to determine P-phase and coda characteristics. A variety of computer codes developed at the USGS in Menlo Park are used to verify and filter automatically located events. Hypo71 and Hypoinverse are currently used to compute final locations.

A key component of the Earthworm automated processing system is the rapid phase associator (Johnson, 1994). The problem is to consolidate phases from a variety of sources (possibly many earthquakes intermingled in an arbitrary time order) into a catalog of discrete events, each associated with a list of supporting arrival time data. To obtain the

This issue's bannergram: The seismograms on the cover and inside pages show vertical component records from broadband PASSCAL instruments at four stations of the MOMA experiment (Missouri to Massachusetts Broadband Seismometer Array: co-PI's: Karen Fischer, Michael Wysession, Tim Clarke). The records are from the Tonga earthquake of April 7, 1995 (depth = 31 km, Mw= 7.5). The goals of the experiment are to constrain the seismic character of the core-mantle boundary, the properties and extent of subducting slabs, and the detailed structure of the upper mantle beneath the eastern United States. The azimuth of propagation from the Tonga earthquake is roughly parallel to the strike of the array. Core phase travel-times, amplitudes and shapes should provide new constraints on the structure of the core-mantle boundary beneath the Pacific Ocean.



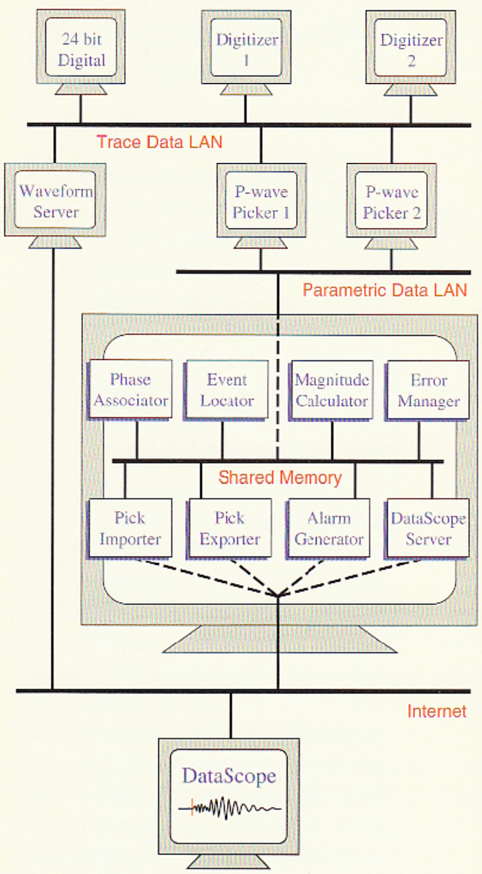


Figure 2. Earthworm configuration at USGS Menlo Park. The system offers acquisition of analog and digital data, rapid hypocenter determination, pager notification, catalog generation, and an interactive graphic quick-look facility.

efficiency necessary to process data during a vigorous aftershock series or swarm, a robust stacking algorithm was developed. Back-projections for all phases arriving within a given time window are stacked over a four dimensional grid of latitude, longitude, depth, and time. With a spatial grid size of 3 to 5 kilometers, the algorithm is capable of correctly resolving co-located events differing in origin time by a few seconds, or simultaneous events spaced at least 10 km apart. Both conditions are frequently encountered during vigorous seismic sequences.

Current Applications

Several Earthworm systems and derivatives are currently in operation: At USGS, Menlo Park, a 512-channel, analog telemetry Earthworm system is in production, as shown in Figure 2. Its performance has been certified by observing its performance on 38 selected segments of historic digital waveform data representing various seismic crises over the last 11 years. Figure 3 shows the seismicity reported by Earthworm in its first 20 days of real-time operation. In addition, integration of 24-bit digitally telemetered data has been demonstrated and is awaiting the completion of field stations. Exchange of phase data in near real-time has been demonstrated in a cooperative effort with the California Institute of Technology, and the USGS, Pasadena. Through the combined efforts of personnel at the Geophysical Institute, University of Alaska, Fairbanks and USGS, Menlo Park, the DataScope package developed at the IRIS JSP Center has been integrated and is scheduled to serve as the rapid-response event verification system at Menlo Park by the first quarter 1996.

At University of Alaska at Fairbanks, an Earthworm system capable of processing 256 channels is in operation. The DataScope integration mentioned above is in operation, and the system is being actively enhanced. Several valuable enhancements produced at Fairbanks have also been incorporated into the Earthworm system.

Another 256-channel system is being assembled for the University of Utah at Salt Lake City, and is scheduled for installation by January1996. The overall objective of this effort is to install similar systems at various networks in the Intermountain region and to enable peer-to-peer data exchange in near real-time. In addition, derivative systems are in operation at University

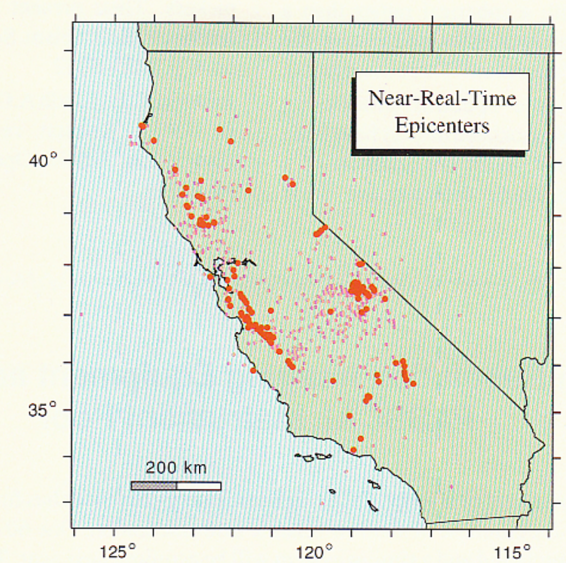


Figure 3. Map of California showing the epicenters reported automatically by the Menlo Park Earthworm system in its first 20 days of operation on live CALNET data (July 19, 1995 to August 7, 1995) prior to system tuning. Red dots show hypocenters having at least 8 arrivals, rms < 0.3 sec, horizontal error < 2.5 km and vertical error < 5 km. Pink dots show all other reported epicenters.

of California at Berkeley, University of HawakÇ at Hilo, and University of Washington at Seattle.

Future Directions

Development of the Earthworm system is ongoing, and a number of enhancements are in various stages of planning and completion.

We plan to enhance the facilities at Menlo Park to provide rapid urban damage assessment in case of catastrophic earthquakes. The initial phase will consist of integrating existing ground motion prediction codes into the Earthworm system, thus permitting maps of predicted ground shaking and damage patterns to be computed within minutes after an event. Subsequent phases will integrate telemetered strong-motion data to improve the reliability of such maps.

