

2010

Annual Director's Report



The year 2010 has been another successful year for the ISC and its data users. The staff numbers increased again as the Centre became involved in several major projects. Bulletin data for current events in 2008-2010, as well as events going back to the beginning of the 20th century, were added to the ISC database. Historical station bulletin data from the ISC warehouse were put to good use as part of the GEM project. The new ISC earthquake Locator program was designed, tested with validated using the IASPEI Reference Event List. A Link between the computer facilities at CTBTO and the ISC database was put into operation with a healthy stream of queries from the NDCs and PTS recorded. Essential improvements to the ISC building have been carried out without noticeable interruptions to the ISC operations. The Centre received good publicity throughout the year. A large number of scientific articles indicate an extensive use of the ISC data by researchers worldwide.

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EXECUTIVE SUMMARY

2010 has been another successful year for the ISC.

- ❑ With unceasing generous support from Member-Institutions and additional grants from the UK FCO, NORSAR, FOI, GEUS, US NSF, GEM Foundation and the CTBTO, the ISC's finances stayed healthy, staff numbers increased and essential improvements to the ISC building have been made.
- ❑ Current reviewed bulletin collection from 126 networks now stands at 12 months behind real time. The reviewed ISC Bulletin stands at 24-25 months. In addition, the ISC collects preliminary reviewed bulletin data from 21 data centres around the world; this information arrives within days and weeks after event occurrence and is being grouped and distributed within a few hours after submission as part of the automatic preliminary ISC Bulletin.
- ❑ For data year 2008, ~52 thousand reviewed and ~240 thousand un-reviewed (small) events were added to the ISC database.
- ❑ The ISC database size has increased by ~63% in just one calendar year and reached 75 Gb in total.
- ❑ The ISC Bulletin is more complete by at least half a unit of magnitude than the bulletins of either the NEIC/USGS or the IDC/CTBTO.
- ❑ The new ISC seismic event location program was designed, tested and validated using the IASPEI Reference Event List that the ISC maintains. It is ready to be put into operations to provide small but consistent location improvements, considerable improvements in depth determination and significantly more accurate formal uncertainty estimates. It is also expected to reduce the load on the analysts reviewing the ISC Bulletin.
- ❑ CTBTO Link to the ISC database has been put into operation with a healthy stream of queries from the NDCs and PTS being registered.
- ❑ The ISC is leading an international team in compilation of the GEM Global Reference Instrumental Earthquake Catalogue (1900-2009). As part of the project, the data from printed historical station bulletins stored in the ISC warehouse are being entered into the database in an attempt to compute surface wave magnitudes for the largest earthquakes of the first three quarters of the 20s century.
- ❑ The ISC now has as many as five members of staff in possession of PhD that has a positive effect on the quality of the ISC development and services.
- ❑ The ISC received good publicity throughout the year. The large number of scientific articles indicates a wide-range use of the ISC Bulletin data by many researchers worldwide.

STAFF

OPERATIONS:



James Harris, *United Kingdom*, System & Database Administrator



Emily Delahaye, M.Sc., *Canada*, Seismologist / Analyst



Beatriz Vera, B.Sc., *Colombia*, Seismologist / Senior Analyst



Shengzao Chen, Ph.D., *Canada/USA*, Seismologist / Analyst, **left in October**



Elizabeth Robertson, M.Sc., *New Zealand*, Seismologist / Analyst



John Eve, B.Sc., *United Kingdom*, Data Collection Officer

DEVELOPMENT:



István Bondár, Ph.D., *Hungary*, **Senior Seismologist / Developer**



Domenico Di Giacomo, Ph.D., *Italy*, **Seismologist (GEM), joined in August**



Oriol Gaspà Rebull, M.Sc. *Spain*, **Seismologist / Developer, left in October**



Juan Benjumea Cadavid, M.Sc. *Colombia*, **Seismologist / Developer**

HISTORICAL DATA ENTRY



Wayne Richardson, Ph.D., *New Zealand*, **Senior Seismologist, joined in September**



Rosemary Wylie, M. Phys. Geog., **Data Entry Officer (GEM), joined in August**



Ben Dando, Ph.D., *U.K.*, **Seismologist / Developer, joined in November**



Agne Baranauskaite, B.Ed., **Data Entry Officer (GEM), joined in August**

MANAGEMENT&ADMINISTRATION:



Dmitry Storck, Ph.D., *Russia/United Kingdom*, Director



Maureen Aspinwall, *United Kingdom*, Administration Officer

OPERATIONS

INTERNATIONAL SEISMOGRAPH STATION REGISTRY

Traditionally the ISC maintains the International Seismograph Station Registry (IR) together with the World Data Center for Seismology, Denver (NEIC). The IR allocates globally unique codes to seismic stations worldwide. 16.5 thousand stations with known positions are currently registered in the IR. Those stations that have reported to the ISC for data year 2008 are indicated on figure 1 in red. The ISC runs a popular web-page allowing review of already registered stations as well as submission of parameters required to register a new station.

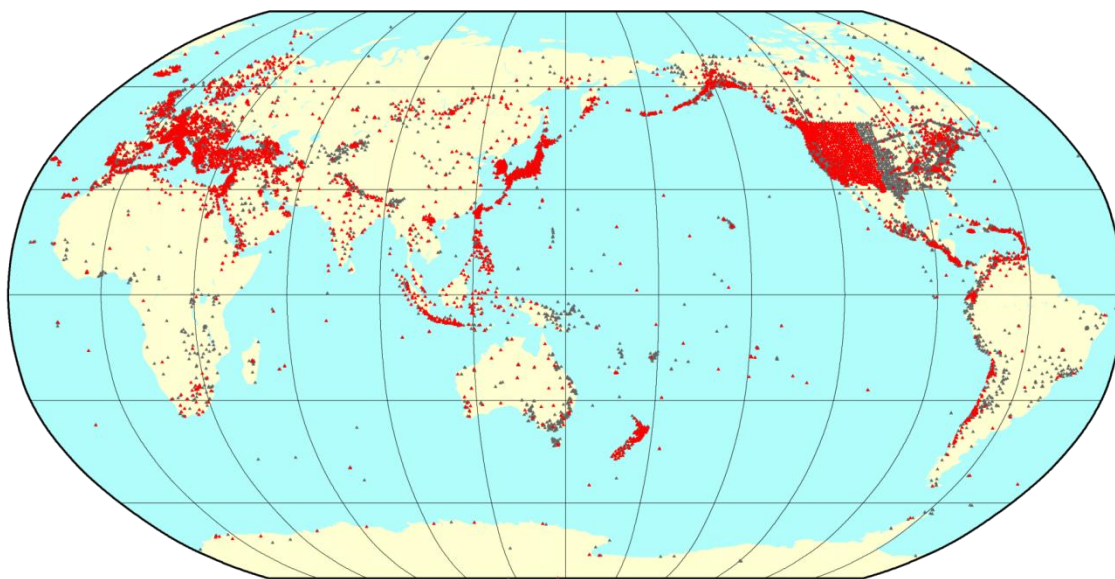


Figure 1. 16,606 stations, open or closed, are currently registered in the IR; 5445 of those (red) reported seismic arrival data to the ISC for data year 2008. USArray is a prominent feature of the Registry in North America.

Valuable assistance was received from IRIS during the process of registering and updating coordinates of the USArray stations. Station codes for projected sites of the Transportable Array have been initially reserved for future use without specifying exact coordinates. During the actual installation process sites are often shifted some in search for better local geological and noise conditions. Once re-measured these coordinates are fully registered in the IR.

Joint work with the NEIC is currently underway to set up a new International Station and Network Registry in accordance with the IASPEI recommendation. The new registry will feature station codes being unique within each network deployment as opposed to being globally unique. The new registry will help to give credit to all institutions that perform different parts of the monitoring job: operating seismic stations, performing waveform analysis or reporting parametric data.

PRELIMINARY BULLETIN DATA COLLECTION, PRELIMINARY ISC BULLETIN

In 2010 the ISC continued improving its collection of preliminary bulletin data from various networks and data centres. These data are expected to undergo at least a minimal review by local analysts. Typically these data include a preliminary hypocentre location, magnitude estimates, moment tensor solution and station arrival data, though variations are large from agency to agency. 21 agencies reported preliminary data to the ISC in 2009 (figure 2).

