

## ***ISC 2002 Report to the FDSN***

### **More Waveforms Links Added to the On-line Bulletin**

After finding events in the ISC Bulletin relevant to their work, the next step for many seismologists is obtain waveforms for further study of the source or of earth structure. Waveform archive centres assemble sets of data for events that they expect to be of interest to many seismologists, and the On-line Bulletin has included links to such sets for some time now. But these pre-assembled sets exist for only a small fraction of all events in the Bulletin.

Recently, the ISC added a new type of link to the On-line Bulletin to help users to compose requests for customised selections from the continuous waveforms at the IRIS DMC. The continuous waveforms include data at the time of every recent event, of course, so custom requests can be made for any event.

The challenge in making this system useful was to provide users with a summary of the data that are available, helping them to avoid a scatter-shot request. An inventory at the ISC of IRIS DMC waveforms would require nearly continuous maintenance and might fail to let users know of valuable data if the ISC's inventory were out of date.

Instead, when a user clicks on one of the new links the ISC obtains an up to date inventory of waveforms. The IRIS DMC lent a hand to make this work by adapting their "SeismiQuery" system to provide the information required by the ISC web server. After obtaining an inventory of data available in the hour after an event, the ISC posts a summary to the user and prompts for further information on which data the user wants. The ISC then composes a draft request, which the user edits or confirms before the ISC e-mails a message to the IRIS DMC on their behalf.

This is not the quickest service available from the ISC, since users wait for the summary of available waveforms while the ISC asks the DMC for an inventory. The system also could be improved to get inventories from several waveform archives and then despatch requests to each of them. But for many events the system already provides an easy way to obtain most of the waveforms that are available on the Internet, and it's an example that can be used in developing co-operative arrangements with other waveform archives.

### **New at the ISC: Old Data!**

One goal in recent development at the ISC has been to archive and re-distribute sets of data that were not available when the Bulletin was published. Our objective is to fully integrate the newly available data into the ISC's data collection. For example, a new contribution may include hypocentres computed from local readings for an event that is already in the Bulletin based on teleseismic readings. If so, the ISC will group the new hypocentres with the existing events, making it easier for users compare the differently computed hypocentres.

The challenge for the ISC was to integrate further data while still being able to retrieve data efficiently just as they were at the time that the Bulletin was published. To accomplish this, each datum inserted after the Bulletin is published is specially marked. For users of the On-line Bulletin who request the "published" version of ISC data, the data inserted later are

excluded.

"Old data" already integrated with other data at the ISC include

- hypocentres by Engdahl, van der Hilst and Buland from ISC phase readings
- epicentres by Fox et al. from hydroacoustic arrival times.
- focal mechanisms by Malone and Qamar from PNSN first motions.
- regional CMT's by Morelli and Pondrelli from MedNet data.
- catalogues by McCaffrey et al. and by Nyblade from PASSCAL deployments.

Integration of further data into the "comprehensive" version of the Bulletin shows one of the advantages of an on-line service over other means of data distribution. Bulletins from PASSCAL experiments show how the on-line service can link different types of data. Each of the hypocentres in the on-line Bulletin from a PASSCAL experiment includes a button that can be used to send a request to the IRIS DMC for related waveform data that were collected during the experiment.

Phase readings and hypocentres from experiments are the intellectual property of the original investigators, so these data are available through the generosity of individual scientists. Of course users generally acknowledge the data sources, cite descriptions of the data collection, and sometimes even collaborate with the original investigators. Thus, in the long run data contributors are likely to benefit from their own generosity.

### **Preliminary Bulletin Posted**

The ISC web site and e-mail servers now offer a preliminary Bulletin that includes even the most recently contributed data. Periodic re-processing excludes most duplicate readings and hypocentres, groups independently computed hypocentres for the same events, and associates phase readings with events.

Many smaller events are found only in regional catalogues that are not available in final form until more than a year later, but most large earthquakes ( $M > 5$ ) are reported soon after they occur. ISC's automatic grouping and association are subject to review by ISC seismologists, but only a few per cent of processing results are changed in analysis so the preliminary Bulletin is generally reliable.

The on-line Bulletin includes links to further data for most of the larger events, including details regarding calculation of moment tensors and source time functions, as well as sets of Spyder® and FARM waveform segments from the IRIS DMC and the Orfeus Data Centre.

Further development in the near future is planned to include maps and links to other on-line databases, especially when criteria used in selecting events from the ISC Bulletin suggest interest in further data that the ISC knows of elsewhere.

### **IDC Contributes Seismic Parameters to the ISC**

The Comprehensive Test Ban Treaty Organisation (CTBTO) has made seismic data from its Reviewed Event Bulletin (REB) for 2000 and 2001 available to the ISC. The release of seismic parameters from the REB was recommended by Working Group B at its meeting in February and later approved by the Preparatory Commission, which sets policies for

operation of the CTBTO. The ISC has accepted the data, integrated them into its database, and made them available in the printed and on-line versions of the ISC Bulletin.

The ISC's role, of course, is to integrate data from disparate sources and prepare an analysis of the combined data. In fulfilling this role, ISC seismologists carefully review both the grouping of origin estimates for the same event and the association of IDC phase readings with events in the ISC's more comprehensive catalogue. Thanks to this review, the Bulletin will continue to be a useful resource for seismologists evaluating the REB and developing new methods to produce even more complete and accurate bulletins.

Data from the REB of the prototype IDC has also improved the ISC Bulletin for all other applications. Thanks to the numerous teleseismic amplitudes reported in the REB, mb is computed now for almost every event with a teleseismic arrival time. In addition, results from processing at the ISC suggest that very few large events now go undetected in broad oceans and other regions with few seismic stations.