The phase association module could be adapted to sparse regional networks of the sort used for nuclear test ban monitoring. The primary modification would be the stacking of multiple phases, and modifying the phase associator to operate with a spherical rather than a planar geometry, thus addressing the problem of teleseismic phase association.

A real-time spectral processing module and associated display have been demonstrated. With the addition of a tremor amplitude detector, the basic Earthworm configuration could serve the needs of the volcano monitoring community. The scalable nature of the design facilitates its use in relatively small networks such as those used in volcano monitoring, where cost is a primary consideration.

In a general sense, though, it would seem that the most important feature of the Earthworm system with respect to future applications is its ability to assimilate rapidly evolving technology so that network processing capabilities can evolve smoothly, without major breaks and periods of retraining. It is no minor concern in these times of tightening budgets that the survival of dense regional seismic networks depends upon efficient and economic processing capabilities.

References

Allen, R.V., 1978. Automatic earthquake recognition and timing from single traces. Bull. Seism. Soc. Am., vol. 68, no. 5, p.1521-1532.

Allen, R.V., 1982. Automatic phase pickers: Their present use and future prospects. Bull. Seism. Soc. Am., vol.72, no.6, p.S225-S242.

Johnson, C.E., Lindh A.G., and Hirshorn, B. 1994. Robust regional phase association. USGS Open File Report 94-621. •

High Resolution Imaging Equipment added to PASSCAL Instrument Pool

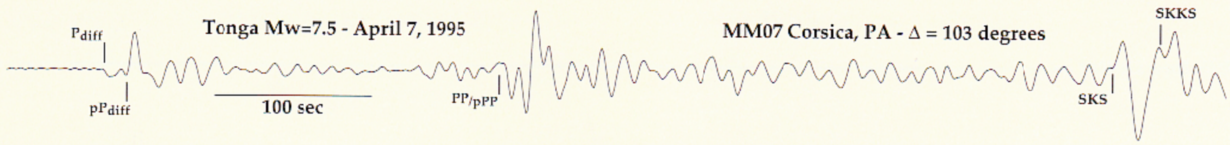
The Department of Energy, Office of Basic Energy Sciences has funded a proposal from IRIS for purchase of shallow seismic instrumentation. One 60 channel system has been purchased and a similar system will be acquired next year. The instruments are intended for use in a variety of different types of projects: in detailed studies of the upper 100 meters; as high resolution adjuncts to PASSCAL instruments in crustal imaging; and in teaching applications. The first set of instruments will be available early in 1996. Until a clear use pattern develops, the policy for use for these instruments will be the same as for the rest of the PASSCAL instrument pool. Contact Jim Fowler (jim@iris.edu) for more details. •

IRIS-2000 Submitted to NSF

IRIS-2000 - a proposal for support of IRIS activities over the next five years - was submitted to the National Science Foundation in August. IRIS-2000 presents a challenging program to lead the development of seismological facilities into the next century. The proposal is now under review by NSF and the results are expected early in 1996.

Many individuals contributed to the development and writing of the proposal. A Science Task Force, chaired by John Orcutt and Bob Phinney, considered some of the new scientific directions which IRIS could help to support of the next five years. The IRIS Executive Committee guided the overall development of the proposal, with input and direction from the Standing Committees and IRIS staff. The central part of the proposal is a collection of contributed articles from scientists who have made use of IRIS facilities in their research. The broad spectrum of activities presented in this "Science Section" is a powerful statement of the impact that IRIS has had on the Earth sciences over the past decade. To all of those who contributed, we extend our sincere thanks.

The proposal has been distributed to all members of the IRIS Board of Directors. Those who contributed "one-pagers" received copies of the Science Section. A limited number of additional copies are available for distribution. Many are finding the Science Section to be an excellent review of current research for use in seminars and classes. Contact the IRIS office if you would like to receive a copy. •



IDA Update

Holly Given, Project IDA, University of California San Diego

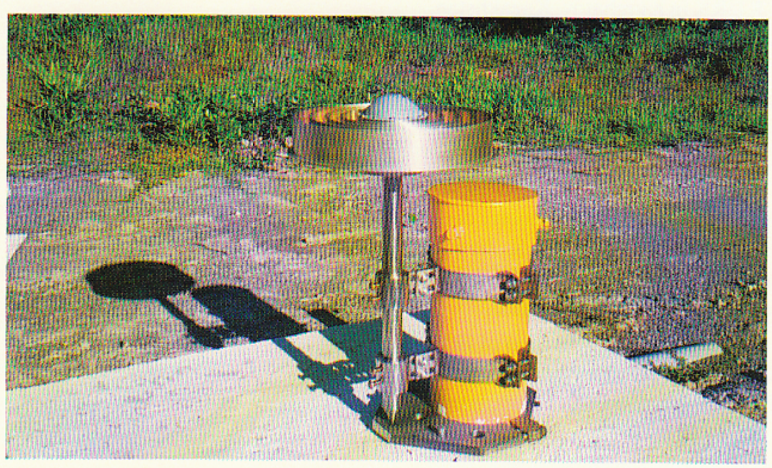
Happy Anniversary! 1995 marks 20 years of Project IDA, the first globally deployed, digitally recorded network to expand significantly the bandwidth of seismology by making fundamental new observations of the Earth's free oscillations. Also, on August 6 of this year, our friend Dr. Cecil H. Green celebrated his 95th birthday. Along with their numerous other gifts to academic geophysics, Cecil and his late wife Ida Green were early patrons of the IDA Network. The first IDA grant from NSF to principal investigators Freeman Gilbert and Jonathan Berger was backed by a pledge from the Greens to buy instruments and the first IDA station began operating near Canberra, Australia (CAN) in January 1975, quickly followed by stations NNA and PFO. The continued support of the Greens helped the IDA Network to reach a steady-state configuration of about 20 stations by 1983. This "original configuration" IDA Network using modified feedback gravimeters was a unique facility for many kinds of seismological studies.

By the mid-1980's, broadband seismographic systems that could accurately record ground motions from a few milliHertz to a few Hertz were a reality. The vision of a broadband network with 100 stations or more uniformly covering the globe required a coordinated effort by the university community, and led to the formation of the IRIS Consortium in 1985. Project IDA, again with help from Cecil and Ida Green, committed to upgrade and expand the IDA Network as an integral part of the IRIS program. The first of the new generation of broadband IRIS/IDA stations were PFO and ESK installed in 1986.