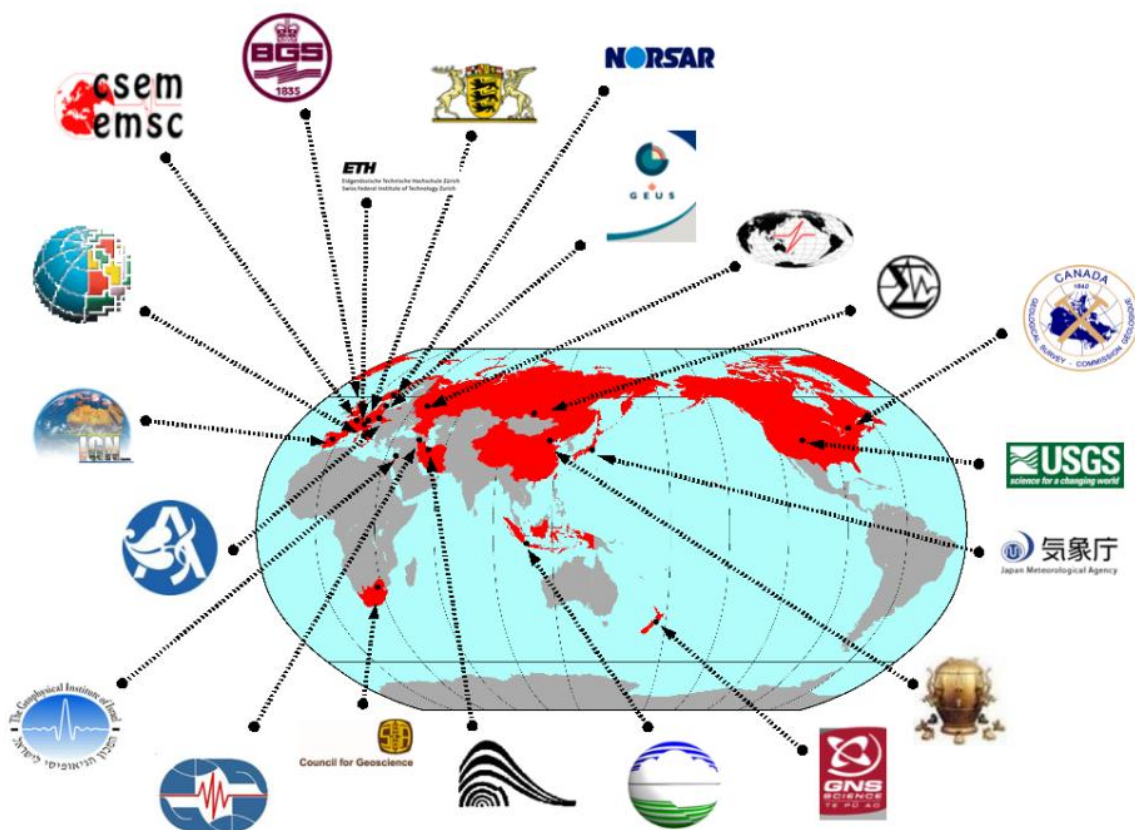


Figure 2. 21 networks and data centres report preliminary reviewed bulletin data to the ISC. These reports cover areas coloured in red. In addition, grey coloured areas are covered by reports from NEIC, EMSC, Geophysical Survey of Russian Academy of Sciences (GSRAS) and China Earthquake Networks Center (CENC).

Preliminary hypocentre solutions and station arrivals are grouped in the ISC database within a few hours after receipt and made available through the standard ISC Bulletin search procedure. For each event an output includes several hypocentre solutions reported by various agencies, all reported source mechanisms and magnitude estimates as well as corresponding station arrival data. Each earthquake header includes logos of reporting agency. By clicking on the logo, Preliminary ISC Bulletin user can get further information from each agency directly.

Figure 3 shows the map and magnitude distribution of events reported to the ISC within 3 days, 7 days, 1 month, 4 months and greater than 4 months of occurrence. It appears from the graph that almost all events with magnitude 4.5 and above and many of smaller magnitudes are reported within the first week. Further reports beyond one week add information to already reported large and moderate events and also inform about smaller events.

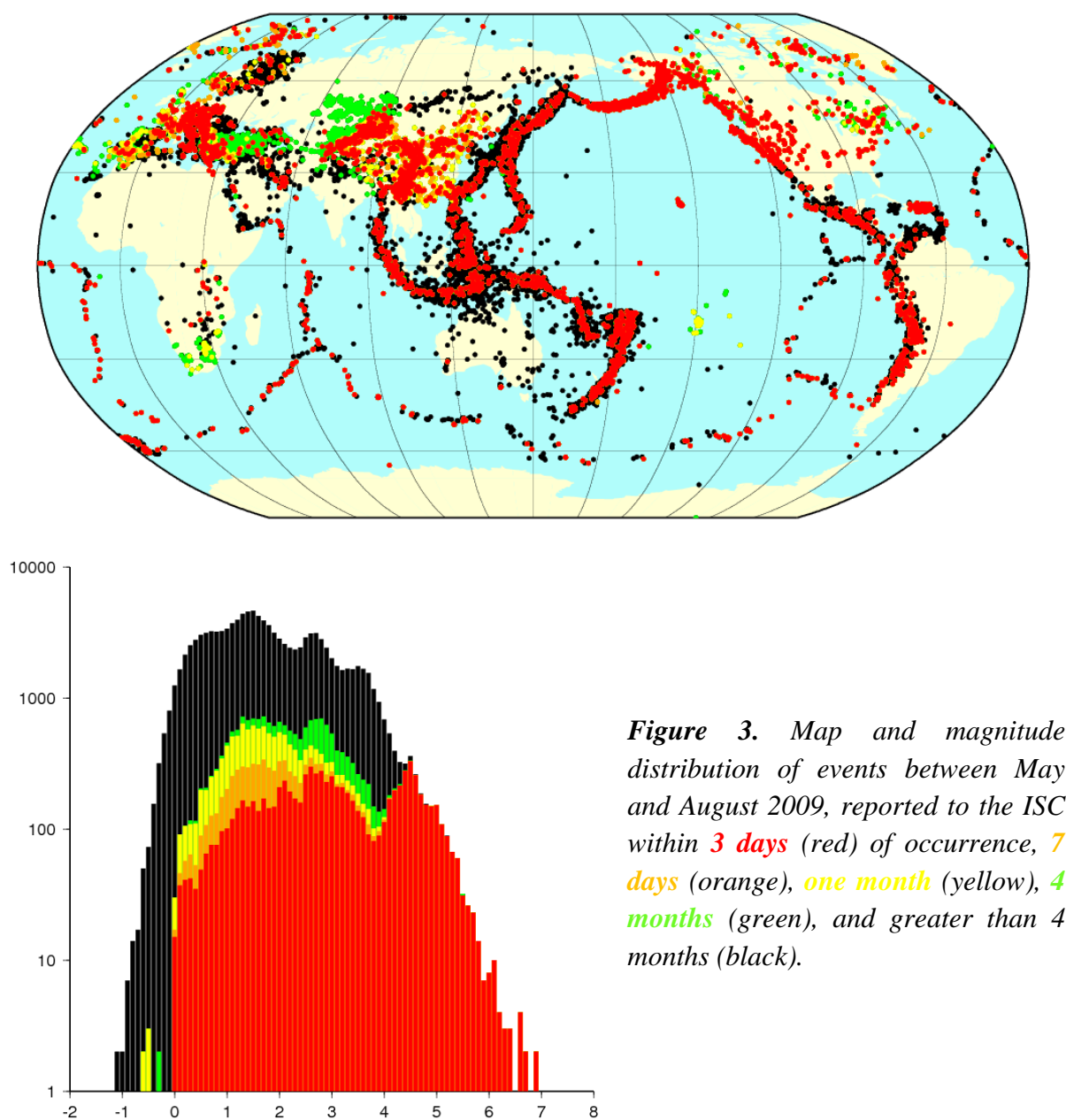


Figure 3. Map and magnitude distribution of events between May and August 2009, reported to the ISC within 3 days (red) of occurrence, 7 days (orange), one month (yellow), 4 months (green), and greater than 4 months (black).

This additional initial data collection is intended to fill the gap between the event occurrence and the time when the final Reviewed ISC Bulletin becomes available. It presents an attempt to consolidate the effort of many data centres and networks to make their data available internationally in good time. At this stage ISC does not compute or publish its own event solutions. This service is not intended to be used by media or civil protection agencies. It is

designed to be used by seismologists wishing to receive as much information as possible in one single format from one single place and then to get access to details using provided links to the original data reporters.