The CTBTO does not plan to release data from 2002 REBs until the Preparatory Commission agrees on a general data policy. A general policy would cover all CTBT monitoring data and IDC products, including waveforms and non-seismic data in addition to seismic parameters from the REB.

### **Analysing 13 months per year**

The ISC is now working ahead of its nominal schedule, which calls for the Bulletin to be published within two years of the events. At its meeting in 2001 August the Governing Council directed the ISC to continue analysing approximately 13 months per year unless important data could not be obtained in time. In 2002 May the ISC completed its final analysis for 2000 July. The results were made available on the Internet immediately and distribution of the printed July/August Bulletin is expected in July. Distribution of the CD with data for all of year 2000 is expected in October.

### **IASPEI Seismic Format (ISF) for Bulletins**

The IASPEI Commission on Seismic Observation and Interpretation formally adopted IASPEI Seismic Format (ISF) at its meeting during the 2001 Assembly. The agreement concludes a 16-year process seeking consensus on a standard to succeed the "Telegraphic" format that is described in the 1979 edition of the Manual of Seismic Observatory Practice.

Seismologists are familiar with the benefits of standards, which make it easier to exchange data, re-use data collected for past projects, and employ programs developed elsewhere. This wide variety of advantages is also part of the problem, however, since each imposes different and sometimes conflicting requirements for conciseness, transparency, and completeness.

Consensus was reached partly by including many optional items. Optional event parameters such as scalar seismic moment, focal mechanism, and stress drop are likely to be included in many ISF bulletins. In addition, however, ISF includes extensive optional phase data, such as the filter used while reading and asymmetrical uncertainty ranges.

ISF is defined as the parts of IMS1.0 for seismic parameter data, plus a specific set of extensions. IMS1.0 was developed for exchanging data from the International Monitoring

System of the Comprehensive Test Ban Treaty (CTBT). By including this format as a subset, ISF immediately gains the CTBT International Data Centre and National Data Centres around the world as users. The ISC and the US National Earthquake Information Center already use ISF for private data exchanges. ISF is one of the formats in which data are available publicly from the NEIC, and ISF is the default format of the Bulletin on the ISC web and AutoDRM servers.

Bulletins from many sources should help ISF to be accepted widely, but software is also important. The ISC is developing FORTRAN and C subroutines that other seismologists can link into their own programs to write and parse lines from ISF bulletins. The subroutines will be included on the ISC 1999 Catalogue CD, which is planned for release this December. In addition, Jens Havskov plans to add translators between ISF and "nordic" format to his SeisAn package, and British Geological Survey is considering development of an ISF version of WizMapII, its freely-available interactive earthquake mapping program for Microsoft Windows.

### **Station Coverage Maps Posted**

Readings from more than 2500 seismic stations helped to ensure reliability of the Bulletin of 1999 events. But the density of stations varies widely around the world, partly because the ISC aims to be comprehensive rather than uniform. The effect of station density is important but difficult to quantify. It can be hard to distinguish between true changes in seismicity and artefacts from changes among reporting stations, for example, especially if magnitude is not computed for some events.

A general view of detection capability can be gleaned from station distribution statistics such as azimuthal gap, i.e. the largest angle between two adjacent stations as viewed from an event. If the stations that detect an earthquake leave an azimuthal gap more than  $180^\circ$  then it may not be possible to compute an epicentre and the event may fail to be included in the Bulletin.

Within a sufficiently small distance from any point a seismic network includes no more than two stations, which unavoidably have an azimuthal gap of at least  $180^\circ$ . Conversely, when stations at sufficiently large distances are included then azimuthal gap is less than  $180^\circ$  around any point within a network. The coverage of a network at a particular location can be characterised by the distance beyond which one must go to find stations with an azimuthal gap less than  $180^\circ$ .

If arrival times at two or more stations in any semicircle around an event are used to compute a location then no single arrival time controls a trade-off between epicentre and origin time. Thus the distance at which the second azimuthal gap (i.e., azimuthal gap ignoring the most isolated station) falls below  $180^\circ$  is sometimes regarded as a better measure of network coverage. A global map of this distance among stations that contributed to the 1999 ISC Bulletin is show below, and regional maps of station coverage are available at <http://www.isc.ac.uk/coverage.html>

It is unsurprising that detection at teleseismic distances is required to reliably locate events in the oceans, but the maps also show that island stations can be critical to effectively illuminate our view of seismicity off shore from even extensive continental networks.

Coverage is understandably sparse in parts of some continents where large earthquakes occur only infrequently, such as eastern South America and Saharan Africa. In addition, however, the maps show that reporting stations were insufficient for good coverage during 1999 in parts of western South America, and northernmost Africa, and much of central Asia.

Members of the ISC staff are working to improve data exchange with earthquake monitoring agencies around the world, especially where coverage is sparse. New catalogues have been contributed from Vietnam and Iran, and additional bulletins are hoped for from Peru, Algeria, Kyrgyzstan, Korea and Iceland. Nevertheless, Bulletin users are encouraged to suggest other agencies that might contribute a catalogue or bulletin to the ISC.

### **SKS splitting**

The University of Leeds has received a grant from the UK Natural Environment Research Council to develop a system to automatically measure SKS splitting, with the objective of collecting enough measurements to test the hypothesis that splitting is caused by a single layer of homogeneous anisotropy. The ISC is named in the proposal as a collaborator, with the roles of carrying out measurements after the automated system is developed and of making the measurements readily available. In order to ensure that the automated system works well with other elements of ISC processing, a University of Leeds researcher will work primarily at the ISC rather than at Leeds. Work is planned to begin in 2002 June.