Today, Project IDA operates 27 stations of the Global Seismographic Network, including six new locations since the last IDA Update in the Fall 1994 IRIS Newsletter; three of these are on islands in the Southern hemisphere, and three are on continents in the Northern hemisphere. Stations ASCN and SHEL are located on Ascension Island and the Island of Saint Helena, respectively. Both small islands are territories of the United Kingdom in the southern Atlantic Ocean. Both use Teledyne Brown KS54000 borehole seismometers as the basic broadband sensors and Streckeisen STS-2s as short-period sensors; SHEL is the first IRIS station to deploy the STS-2 in a shallow (6 meter) borehole using a "cradle" designed at IGPP that allows remote leveling. Saint Helena, where Napoleon I died in exile in 1821, is in some ways the most remote IRIS/IDA station. There is no airport, and a mail/passenger ship calls once per month. ASCN and SHEL are accessible in near-real time and participate in the IRIS SPYDER system. ASCN began operation on October 1, 1994, and SHEL on June 19, 1995.

Station MSEY is located on the island of Mahe, Republic of the Seychelles, in the Indian Ocean. It began operation on May 15, 1995 with a KS54000 borehole seismometer and a Guralp Systems CMG-3T in a shallow (6 meter) borehole as the short-period sensor. MSEY is the first IRIS/IDA station to co-locate continuously recorded, geodetic quality GPS data in collaboration with the GPS Networks and Operations group at Jet Propulsion Laboratory. The seismometer borehole casing itself, cemented to granitic rock to 100 meters depth, forms the fiducial benchmark for the GPS receiver. An antenna mount designed by JPL engineers can be removed and accurately re-installed if work is required in the borehole. MSEY is accessible in near-real time.

Station JTS, near the small town of Las Juntas de Abangares ("Juntas") in northwest Costa Rica, began operation on April 23, 1995. It is a joint station with Costa Rica's national network operated by the Volcanological and Seismological Observatory of Costa Rica



Picture: GPS antenna mount and benchmark coupled to the seismometer casing wellhead at MSEY (Mahe Island, Seychelles; photo by Garth Franklin, JPL).

(OVSICORI) under the direction of Dr. Federico Guendel. JTS is located on former mining property; the current owner, who is also the station operator, relocated from Switzerland some years ago to explore for gold. For a sensor environment, we enlarged an old dynamite storage tunnel and built a pier about 13 meters back into the hillside for the STS-1, STS-2, and FBA-23 sensors, adding doors to provide some isolation from the outside. A dedicated phone line was installed from JTS to OVSICORI, which is on the Internet. Costa Rica has officially submitted JTS for use in the "GSETT-3" experiment on global seismic data exchange currently being carried out by the United Nations Conference on Disarmament.

Station NIL in Nilore, northern Pakistan, is in collaboration with the Pakistan Institute of Nuclear Science and Technology (PINSTECH), which had previously operated a station at this location with a Teledyne Geotech KS36000 borehole sensor. NIL began operation as an IRIS GSN station December 18, 1994 using the KS54000 borehole sensor with an STS-2 and FBA-23 deployed on a pier in a nearby building. NIL became accessible in real time in October.

KURK in Kurchatov, Kazakhstan, is located on the grounds of the former Soviet underground nuclear test site near Semipalitinsk and is operated by the National Nuclear Center of Kazakhstan. The sensors (STS-1's, STS-2, and FBA-23) are in an instrument room in a 25-meter deep vault complex. KURK began operation March 26, 1995. KURK is not yet accessible in real time.

More on the configuration of IRIS (GSN) stations operated by Project IDA can be obtained by accessing our home page http://www-ida.ucsd.edu/public/welcome.html (select "map of IDA stations" and then click on the station's symbol).

On July 21, 1995, RPN (Easter Island, south Pacific Ocean) became the sixth IRIS/IDA station that is an Internet node with full-period connectivity, thanks to a cooperative agreement with NASA and the University of Chile. These stations provide routine and continuous real-time telemetry of broad band (BH*) and very long period (VH*) data.

Site preparation has been nearly completed at CMLA (Chã de Macela, São Miguel Island, Azores) and EFI (Mt. Kent, East Falkland Islands) and are the next installations planned. Site reconnaissance trips were recently carried out in Uganda, and the Cocos (Keeling) Islands in the Indian Ocean.

We are happy to announce the addition to our staff of development engineer Arthur Endress. Art is familiar to many in geophysics from his long career in the instrument group at Teledyne Geotech; recently he has worked as a field engineer for Schlumberger International. Field technician Phil Porter also has joined Project IDA after acquiring years of valuable experience with the Kyrgyzstan Network (KNET) group at IGPP. •

Execom News

The IRIS Executive Committee has been busy over the past year with preparation of the IRIS-2000 proposal. As the review of the proposal progresses, the Executive Committee will work with NSF to develop a revised program plan and budget which will form the basis for a new Cooperative Agreement to begin in July, 1996. If you have comments you would like to have considered in the development of this final plan, please contact the Executive Committee or IRIS staff.

After the 1995 Workshop, the Executive Committee and IRIS staff solicited membership views on the importance and benefit of the annual Workshop. Over 100 persons responded, and the overwhelming consensus was that the Workshop served an extremely valuable role. Many successful field experiments originated at past IRIS meetings, and the style of focused science sessions nurtured scientific collaboration. In fact, a significant number of respondents stated that the IRIS Workshop was their most important science meeting. There was a preference to continue the tradition of holding the meetings in a different location each year, preferably in a stimulating geological setting. One of the most commonly expressed concerns was the overall expense to IRIS of the meeting. With this in mind, we will charge a nominal registration fee for future meetings to partially offset costs. We will continue to experiment with the structure of the meeting to assure that it evolves to serve the community. •

Terry Wallace, Chair
IRIS Board of Directors

SOD: An Automated Method for Processing Standing Orders at IRIS DMC

Robert Casey, IRIS Data Management Center

The efforts of IRIS over the years have allowed for ever-increasing amounts of seismic information to become available to member institutions and the scientific community at large. This increase in supply and accessibility has ultimately resulted in a very large user base with continuous data retrieval needs. So large is this user interest that personnel associated with the *Data Management System* (DMS) find themselves constantly pressed to develop new and innovative techniques, including automation, to continue providing a rich array of quality data, made to specification, and delivered with minimal delay.

A new technique has joined the ranks of data request processing methods at the Data Management Center. Called *SOD* (Standing Order for Data), this system allows for researchers to request data *before* it becomes available at the DMC. A request sent through SOD becomes a *standing order*, which is a request that remains active over a period of time, known as the request's *shelf life*.