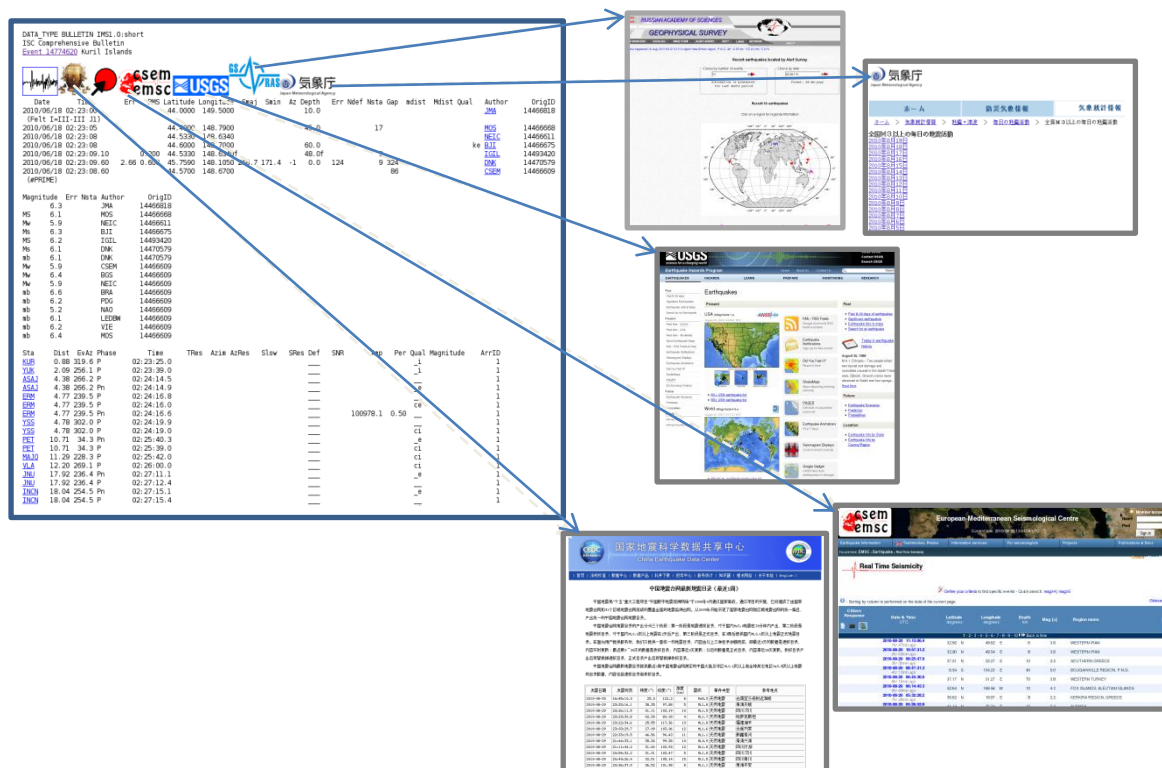


Figure 4. This figure illustrates the output of the standard ISC on-line Bulletin search when data for a very recent event are requested. Users can see a list of reporting agencies identified by their institutional logos, their hypocentre solutions, magnitude estimates and types as well as station arrival information available to the ISC at the time of request. On clicking any of the reporting institution's logo, users are directed to a special recent event page of the chosen institution where further information on the event of interest is available.

No later than one year after each seismic event occurrence, the preliminary data from agencies are substituted with their final reviewed bulletin data; this is well before the ISC analysts make their final review of the ISC Bulletin. The ISC hypocentre solutions are still based on the final set of bulletin parametric data given by each reporting institution.

STANDARD BULLETIN DATA COLLECTION

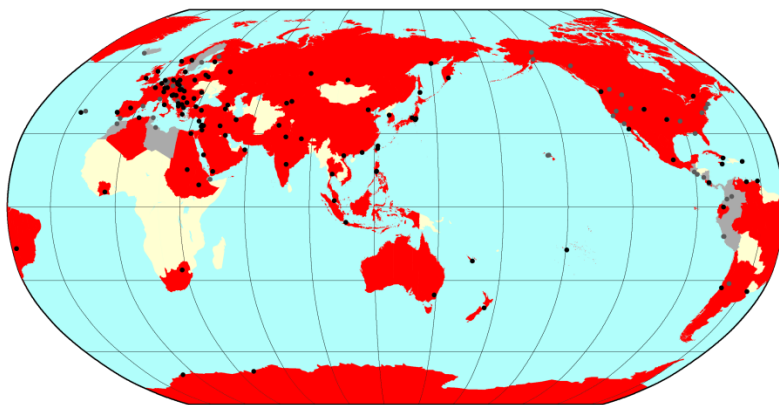


Figure 5. 126 agencies around the world (black dots) report bulletin data to the ISC. Dry land territories covered by these reports are in red. Grey areas and grey dots indicate those territories and agencies that are covered indirectly via reports from NEIC, EMSC and CASC. Light colour indicates areas that are not covered by local network operator reports.

The standard ISC data collection is the collection of final reviewed bulletin data from 126 agencies around the world. In the past few years we have been reducing the delay in collection of data with respect to real time by 2.5 days per month on average. Finally, on April 1, 2010 this delay reached 12 months exactly. At this point a decision was taken to stop further acceleration

and from there onwards continue data collection 12 months behind real time. With the exception of just a few agencies that have temporary problems, this delay gives the data contributors enough time for reviewing and finalising their bulletin data before submission to the ISC.

Figure 5 shows 126 agencies that routinely report final reviewed bulletin data to the ISC. Large events with magnitude 4.5-5.0 and above in Africa and on mid-oceanic ridges are reported by the National Earthquake Information Center (NEIC), International Data Centre (IDC/CTBTO), Geophysical Survey of Russian Academy of Sciences (GSRAS) and China Earthquake Networks Center (CENC). It is clear that further work on improving the ISC data collection in Africa, South America and parts of Eastern Europe and Asia is required.

During 2010 we experienced a loss of data contributions from Saudi Geological Survey and Geological Research Authority of Sudan. At the same time, we started receiving data from Republican Seismic Survey Center of Azerbaijan National Academy of Sciences as well as the West Bohemian Seismic Network run by Institute of Geophysics of Czech Academy of Sciences. A few thousand hypocentre solutions in West Bohemia along with arrival time picks from a very close network have been reported to the ISC at a short notice. These data were requested at the time when ISC analysts were reviewing yet another swarm in the area, hence speedy delivery of new data from West Bohemian network was a great help in improving depths of many events in the area already reported by nearby permanent networks in Europe. The largest benefit came from the fact that one of the stations of the Bohemian network is positioned “right on top” of many events of the swarm, which gives extra control of these event depth.

During 2010, IRIS DMC continued its contribution of station arrival times that were picked and reviewed by USArray Array Network Facility in San Diego. The data set represents a considerable increase in station arrival numbers associated to already known events in the US and moderate to large events worldwide (fig. 6). Whilst being a major source of data for tomographic research, this data set presented a major challenge to the ISC:

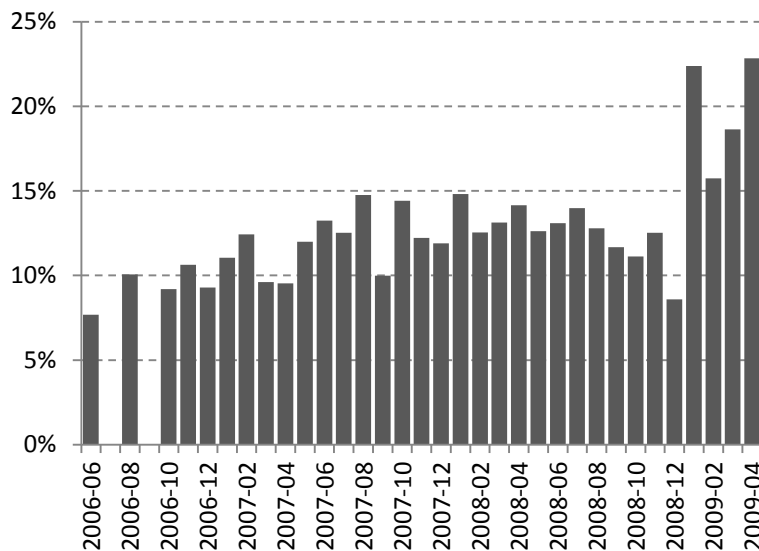


Figure 6. Fraction of arrival picks reported by USArray ANF facility as compared to the total number of arrivals associated to events in the ISC Bulletin with magnitude in excess of 4.5.

- The old ISC location algorithm, used until the end of calendar year 2010 and data year 2008, was not designed to cope with the bias caused by large concentrations of seismic stations in specific azimuthal directions.
- Current ISC Bulletin review procedures are designed for analysts to review the parameters of each station arrival. The increased numbers of stations, reporting the same event, create major overload for the ISC Analysts.

ISC BULLETIN REVIEW

The ISC seismologists/analysts review and correct results of automatic procedures that compile and update the ISC Bulletin as the data from agencies arrive to the ISC. This is the analyst's review that makes the ISC Bulletin accurate and trustworthy.

The accuracy of ak135-based ISC solutions and magnitude estimates, proper grouping of reported information between the events in the bulletin is under constant scrutiny. The ISC analysts also review the correctness of automatic association of reported station arrivals to events, reported arrival's phase identification and travel-time residuals. When the time comes, one month worth of data is pulled into separate table space, a set of automatic procedures are run and the first automatic ISC event locations and magnitude determinations are made for those events that are large enough to be reviewed by the ISC seismologists. It would be impossible for the ISC to sustain a review of every reported event, so from data year 1999 the data collection thresholds were removed and review thresholds introduced. Following various recent improvements this system continues to serve its purpose by restricting the number of seismic events to be reviewed by ISC analysts. The threshold criteria are complex yet almost all events of magnitude approximately 3.5 and larger are reviewed.

The team of four analysts reviewed 12 months of the ISC Bulletin (Jan-Dec 2008) during the calendar year 2010. The team was also helped by the Director during the last steps in the analysis procedure as well as by one of the Senior Seismologists working on the ISC Bulletin Re-build project (see below). His advice was extremely useful for the team of four analysts whilst two of them were still in training. During 2010 the ISC Reviewed Bulletin was made available between 24.1 and 25.4 months behind real time.

One of the newly trained analysts left the ISC to work at the NEIC just one year into his contract. This nevertheless didn't affect the results substantially as the three remaining analysts were able to keep up the schedule until a replacement was found and trained.

The issue of the ever increasing number of station arrival information available for each event is still pressing. It was recognised earlier that a new approach to the Bulletin review process is required. One of the answers is the introduction of an interactive editing system in place of the paper-based batch-type analysis. Also, the ISC needs to concentrate on the review of outliers instead of reviewing all data. Following the ISC Executive Committee decision we are reviewing our options in producing the new analysis tools.

A post of computer programmer was advertised yet candidates who answered the advertisement were lacking necessary skills for the salary we could afford to offer. In addition, we made a number of approaches to private software companies to see if the task of building new software package could be outsourced. Overall the outcome was that even an initial stage of the software design done by a private company would cost the ISC an overwhelmingly large fraction of all available funds. After a number of initial negotiations we arrived to a conclusion that a clear design and specification of the tool need to be put together at the ISC first. We ran a brain-storming meeting at the ISC and quite a few useful ideas and suggestions moved us forward. Further to that we have made an approach to the Computer Department at nearby Reading University to see if a suitable end-year student could be identified to perform a joint project with the ISC under a supervision of the Reading University specialists. This would have been possible under the current UK Government Program of Knowledge Transfer Partnerships (KTP), which would also commit some of the government funding to the project. Nevertheless, the Computer Department was unable to identify a suitable candidate and we are currently making enquiries for suitable candidates among earth science students in leading UK universities.

In the meantime, the introduction of the new ISC Locator into operations at the beginning of the next calendar year (2011) and new data year (2009) is expected to relieve the ISC analysts from performing some of the routine tasks that take a large proportion of their time. This alone is expected to buy the ISC a little more time, whilst the search for suitable programming staff is taking place.

ISC BULLETIN EVENT NUMBERS

The ISC Bulletin grows by the day in both event numbers and reported arrival picks (fig 7a,b). During year 2010, ~52 thousand reviewed and ~240 thousand un-reviewed (small) events were added to the ISC database. At the same time ~8.7 million associated and ~1.0 million un-associated seismic arrivals were added. The term “associated” identifies those seismic arrivals that are associated in the ISC database with known to the ISC seismic events.

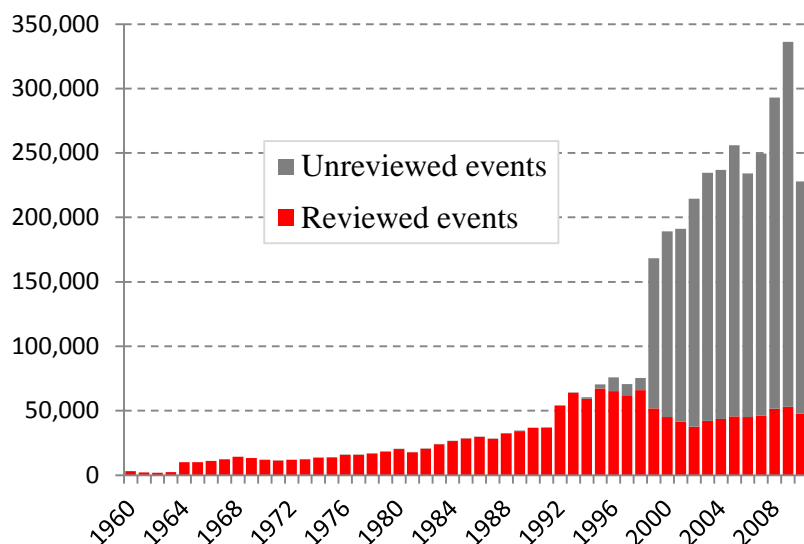


Figure 7a. Timeline (stacked) of the annual number of reviewed and un-reviewed (small) events in the ISC Bulletin.

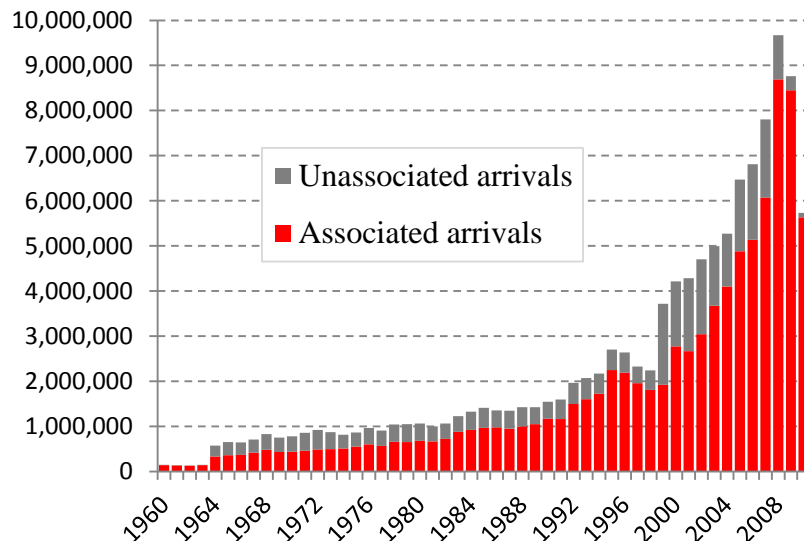


Figure 7b. Timeline (stacked) of the annual number of seismic arrivals associated with events in the ISC Bulletin and those not associated to any known to the ISC events.

Notably, the ISC database itself has grown 63% in one year and reached 75 Gb in size.

Figure 8 demonstrates a comparative magnitude completeness of the ISC Bulletin and those of the NEIC/USGS and IDC/CTBTO. The ISC Bulletin appears to be more complete globally than any of NEIC or IDC by at least half a unit of magnitude. NEIC is progressively close to adopting its new global threshold of completeness of magnitude 4.5. The IDC is unlikely to

use many more seismic sites than they use at present. Hence, it is likely that there will be even more seismic events in the future that are unique to the ISC Bulletin.

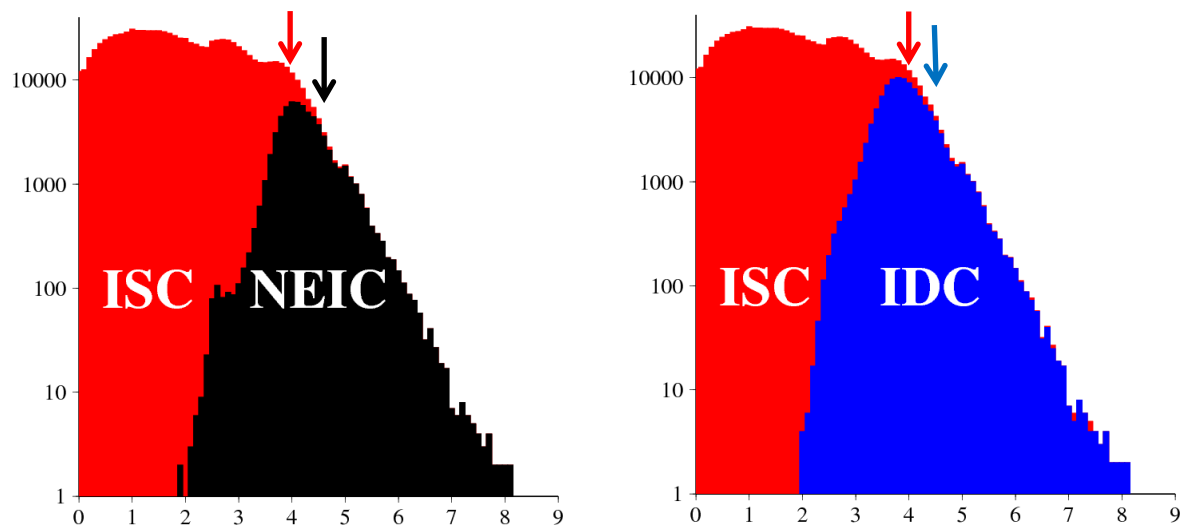


Figure 8. Comparative global magnitude completeness of the ISC, NEIC/USGS and IDC/CTBTO (REB) bulletins (2005-2008). The ISC appears to be more complete than any of NEIC or IDC Bulletins by at least half a unit of magnitude.

IASPEI GT LIST

The International Seismological Centre maintains the IASPEI database of Reference Events (earthquakes and explosions) for which epicentre information is known with high confidence (to 5km or better (GT5)) with seismic signals recorded at regional and/or teleseismic distances. It should be noted that the depth of these events is not known to the same level of accuracy as the epicentre. The global effort of collecting and validating GT events was coordinated by the CoSOI/IASPEI working group on Reference Events for Improved Location chaired by Bob Engdahl and Paul Richards. This database of a significantly large number of reference events (7,410) (fig. 9a) and approximately 500,000 station arrivals facilitates better visualization of the Earth structure, better modelling of velocities of seismic waves, more accurate travel time determinations and increased accuracy of event locations. ISC users are able to search this database at the ISC website and receive GT locations and corresponding ISC locations along with station arrival data available for each event. A cross-link to the ISC Bulletin is provided for users to go between ISC and GT databases. Figure 9b shows comparative numbers of nuclear explosions, chemical explosions and natural seismic events in each GT category.