In the past, on rare occasions, a user would ask the DMC to hold a request until the data asked for became available. This made request processing difficult because the DMC staff had to manually log the standing order in some fashion and then remember to go back to the request when the data finally came in. It is such problems as this for which members of the DMS seek automated solutions. The efficiency of automation has shown positive results for both the technicians processing data and the users who ideally want their data error-free and as soon as possible.

SOD is an automated solution to the standing order problem and has many other benefits besides satisfying requests with future data. In effect, a SOD request is satisfied the *instant* that matching data is archived at the DMC. Thus, a SOD request can also have the benefit of allowing a university to maintain an up-to-date archive of data, pruned to their specifications.

The data cannot, in general, be shipped the instant that it is processed. Since hundreds of matches can occur for just one SOD request during an archiving day, the problems of email flooding and shipping quantity would be staggering if shipments occurred a piece at a time. Hence, it was determined that the data generated by SOD would be bundled together and shipped no more frequently than a week at a time. Although this eliminates any semblance of real-time data acquisition, the efficiency and maintainability of this scheme more than makes up for the delay.

Requesting Data with SOD

The method of submitting a SOD request is very similar to *BREQ_FAST*, which is a simple text-based request format that has been used at the DMC for quite some time. It is not necessary for the reader to be familiar with BREQ_FAST in order to understand SOD.

```
.SOD
.NAME Chris Smith
.INST University of Kalamazoo
.MAIL 1101 Thurston Blvd., Howell, PA  99111
.EMAIL joe@kalamazoo.edu
.PHONE 555-555-9999
.FAX 555-555-9991
.MEDIA Exabyte 2 GB
.ALTERNATE MEDIA Exabyte 5 GB
.SHELF LIFE 941007 941229
.SHIPMENT FREQUENCY 2
.LABEL my_request
.END

ANMO  IU   94 09 10  00 00 00.0  94 11 30  23 59 59.9 2 SHZ BHZ
FFC   II   94 08 16  12 00 00.0  94 10 31  14 26 23.5 1 L?E
????? II   94 09 01  02 00 00.0  94 09 30  06 00 00.0 1 B??
```

Figure 1. Sample SOD request text file.

A sample SOD request is illustrated in Figure 1. This request can be created with any text editor. Each of the fields are separated by spaces. Those that are familiar with BREQ_FAST requests will recognize the layout, although it should be stressed that there are distinct differences that BREQ_FAST users should take careful note of (these differences are highlighted in Figure 1).

A SOD request must always begin a line with ".SOD", typed in exactly as shown in the example. What follows are fields indicating the name and institution of the user, the mail and email addresses, phone and fax numbers, shipment media selections, the shelf life of the request, the shipment frequency in weeks, and the label for the request. This set of information does not need to be in any particular order, but the field names must be spelled correctly and the entries must end with a ".END" line.

Finally, the request continues with any number of *request lines*, specifying the station, network, time window, and channels desired. Three lines are shown in the Figure 1 example. It looks exactly like the BREQ_FAST format, but the way the time windows are interpreted is distinctly different.

The set of numbers on each line can be broken into four groups of three. Group 1 is the starting year, month, and day of the data desired. Group 2 is the starting hours, minutes, and seconds for *each* matching day (this is different from BREQ_FAST). Group 3 is the ending year/month/day of the data wanted and Group 4 is the ending time of each matching day.

What results is a span of days requested with time windows of data within each of those days. As an example, the FFC line asks for data between August 16th and October 31st of 1994, windowing out data between noon and 2:26 PM from each of those days. Users may find this handy if they are interested in data from only certain times of the day and it helps in cutting down data volume.*

The last fields on the line are the channel descriptors. The number indicates how many channel descriptors are listed and is followed by the descriptors themselves. What may be apparent is the use of question marks ("?") in the request lines. These are wildcards and essentially match to any character, if present. Thus, "B??" as a channel descriptor asks for all broadband channels. A "?????" in the station field asks for all stations.

After the SOD request is generated, it is mailed to the DMC, specifically to *sod@iris.washington.edu*. The request is then processed by automated programs and placed on a file system where it can be monitored. When the current date reaches the start time of the request's shelf life, the request becomes *active*. Only active requests are scanned by SOD when new data are archived at the DMC. All of the data files read in by an archive tape are checked to see if they match to any active SOD requests. If one or more matches are found, a copy of that data file is sent to a temporary file system. Once there, each match spawns its own running copy of the miniSEED generator, using the copied data files as the source.

What results is a miniSEED volume consisting of many stations and channels, with time windowing, as specified in the user's request. Once a particular matching set is completed, the miniSEED volume is moved to a permanent location in the archiving system. On a weekly basis, the most current miniSEED compilations in the archive are shipped to tape or to the ftp file system, depending on the size of the file, and made available to the user. This constant periodic flow of data continues until the request exceeds its shelf life, wherein the request becomes inactive and is deleted shortly thereafter.

The SOD system was designed to keep the remote user continually apprised of the status of his requests. Any time the request changes state or a shipment is generated, the user is notified by email. The user can also track the progress of his requests by *finger sod@iris.washington.edu*. The table displayed will show all of the SOD requests in the system, their status, the size of the current miniSEED file, and shipment dates.

Making Use of SOD Data

SOD products are playfully called *compost files*, which illustrates the fact that the data records are lumped and packed together into one file.

If the size of the miniSEED shipment is less than 20 megabytes, it will be moved to the ftp site. The user can then retrieve these data by initiating an anonymous ftp session to *dmc.iris.washington.edu*. The directory and filename of the user's data shipment are provided in the email notification. The grace period for picking up data from the ftp site is generally about seven days, at which point it will be removed to make space for new request shipments. If for any reason the user is unable to retrieve the data in time or the retrieved copy is lost, the DMC can restore the data with little difficulty.

For SOD products larger than 20 megabytes, the data are shipped on tape. The tape medium of choice is sometimes specified by the user on the .MEDIA or .ALTERNATE MEDIA lines in the SOD request. The default is 2GB 8mm Exabyte, but 5GB 8mm, DAT, and 1/2 inch tape formats are also supported.

When the user has the SOD data, it can be read and analyzed by any software that is capable of reading miniSEED. However, it may be desirable to form a full SEED volume from the SOD data. This is performed with the most recent versions of *rdseed* (versions 3.46 and later), available from IRIS DMC.

In forming a full SEED volume from

* A caveat for BREQ_FAST users: It is common practice to enter all zeroes for the hour, minute, and second fields of a BREQ_FAST request. This is interpreted as a day boundary for start and end dates of the request. However, since SOD interprets the start and end times as time windows for *each* day, entering zeroes for starting and ending time would window out zero hours, zero minutes, and zero seconds out of every day in the date span, effectively nullifying the line.