During the calendar year 2010, 74 natural earthquakes and one explosion in data year 2008 were added to the IASPEI Reference Event List. Members of the CoSOI/IASPEI working group had a chance to review both the criteria and individual events.

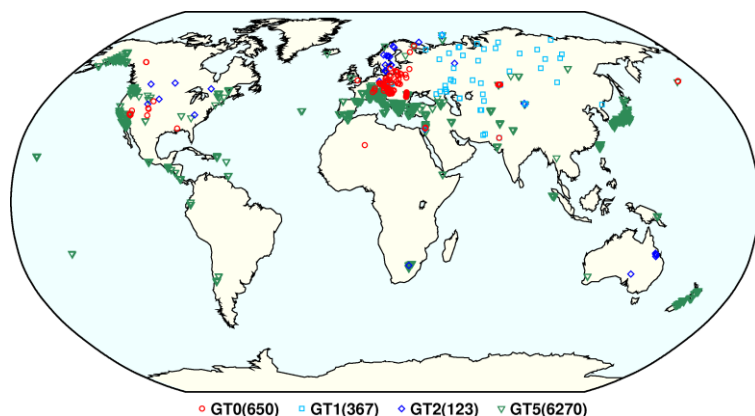


Figure 9a. Top map: events in the IASPEI list of Reference earthquakes and explosions. Colours indicate the GT accuracy to which the position of epicentre of each event is known.

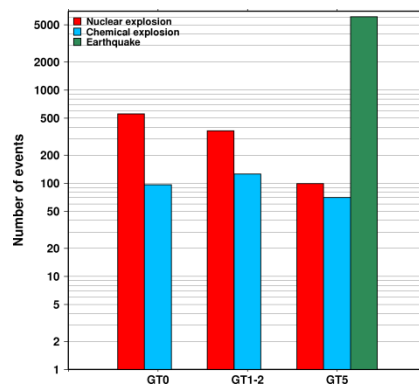


Figure 9b. Number of nuclear explosions, chemical explosions and natural earthquakes in each GT category.

EHB (Groomed ISC Bulletin)

The EHB (E.R. Engdahl, R.D. van der Hilst, R. Buland, 1998) catalogue contains a set of most accurate seismic event locations regularly used in academic research, especially in seismic tomography. The EHB algorithm has been used to significantly improve routine hypocentre determinations of well recorded events (fig. 10) made by the ISS, ISC and NEIC/PDE.

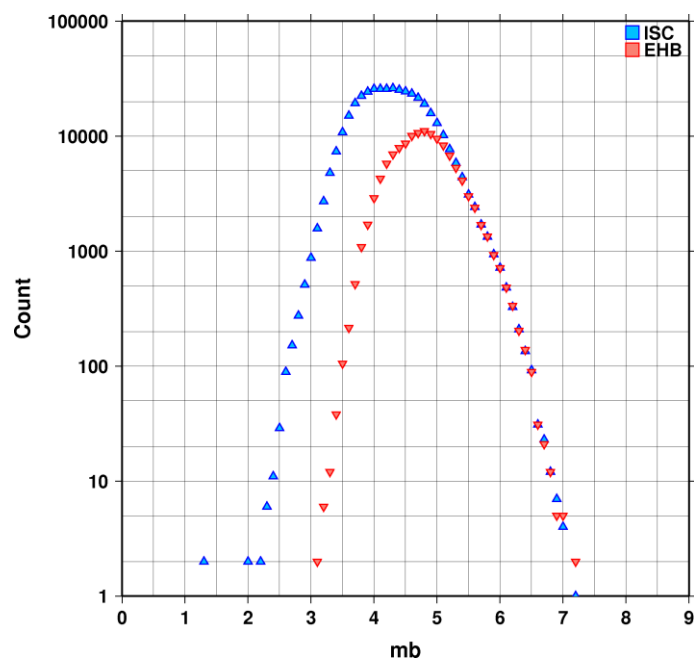


Figure 10. Comparative magnitude distribution of events in the ISC and EHB (groomed ISC) Bulletins.

The EHB algorithm uses:

- the ak135 1D global travel-time model with ellipticity and elevation corrections;
- iterative relocation with dynamic phase identification;
- first arriving P, S and PKP phases and teleseismic depth phases pP, pwP and sP;
- empirical teleseismic patch corrections (for 5x5 degree patches);
- weighting by distance-dependent phase variance;
- selection criteria for EHB events having 10 or more teleseismic ($\Delta > 28^\circ$) observations with a teleseismic secondary azimuthal gap $< 180^\circ$.

Following the agreement with Bob Engdahl, the EHB is hosted on the ISC website and currently contains ~138,000 events between 1960 and 2007 accompanied with ~22,500,000 arrival data. The bulletin is updated by Engdahl and made available to the ISC for inclusion into the ISC Bulletin and for re-distribution to all ISC users. The EHB can be browsed, searched or downloaded from the ISC web-site. Corresponding events of the ISC and EHB Bulletins are cross-referenced for convenience of the ISC users.

ISC WEB and FTP SERVICES

The ISC web-site as a whole and the ISC Bulletin search in particular continued to grow in popularity over 2009 (fig. 11). The number of hits reached 5 million, having increased 30% compared to year 2009. The number of Bulletin searches compared to 2009 went up by 15% with 90 Gb data taken that is equivalent to 900 full recent monthly bulletins. We noted that users chose to use interactive web search progressively more often.

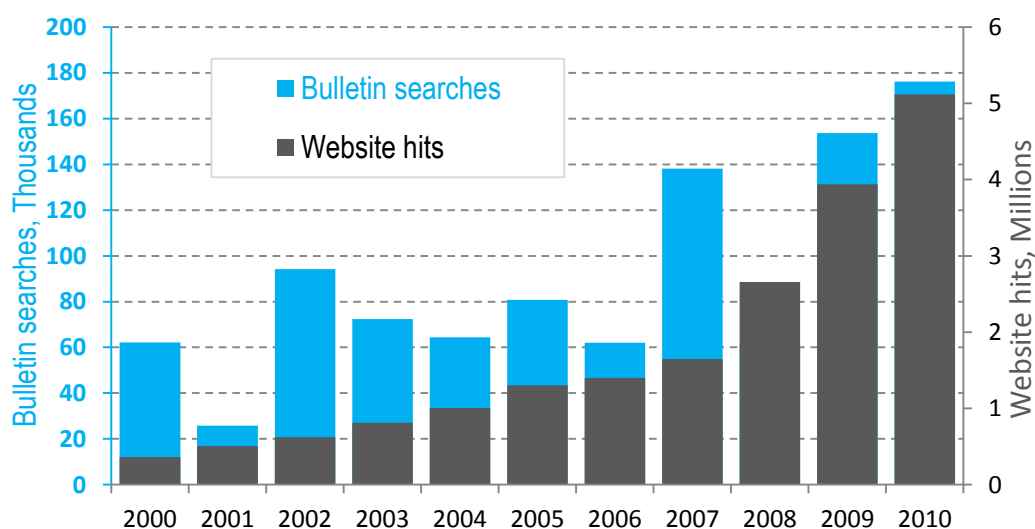


Figure 11. Number of ISC Bulletin searches (blue, left axis) and website hits (dark grey, left axis) per month.

The most popular services were (in the order of presentation):

- International Station Registry,
- Standard ISC Bulletin search,
- Interactive ISC Bulletin search,
- EHB,
- Links to agencies providing real time data,
- Search of original data contributed to the ISC,
- GT

The most popular documents on the website (in the order of presentation):

- Description of IMS1.0,

- Automatic ISC Special Event page,
- ISC Newsletter,
- What's new,
- Selection of posters with the summary of the annual ISC Bulletins,
- Analysis papers involving the ISC staff,
- Notes on the ISC data collection procedures,
- List of the ISC Member-Institutions,
- Regional Catalogue of Earthquakes.

The statistics of the ISC **web-site** use per country are shown on figure 12a. Although .net, .edu and .com are the domains mostly registered in the US, they are shown separately. In any case the US is the largest user, followed by .net, Chile, Russia, UK, Norway and others. The statistics of the ISC **ftp-site** use per country is shown on figure 12b. Again, the US is the main user of ftp services followed by Japan, Germany, Russia, Australia, India and others.

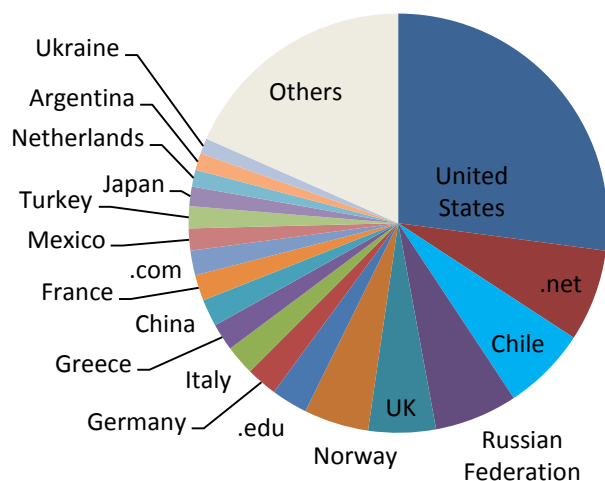


Figure 12a. Usage of the ISC **web-site** per country, percentage of hits. Category "Others" includes all countries with a share of less than one per cent of total number of hits.

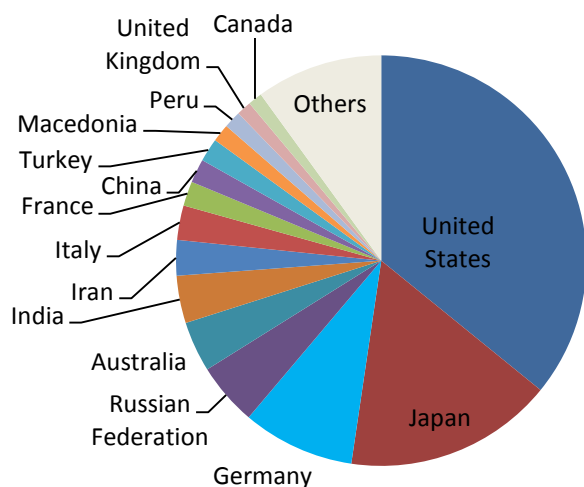


Figure 12b. Usage of the ISC **ftp-site** per country. Category "Others" includes all countries with a share of less than one per cent of total number of files transferred.

DEVELOPMENTS

NEW ISC LOCATION PROGRAM

The ISC was engaged in the project of improving the ISC earthquake location algorithm for a number of years, yet the major advance came at the end of 2010, when the new algorithm and the corresponding software program has been tested in order to be put into operations from the beginning of 2011.

The new location algorithm uses all *ak135* predicted phases, obtains the initial hypocentre via the Neighbourhood Algorithm, accounts for correlated travel-time prediction error structure, performs iterative linearized inversion using *a priori* estimates of the data covariance matrix, obtains depth-phase depth via depth-phase stacking and provides robust network magnitude estimates with uncertainties. The Locator attempts free-depth solution only if there is depth resolution determined by presence of local networks or reported depth-sensitive phases. Otherwise the depth is fixed to a region-dependent default depth.

During the second half of 2010 numerous validation tests were done by re-locating more than 7,200 events from the IASPEI Reference Event List, as well as by re-locating the entire ISC bulletin. A report describing the new ISC Locator has been circulated among the ISC Executive Committee and Governing Council members and after receiving some feedback a paper has been submitted to the Geophysical Journal International for publication.

Testing of the locator in the ISC operational environment began in late autumn to ensure flawless interface between the new ISC Locator and the existing bulletin editing software. This also offered an opportunity to the ISC editors to familiarise themselves with the new locator and provide their comments and suggestions. The feedback from ISC analysts concerning phase identification procedures and using default depths helped to further improve the locator.

During the re-location tests on seismic events in the IASPEI Reference Event List we demonstrated that the new ISC location algorithm provides small, but consistent location improvements, considerable improvements in depth determination and significantly more accurate formal uncertainty estimates. Owing to the tests for depth resolution and the use of depth-sensitive phases in the location, hypocentre estimates improved the most in the case of free-depth solutions.

All reported events (1960-2009, some 2.5 million) stored in the ISC database were re-located in order to obtain the default depth grid derived from the seismicity itself, collect runtime statistics and make comparisons between the automatic locations with the new locator and the reviewed ISC bulletin. The default depth grid, derived from the EHB bulletin and free-depth solutions of events in the entire ISC database re-located with the new Locator, provides reasonable default depth estimates in seismic areas.

The new locator is more CPU and memory intensive in comparison with the old version. Nevertheless, 96% of all events can be re-located within a second. On average it takes more than a minute to locate events when the number of associated phases exceeds 1,500. The execution time includes the grid search with the Neighbourhood Algorithm, the inversion of the data covariance matrix, the iterative linearised location algorithm and magnitude calculations.

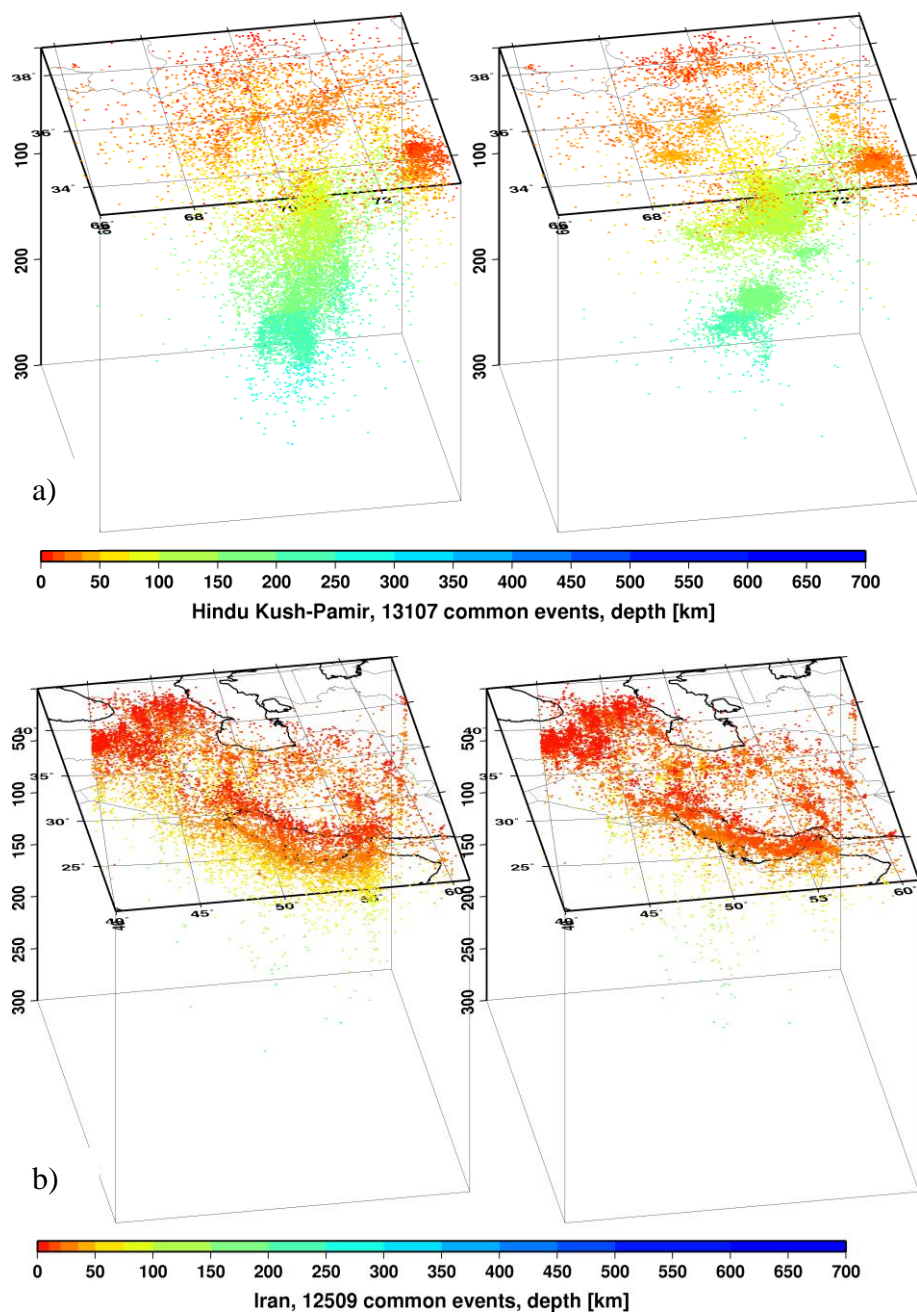


Figure 13. 3D view of seismicity in Pamir-Hindu-Kush (a) and Iran (b) as located by the old (left) and the new (right) ISC Location algorithm.

Finally, the comparison between the automatic re-locations and the reviewed ISC bulletin (some 1 million events) reveals that the new Locator considerably reduces the scatter in event locations by providing better clustering of the events. The figure 13 shows two examples, one for the Caucasus – Zagros mountain region (a), the other for the Pamir - Hindu Kush mountain region (b). The tightening of the seismicity, through the use of later phases and accounting for correlated travel time prediction errors which effectively changes the network configuration, is visible even at the relatively large map scale.

We expect that the new ISC location algorithm, when in operations, will provide an improved view of the seismicity of the Earth.

References:

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PROJECTS

NSF: ISC BULLETIN Re-BUILD (1960-2009)

The value of the ISC Bulletin is dependent upon following uniform procedures over a long period of time. Nevertheless, essential changes in the ISC procedures have occurred:

- The *ak135* velocity model has been used since 2006 whilst *JB* travel times were used in the past.
- A new event Locator based on different approaches and techniques will be introduced from data year 2009.
- Throughout the ISC history different sets of seismic phases were used for location: P & (from 2001) S with other phases to be introduced soon.
- Latitude & longitude error estimates were computed before Oct 2002, followed by full error ellipses later on.