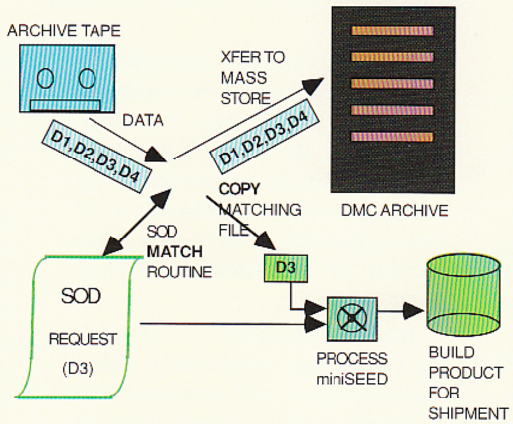
miniSEED, the data records must be knit together with header information. To supply this, the user must obtain a *dataless SEED* volume from the IRIS DMC for the network in question. A dataless SEED volume is a SEED volume without the data records. The DMC maintains dataless SEEDs covering all of the stations for each network supported. These SEED volumes can be retrieved by anonymous ftp in /pub/RESPONSES. Some networks have multiple dataless SEEDs listed, each with a date tag. It is usually best to get the most recent one.

Now armed with a miniSEED volume, a dataless SEED volume, and the latest version of rdseed, a full SEED volume can be formed. The stipulation currently is that the SEED volume formed can be only for one network, since any one dataless SEED supplied by the DMC applies to only one network. Before running rdseed, the user must set an environment variable called ALT_RESPONSE_FILE, set equal to the dataless SEED filename. This will tell rdseed that the response information for the data provided by the miniSEED can be found in the file specified.

The user types 'rdseed' on the command line to start up the program and then answers a series of questions to select the nature of processing desired. Enter the name of the SOD volume for the *Input File*, under *Options* enter 'd' for data output, and under *Output Format* enter '5' (the selection number for SEED output). Provided everything is set correctly, the end result is a file called *seed.rdseed*, which is the output SEED volume produced from merging the data records from the SOD volume with the dataless SEED indicated by the ALT_RESPONSE_FILE variable.

Items to Consider in Using SOD

The IRIS DMC supports many different request formats, each satisfying a special need. It is important to consider what each of these request formats is intended for, so as to make an informed decision about which tool to use to satisfy your needs. The old adage goes: "The right tool for the right job."



Which brings us to consider the proper and intended use of SOD, as opposed to other request formats. SOD can supply recent data, but only if the data is in the process of being archived. Data that is already in the Data Management System, should be requested with BREQ_FAST, XRETRIEVE, or SPROUT. SOD is not currently capable of extracting events, which is better tackled with a RUMBLE request or extraction of FARM products from the DMC's ftp site.

In addition, responsible consideration should be taken when submitting a SOD request. It is not the DMC's intention to let SOD become a *mirroring* tool for other sites, where **all** of the data being archived at the DMC gets bundled up and sent off to another group. This is simply too CPU and media intensive to be feasible. However, a SOD request asking for a handful of stations with selective time windows and channels is certainly welcomed. In other words a good SOD request is one that meets specific aims and where thought is given to minimizing the volume of data produced.

One final point to note is that a SOD request cannot remain in the system indefinitely. There is a current limit of 6 months imposed on the shelf life duration of a SOD request. Within two weeks of the expiration of that request, the user will be notified through email, giving that person the opportunity to submit a new request to take its place if so desired. The old request in the system cannot be renewed and will expire at the end of its shelf life.

Help Available for Using SOD

There is currently a man page for SOD on our system retrievable through anonymous FTP in /pub/manuals. This guide lays out the specifics of SOD request design. This manual is also presented in HTML form on our World Wide Web site (http://www.iris.washington.edu) and is accessible through our bulletin board under option 'm'. Any additional questions or help needed can be addressed through email to *rob@iris.washington.edu* or to *tim@iris.washington.edu*.

Conclusion

SOD is a new tool among the ranks of data request service provided by the IRIS Data Management System, forging a unique path where users can stay on top of the latest quality controlled seismic data and do not have to second-guess when new seismic traces become available. The automation involved removes the frustration and uncertainty that would otherwise occur with pending data issues, for both the scientific community and the data management technicians servicing their needs. SOD's credo could be: "*You* get it, when *we* get it."

In essence, SOD may be the first step in bringing more automated data solutions to the scientific community in the near future. The success of this tool will largely depend on its responsible use and the satisfaction voiced from its users. •

Controlling Long Period Air Convection Noise In Borehole Installations With Sand

Gary Holcomb, Bob Hutt, Leo Sandoval
Albuquerque Seismological Laboratory

Many years of experience in operating Teledyne Geotech KS borehole seismometers has established that the horizontal components are usually noisier than the vertical component at periods larger than about 30 seconds despite the fact that the instruments are installed quite deep beneath the surface. This phenomenon is quite frustrating because the purpose of operating the instruments below the surface is to reduce the horizontal noise to lower levels than would be measured on the surface. Several procedures have been attempted to control air motion within the borehole, with varying degrees of success. These include wrapping the seismometer with a layer of foam insulation, wrapping the centralizer assembly with foam insulation, and installing foam plugs just above the sensor and near the top of the borehole. Throughout the years, it has been suggested that the remnant horizontal noise in borehole installations is tilt noise generated by air motion in the vicinity of the instrument package itself.

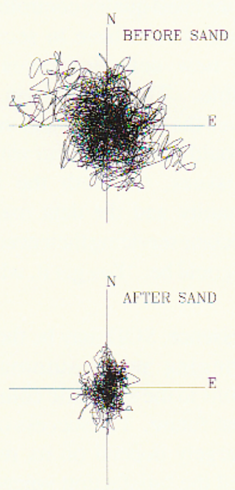


Figure 1. One hour of particle motion before and after sand installation in the 20 to 600 second pass band.

Experiments aimed at controlling air motion near the sensor by filling the empty space with sand have been underway at ASL for about a year and a half. Initial investigations were conducted in a shallow borehole (about 25 feet deep) and were aimed at confirming that the seismometer could be removed from the hole if it was installed in sand; removing the sensor from dry sand proved to be quite easy. During calm atmospheric conditions, the horizontal noise levels observed in a shallow borehole with sand installation indicated significant improvement over those normally observed in a conventional installation. A deeper borehole experiment was deemed necessary.

Therefore, between days 81 and 87 of 1995, ANMO was converted from a traditional KS borehole installation to a sand installation as follows. The holelock was removed from the borehole and discarded; the pilot on the bottom of the sensor package was replaced by a new assembly designed to increase the area of the load bearing surface at the bottom of the seismometer. Ordinary playground sand was poured into the borehole to a depth of approximately two feet above the bottom of the hole. The seismometer was lowered into the hole until it rested on the sand, at a depth of 498 feet below the surface. Sand was then poured into the hole, using a volume calculated to fill up the space between the sensor and the walls of the borehole to the top of the seismometer.

Despite the fact that the original horizontal noise levels were not abnormally high, ANMO long period noise levels using the sand installation are significantly lower than previously, as is illustrated by the particle motion plots in Figure 1. This figure illustrates the relative levels of particle motion in the 20 to 600 second band during an event-free hour. It is evident in this figure that the sand installation produces considerably less noise than the conventional installation. The long-term relative noise levels are illustrated in the time domain in Figure 2 over approximately seven days for both installation methods. Figure 3 demonstrates the improved noise levels in the frequency domain.

Figure 2. Seven day time domain records in the 20 to 600 second pass band of relative noise levels in sand and no-sand installations.

In the future, ASL plans to convert several of the noisier borehole sites in the IRIS/USGS GSN to sand installations. If successful, the sand should reduce the noise level on the horizontal sensors in noisy boreholes.

Users of GSN data should be warned that horizontal borehole sensors installed in sand will probably not be oriented north-south and east-west because a holelock orienting system is not being used. However, the sensor orientation will be known and will be so noted in the appropriate SEED header blockett. As a precaution against inadvertent confusion by data users, the seed names of the horizontal components of non north-south and east-west oriented KS sensors will no longer end in N and E respectively; instead, they will end in 1 and 2 to warn the user to refer to the header for the true sensor orientation azimuth. •

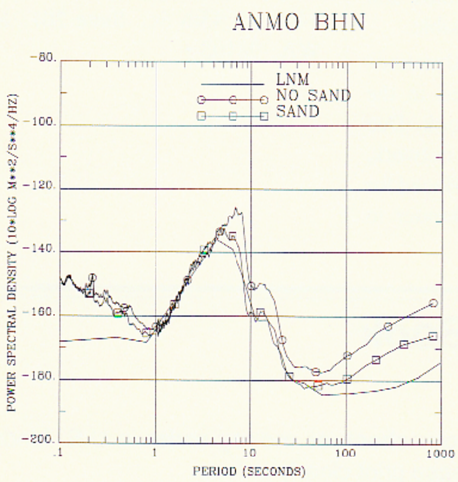


Figure 3. Power spectral densities of SAND and NO SAND installations. LNM is the USGS Low Noise Model.

the IRIS CONSORTIUM

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The Incorporated Research Institutions for Seismology (IRIS) is a consortium of over 80 research institutions with major commitments to research in seismology and related fields. IRIS operates a facilities program in observational seismology and data management sponsored by the National Science Foundation. Major funding for IRIS programs is provided by the National Science Foundation through its Division of Earth Sciences and the Air Force Office of Scientific Research.

The IRIS Newsletter welcomes contributed articles. Articles should be less than 1000 words and four figures. Please send articles or requests for submission of articles to the address listed above.

Executive Editor: David Simpson (simpson@iris.edu)
Production Editor: Anne DeLaBarre Miller (anne@iris.edu)

New PASSCAL Datasets Available

Onshore/Offshore Experiment at Cape Blanco, Oregon

PASSCAL Dataset 95-95-003: Tom Brocher, Mark Davis, Sam Clarke, and Eric Geist; USGS and University of Durham.

1994 Krafla Undershooting Experiment

PASSCAL Dataset 95-002: W. Menke, B. Brandsdottir, P. Einarsson; Lamont Doherty Earth Observatory and Science Institute, University of Iceland.

For more information please refer to the IRIS DMC electronic bulletin board (telnet iris.washington.edu userid = bulletin password = board) or World Wide Web server (http://www.iris.washington.edu/).

GSN Update

Fourteen new GSN stations have been installed since the last Newsletter.

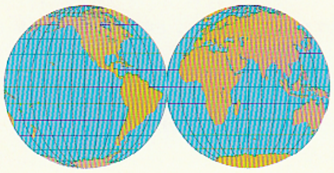
The IRIS/USGS team has completed six vault sites: KIEV, Kiev, Ukraine; NAI, Nairobi, Kenya; HKT, Hockley, Texas; INCN, Inchon, South Korea; BILL, Bilibino, Russia; and TIXI, Tiksi, Russia. The NAI site is a cooperative joint station with the German GEO-FOrschungsNetz (GEOFON). HKT is a cooperative IRIS/ University Network site with the University of Texas, Austin and the US National Seismic Network.

Four new GSN stations have been installed in China in a new partnership between IRIS/USGS and the New Chinese Digital Seismographic Network (NCDSN) to upgrade the CDSN to GSN design goals. These sites include BJT, Beijing; HIA, Hailar; LSA, Lhasa; and WMQ, Urumqi. BJT and HIA are cooperative stations with the Advanced Research Projects Agency (ARPA).

The IRIS/IDA group has completed the installation of four sites: SHEL, St. Helena Island, South Atlantic, and MSEY, Mahe, Seychelles are new borehole sites. KURK, Kurchatov, Kazakhstan and JTS, Las Juntas de Abangares, Costa Rica are new vault sites. •

FDSN STATION BOOK

by Kris Skjellerup



IRIS and the Federation of Digital Seismographic Networks (FDSN) are pleased to announce the publication of the first FDSN Station Book.

With the growth in the number of broadband stations within the FDSN, it has been difficult for independent seismologists to keep track of stations, instrumentation and dates of operation. In response to this need, various member networks of the FDSN coordinated efforts to produce the FDSN Station Book. A working group within the FDSN determined what information should be included and in what format it should be presented.

Each station entry has three main components. The first portion of the station page includes basic information about the location, parent organization, geology and who to contact to receive data. The next section lists current instrumentation, dates of operation, response and channel data, followed by historical information and comments. The last section includes photos and noise study graphs when available.

There are presently over 170 stations from 10 networks represented in the initial version of the Station Book. Due to the dynamic nature of the network, the Station Book has been produced for distribution as a three-ring binder to allow for updates.

The FDSN Station Book is the result of the cooperative efforts of all networks involved. Since its publication in February 1995, the contents have been transferred into an on-line version accessible through the IRIS DMC homepage on the World Wide Web (http://www.dmc.iris.washington.edu). Due to the cost of production of the FDSN Station Book, IRIS can not distribute this publication free of charge. Included here is a copy of the Station Book order form. To order, send the requested information and a check to the IRIS DMC, attention Kris Skjellerup, 1408 NE 45th St., Suite 201, Seattle, WA. 98105 •

FDSN Station Book
Order Form

Please fill out the following information, be sure to **include your check or money order** in U.S. funds. Orders without accompanying funds will not be processed. Please print clearly or type.