- Procedures that determine what reported events require relocation by the ISC were also changed in 1999, 2005 and 2006.

Thus, the ISC Bulletin will benefit from being re-produced using uniform procedures to guarantee homogeneity through its entire period: 1960-2009. The US NSF provided substantial funding for this project to complement the funds already made available by Japan, India and China for further general development at the ISC.

As part of this project we are:

❑ **Re-computing all ISC hypocentres**

- new ISC earthquake locating program;
- ak135 velocity model in place of Jeffreys-Bullen;
- uniform algorithm that decides if an event warrants ISC re-location;
- uniform set of seismic phases (IASPEI Standard Phase List);
- uniform set of error estimates;

❑ **Re-computing event magnitudes:**

- Consistent treatment of amplitude measurement outliers;
- Removing magnitude estimates based on too few measurements;
- Providing previously unavailable magnitude error estimates;
- Providing previously unavailable account of which stations contributed towards the ISC network magnitude in each case.

❑ **Introduction and processing of essential additional datasets that have not been available at the time of original ISC Bulletin production (fig. 14):**

- ISS data covering 1960-1963;
- Late data from permanent networks;
- Data from permanent networks recovered retrospectively following political and administrative disputes;
- Data from temporary deployments, including OBS;
- Data accidentally not used by the ISC.

❑ **Essential corrections and quality control:**

- Known inconsistencies and spurious events;
- Identifying & marking data with erroneous time stamp;
- Re-assigning event type flags to provide consistency and identifying areas/periods of possible contamination of natural events with man-made activities.

❑ **Identifying events for selected manual review**

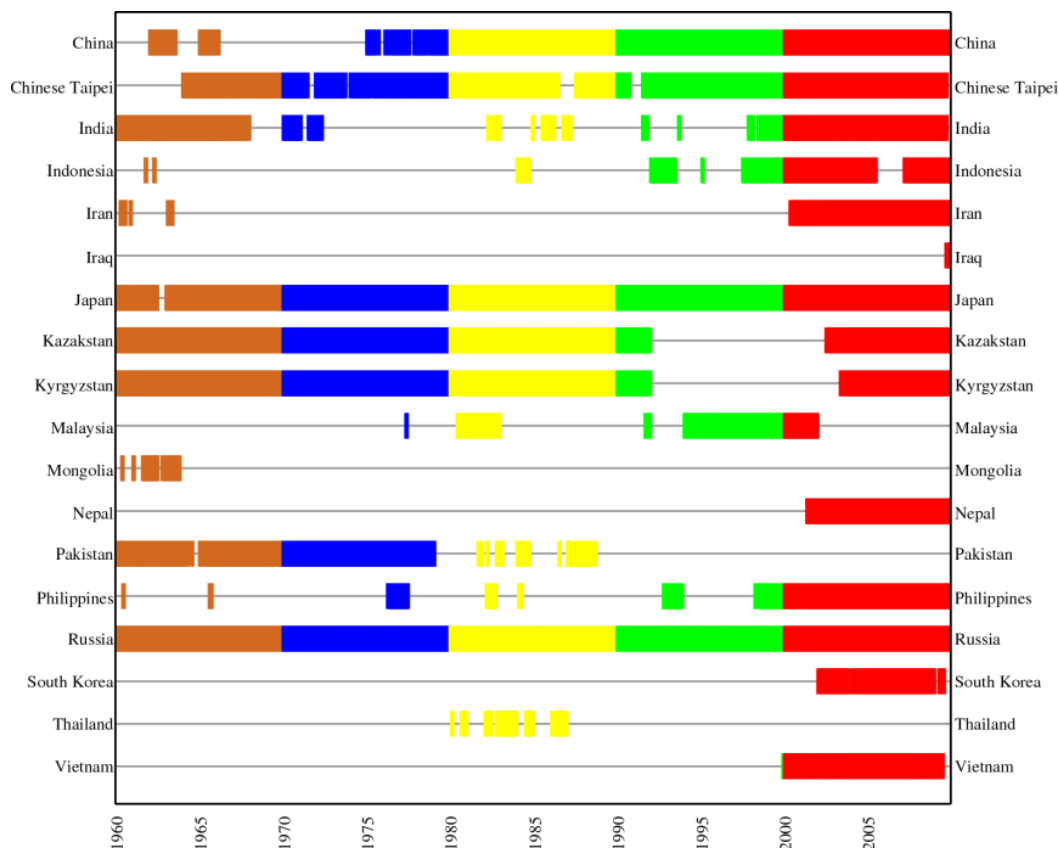


Figure 14. An example of the gaps in reporting from various countries in Asia over a 50 year long period since 1960.

GEM: GLOBAL INSTRUMENTAL CATALOGUE (1900-2009)

From May 2010, the ISC is leading an International Team of Experts that is charged with compilation of the Reference Global Seismic Catalogue of large earthquakes (1900-2009) to be used for characterization of the spatial distribution of seismicity, the magnitude frequency relation and the maximum magnitude. This 27-months long project is funded by the Global Earthquake Risk Model (GEM) Foundation (www.globalquakemodel.org).

In addition to the several members of the ISC staff, the Team includes Bob Engdahl (Colorado Uni, *US*), Antonio Villaseñor (IES Jaume Almera, *Spain*), Peter Bormann (GFZ, emeritus, *Germany*), Willie Lee (USGS, emeritus, *US*), Graziano Ferrari (INGV/SISMOS, *Italy*) and Peter Suhadolc (IASPEI).

The effort is monitored by the team of observers on behalf of the IASPEI: Roger Musson (BGS, *UK*), Johannes Schweitzer (NORSAR, *Norway*), Göran Ekström (Columbia Uni, *US*), Nobuo Hamada (JMA, *Japan*)

The following magnitude cut-off thresholds will apply to the final product:

- 1900-1917: $M_S \geq 7.5$ worldwide + smaller shallow events in stable continental areas
- 1918-1959: $M_S \geq 6.25$
- 1960-2009: $M_S \geq 5.5$

The project deliverables will include:

- ✓ 110 years of relocated earthquake hypocentres, using the EHB depth analysis and the ISC new Location procedures;
- ✓ recomputed M_S (or other) magnitude values for relocated events;
- ✓ M_W values (with uncertainty) based on seismic moment where possible (mainly 1976-2009) and proxy values in other cases using appropriate empirical relationships;
- ✓ Database of above information with references to original sources, including scanned historical bulletin pages.

As a core part of this project the ISC is using the historical seismic station bulletins collected over many years of ISS and ISC operations at Shide on the Isle of Wight, Oxford, Kew, Edinburgh, Newbury and Thatcham. In addition, some data are planned to be recovered from the historical collections at USGS/Berkeley, British Geological Survey, Hamburg University as well as the SISMOS electronic archive of scanned images at INGV in Italy.

The ISC warehouse collection of old station bulletins has been a gold mine for many researchers who study historical seismicity and seismic hazard in many different regions. The ISC staff members also benefitted from this collection whilst working on specific projects re-locating historical seismic events of interest. The current work, funded by the GEM Foundation has stemmed from the experience gained by the ISC staff members making extraordinary findings inside the rows of brown cardboard boxes in the ISC warehouse.

Many of seismic wave amplitudes as well as depth sensitive secondary seismic arrivals, currently being recovered from these bulletins, have never been part of global bulletins before. Those that worked with the ISS Bulletins know that magnitude determinations were not part of this global fundamental publication. The ISC began collecting surface wave amplitudes from 1971. The first ISC M_S magnitudes are dated 1978 when the international community came to a consensus over the methodology of their determinations.

Similarly, not all secondary phase arrivals were entered from the station bulletins at the time of the original production due to severe constraints on operational resources at the time.

We expect that the surface wave amplitudes and secondary depth sensitive phases from a number of quality stations that operated for long periods of time will be extremely useful for constraining the depths and M_S magnitude values of already known large events around the globe in the period between 1900 and 1971.

Unfortunately, due to constant change of bulletin formats over the period of tens of years, varying brightness and sharpness of the printed or hand written pages, the state of the old

paper and various other reasons it was concluded that optical character recognition methods would not be helpful in majority of cases. Hence two full-time data entry officers were hired from the list of 120 applicants based on their skills and ability to perform fast and thoughtful analysis and entry of data from historical publications into the database.

At this point an enormous collection of station bulletins at the ISC was recovered from storage and re-organised per observatory (fig 15 a,b). Particulars of each volume were registered in the database for further reference. Qualities of all observatory bulletin products were assessed and all bulletins subdivided into groups depending on the availability of reliable surface wave amplitude readings and length of time for which each observatory product is available. In addition, content lists of collections of historical station bulletins at USGS/Berkeley and Hamburg University were obtained and reviewed. These collections have a high potential for supplementing the ISC collection with missing volumes of certain critical observatories.