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Total in U.S. funds $__________

IRIS Employee News

In September IRIS bid a fond farewell to Liz McDowell. Liz decided to leave IRIS after 10 years of faithful service. As one of IRIS's first employees in 1985, Liz wore many hats in the beginning from receptionist and accountant, to meeting planner and administrative manager. Liz, working with three presidents, Stuart Smith, Bob Phinney, and David Simpson, helped make IRIS what it is today. Liz will be sorely missed. We wish her much happiness and the best of luck and success.

IRIS welcomes several new employees. Chau Tran has been working hard in the Business Office taking care accounting, purchase orders, and inventory. Jamie Understein is now working with our subcontractors. Christina Wise has taken over the phones, as our new Receptionist/Secretary. We also welcome Susan Strain, Executive Assistant, who will be working closely with the President, Program Managers and Executive Committee on planning of meetings and contact with IRIS members. Shawn Boo has taken on an expanded role as Director of Finance and Administration.

The IRIS DMC congratulates and welcomes back Anh Ngo, who returns after the birth of her son. The DMC also welcomes Deborah Barnes, Interface Specialist. Debbie comes to us from the Borehole Research Group at Lamont Doherty Earth Observatory. Her background includes graphics design and the development and maintenance of World Wide Web pages. Debbie will be involved in many aspects of graphical user interface design for IRIS.

Rhett Butler attended the recent meeting of the Group of Scientific Experts of the Conference on Disarmament in Geneva, Switzerland, participating in discussions of the development of the auxiliary network for use in CTBT.

Tim Ahern, DMS Program Manager has spent much of the month of November on a tour of data centers and seismological institutions in South America.

Gregory van der Vink has been elected to the AAAS Committee on Science and International Security. He is also teaching a course on the Analysis of Environmental and Scientific Policies at Princeton University in the Department of Geological and Geophysical Sciences.

David Simpson, IRIS President, has been elected as a Foreign Member of the Russian Academy of Natural Sciences, and during a recent trip to Moscow was presented with the Medal of the Schmitt Institute of Physics of the Earth. •

Hawaii-2 Observatory (H_2O)

The NSF Academic Research Infrastructure Program has funded a proposal, "The Hawaii-2 Observatory: a deep-ocean geoscience facility re-using the Hawaii-2 telephone cable," submitted by R. Butler (Principal Investigator, IRIS), A. Chave, J. Catipovic, D. Yoerger (Woods Hole Oceanographic Institution), F. Duennebier (University of Hawaii), and J. Hildebrand (Scripps Institution of Oceanography) through IRIS and in cooperation with AT&T, which is generously donating the cable to the project. The site of the Hawaii-2 Observatory (H_2O) midway between Hawaii and California optimizes coverage for the IRIS Global Seismographic Network, and will potentially contribute to geomagnetism, tsunami studies, and physical oceanography. The proposed design of H_2O is simple: a junction box (j-box) with eight independent underwater-mateable connectors will be spliced into the Hawaii-2 cable.

A broadband Guralp seismometer and hydrophone package will be deployed (plugged in) at the same time as the j-box. Ample power available to the observatory (>1000 watts) broadly opens up the types of instrumentation that can be added (or changed) later using a remotely operated vehicle (ROV), a manned submersible, or the Scripps wire-line re-entry thruster package. The installation of an acoustic modem at H_2O makes available an easy, inexpensive deployment mode for future autonomous scientific instrumentation, which can be deployed from an ordinary research vessel passing over the H_2O site. The cable will be powered from the AT&T Makaha cable station on Oahu. Telemetry from the Hawaii-2 cable terminus at Makaha will be linked to a data collection center at the University of Hawaii at Manoa, and will be available in real time via Internet. Data will be archived and distributed by the IRIS Data Management Center in Seattle. •

IRIS Home Page

The IRIS Home Page is now available on Mosaic. Viewers can access the home page through URL: **http://www.iris.edu/** to obtain information on membership, committee members, and IRIS publications, including an on-line version of the latest Newsletter. Selected articles from Section II, Scientific Contributions, of the IRIS-2000 proposal to the National Science Foundation are also being added. The PASSCAL section has copies of the latest instrument schedules, instrument request forms as well as information and manuals for PASSCAL equipment. The DMC connection allows direct access to the DMC for information on data available and on-line data. •

Seventh Annual IRIS Workshop

June, 1995, Jackson, Wyoming

Participants at the Seventh Annual Workshop*

The Seventh Annual IRIS Workshop was held June 22-24, 1995 at Jackson Lake Lodge, Wyoming, just south of Yellowstone National Park. More than 200 IRIS members and friends attended the Workshop, making it the largest to date. The majesty of the Grand Tetons, abundant wildlife and the relaxing ambiance of the Lodge provided a stimulating environment for review of recent IRIS accomplishments and planning for the future. One important purpose of the meeting was to present an overview of the IRIS-2000 proposal, which at the time of the Workshop was in the final stages of preparation for submission to the National Science Foundation.

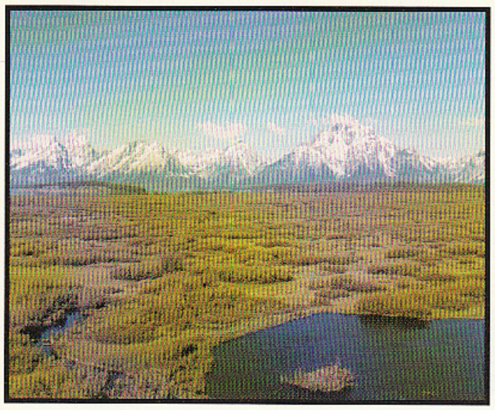
A session on the "Great Deep Earthquakes of 1994" highlighted the significance of the March 9, Tonga (M7.4) and June 9 Bolivian (M8.3) earthquakes which by serendipity occurred beneath PASSCAL experiments. With the extensive data available from the GSN and the PASSCAL deployments, these events are the best studied deep earthquakes and have led to some serious revision of explanations for the origin of deep seismicity. Both events have rupture planes in excess of the dimensions expected for "metastable" wedges of material within the subducted slab. In addition to contributing to the debate about the nature of deep earthquakes and the dynamics of subducted slabs, GSN data from these simple and powerful sources enhance the study of whole Earth and core structure, by adding to the relatively rare collection of free oscillation data and providing clear observations of complex core phases.

The IRIS-2000 proposal identifies new trends in telemetry and communications, for both global and local data collection, as among the most important technical developments for IRIS over the next 5 years. This was the motivation for a Workshop session which covered topics such as frame relay and spread-spectrum radio techniques. A specific application of telemetry in seismology is in the development of arrays and talks and posters presented at the Workshop showed some of the powerful analysis techniques that can be applied to array data. An expanded role for the IRIS Data Management System in helping to coordinate earthquake information is also envisioned in the next five years. Talks on the experience of other groups like the Sequoia Project and UNIDATA, and some predictions on future uses of the Internet, provided stimulating guidance on directions for IRIS activities in this area.

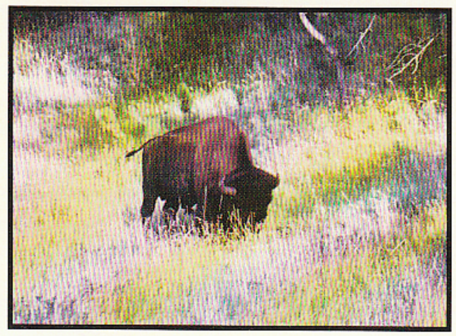
The cataloging of global seismicity and the development of systems for monitoring nuclear test ban treaties benefit from the expanded global coverage of the GSN and the availability of data in near real time. Within regional and national networks, the use of broadband data is revolutionizing the assessment of regional seismicity and earthquake hazards. A session on "Earthquake Parameterization" looked at some of the technical issues involved in making more complete use of these new data and described the improved characterization of sources using broadband data.

Poster displays and demonstrations were even more popular this year than at past Workshops - with presentations overwhelming the poster display area and flowing into the auditorium. Posters described a wide variety of projects based on the use of IRIS facilities and provided a stepping off point for discussion of future projects. Demonstrations of the facilities provided by PASSCAL, DMS and the JSP Center helped new members and students become familiar with the resources available from these IRIS programs.

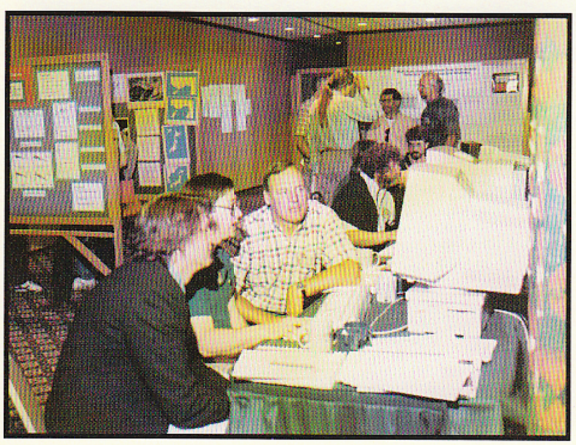
Over the past few years, Workshops have included talks and field trips designed to expose participants to the geology, seismology and ecology of the Workshop environs. In keeping with this tradition, talks and field trips this year took advantage of the stimulating vistas and geological uniqueness of the Teton and Yellowstone areas. One of the scientific sessions highlighted the geophysical structure of the Yellowstone and its significance in the tectonic framework of the western US. Jennifer Ziegler from the Teton Science School presented a talk on the Natural History of the Teton Range. Bob Smith of the University of Utah lead an afternoon field trip to the Teton fault. Bob was one of the original founders of IRIS and grew up in the Teton area . He has devoted much of his professional career studying the geology and seismicity of the region. He also provided an introductory guide to Yellowstone Park, helping many Workshop participants to take advantage of the proximity to Yellowstone to take a day trip there following the Workshop. •



A view of the Grand Tetons from Jackson Lake Lodge *



Bison feeding in Yellowstone National Park
(photo courtesy of Ralph J. Miller III)



Demonstration and poster area*

Bob Smith leading a field trip to the Teton Fault*

(* photographs courtesy of Michael Hasting, Naval Air Weapons Station, China Lake, CA)

Calendar

Dec. 11-15	AGU Meeting, San Francisco, CA
Dec. 12	IRIS Board of Directors Meeting
	1996
Feb. 8-13	AAAS Annual Meeting Baltimore, MD
12	Special Session on CTBT
May 6-10	XXI General Assembly European Geophysical Society FDSN Meeting The Hague
June 19-22	IRIS Workshop Blaine, Washington
Sept. 9-14	XXV General Assembly European Seismological Commission Reykjavik, Iceland

New Members

IRIS welcomes as a new member: University of Miami, Christopher A. Scholz, Representative. IRIS also welcomes as new foreign affiliates: Russian Academy of Sciences, Russia, Dr. Vitaly Adushkin, Representative; University of Bergen, Norway, Eystein Husebye, Representative •

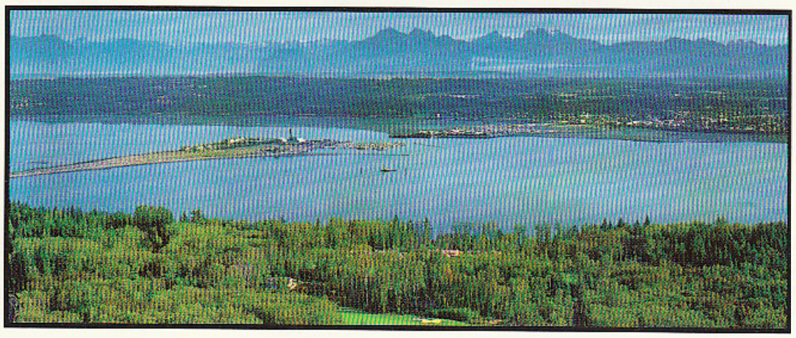
Announcing 1996 Annual IRIS Workshop

June 19-22, The Inn at Semi-ah-moo, Blaine, WA

The 1996 IRIS Workshop will be held at the Inn at Semi-ah-moo, near Blaine, Washington. It is located just south of the US/Canadian border, sitting on a finger which separates Drayton Harbor from Semiahmoo Bay. The Inn provides great meeting facilities as well as many wonderful outdoor and family activities.

The Workshop will begin with an icebreaker and registration on Wednesday evening, followed by scientific sessions Thursday through Saturday. We will tentatively take one afternoon to offer an optional group field trip to nearby Mt. Baker and North Cascades National Park. In keeping with the Workshop venue in the Pacific Northwest, one of the scientific themes will be a review of the numerous studies in recent years of the lithospheric structure of the region and the evolving picture of the tectonic fabric and seismic potential of Cascadia and surrounding areas. There is still time to be involved in the planning for the Workshop. Please contact the IRIS office if you have suggestions for scientific themes, SIGS or demonstrations.

Participation in the workshop is not limited to IRIS members and all interested parties are welcome to attend, subject to availability of accommodations. Mark your calendars, and keep an eye out for more information to be mailed early in the new year. •



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