Figure 15a. Over many tens of years printed materials were received, processed and put away to storage in boxes in chronological order. A total of 15,273

individual seismic bulletins from 300 institutions worldwide, covering the period between 1900 and 1971 have been recovered from the ISC storage, sorted, examined and registered in the database.



Figure 15b. Availability, contents and quality of each publication over a long period of time were carefully

reviewed by a seismologist.

Several interactive data entry screens with underlying checks and database entry programs have been developed by the existing ISC personnel to increase the speed of data entry using the standard web-browser based tools (fig.16). Data are constantly checked by seismologists by means of standard seismological plots (fig 17).



Figure 16. Software applications were developed to organise efficient data entry into the database. The work started with two data entry officers making their way through selected publications under the guidance of a seismologist.

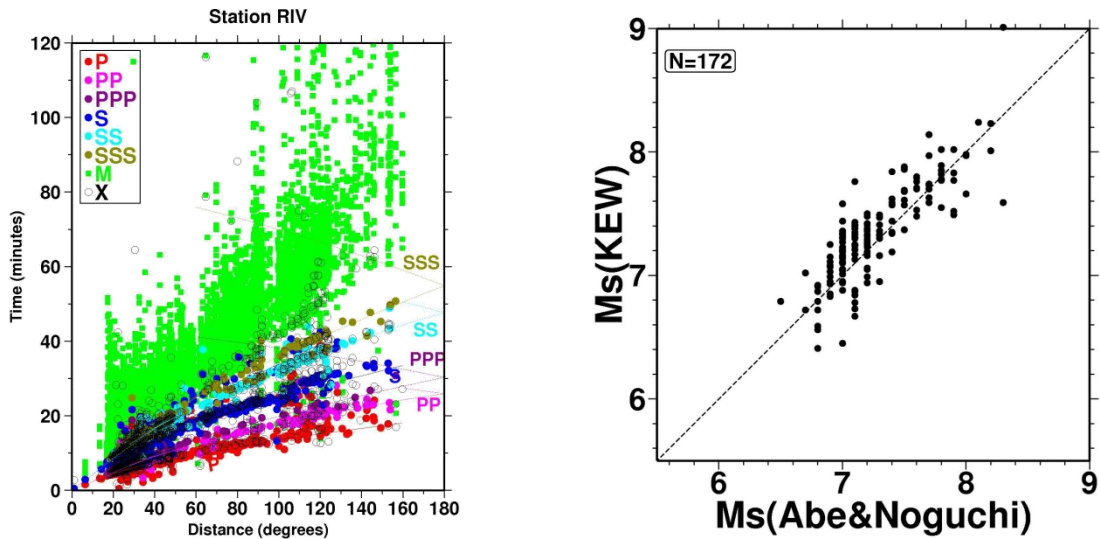


Figure 17. As data are entered into the database, seismologists make routine checks of new data usability by reviewing standard data plots such as travel-time plot for various seismic phases (*left*) and single station magnitude comparisons with known credible sources (*right*).

At this point we limited the bulletin data entry work to the period before 1940. This would allow the other members of the Team to start on event relocation when the data entry officers move into the next time period of 1941 to 1970. The map and the timeline (fig. 18) represent the stations whose bulletins were entered into the database and the period of time that they jointly cover. The most high-quality and long-serving seismic observatories out of those available at the ISC are taken into consideration. Redundancy in the data coverage is pursued as a means of providing more accurate values of uncertainties of event magnitudes, locations and depths.

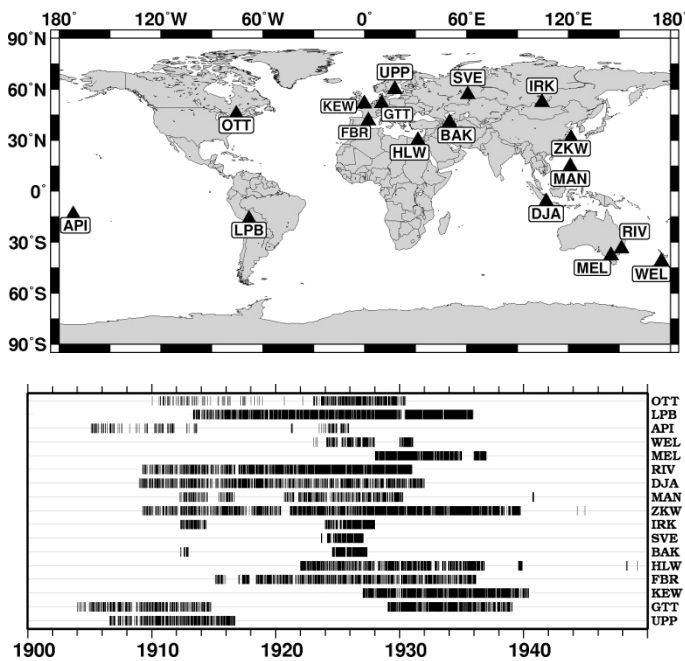


Figure 18. The historical bulletins of the most high quality and long-serving seismic observatories are entered into the database with due regard to the time period they jointly cover.

As the data entry work continues, techniques of relocating historical seismic events are being reviewed and tested using more recent period of time, where the original ISC locations are already available. The figure 19 shows comparative differences in event locations between the new and old ISC hypocentre locations; events with M_S in excess of 5.5 are considered.

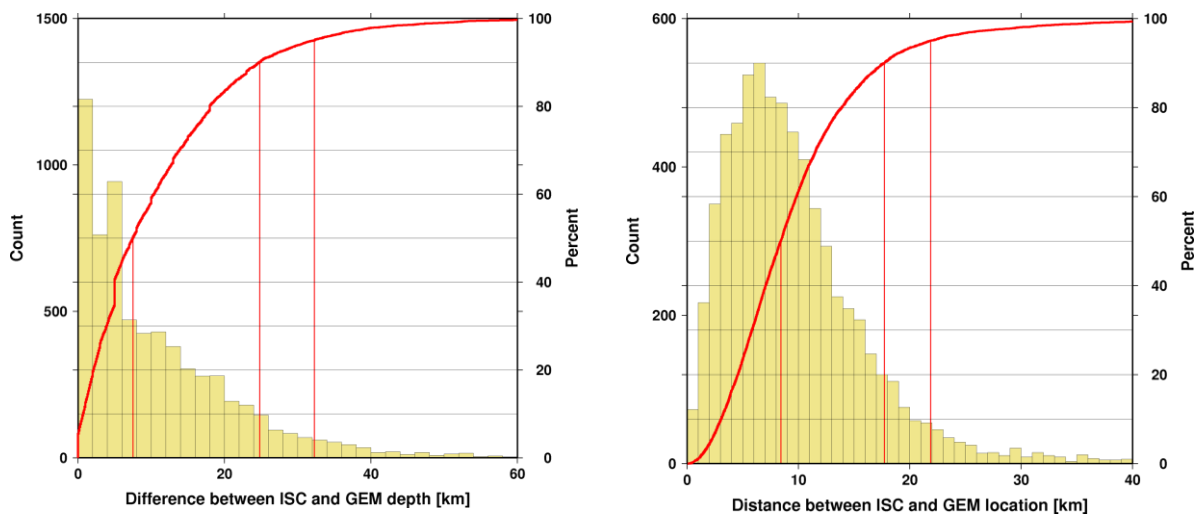


Figure 19. 6601 earthquakes with $M_S > 5.5$ were relocated for the period of 1978-1999. Differences between the original ISC and GEM (new ISC) locations and depths are shown.

The work on the project continues and is expected to be complete by July 2012. As a result, the ISC Bulletin will cover (with different magnitude completeness) a much longer period of time: **1900-2009** that was never the case in the past.

CTBTO: LINK to the ISC DATABASE

Back in 2008, the UK Foreign and Commonwealth Office (FCO) awarded the ISC with a three year grant to set up a dedicated and secure link to the ISC database for the CTBTO PTS and National Data Centres. The UK FCO provided 90% of the total required funding (£89,524) on the condition that four other relevant institutions from Nordic countries contribute the remaining 10%. These institutions were GEUS (Denmark), NORSAR (Norway), FOI (Sweden) and University of Helsinki (Finland).

During 2009 & 2010 the work on the project continued with the purchase and installation of the dedicated server at the ISC that holds a mirror version of the ISC database. We set up an Internet link to the computer systems of the PTS CTBTO and created a comprehensive web-based software package to query the ISC database in ways specific to the explosion monitoring community.

This dedicated software package allows for three types of bulletin searches: an area based, an REB event based and an IMS station based search through the wealth of the parametric information in the ISC database.

The objective of the project was to provide the capacity for NDCs to preform various types of analysis such as:

- assess the historical seismicity in a specific region,
- put an event of interest into context with the seismicity of the surrounding region,
- look at observations reported by non-IMS stations,
- compare hypocentre solutions provided by various agencies,
- investigate station histories and residual patterns of IMS or IMS surrogate stations.

The work on the project has also included the provision of a software manual as well as conducting training sessions for members of staff of the PTS and NDCs.

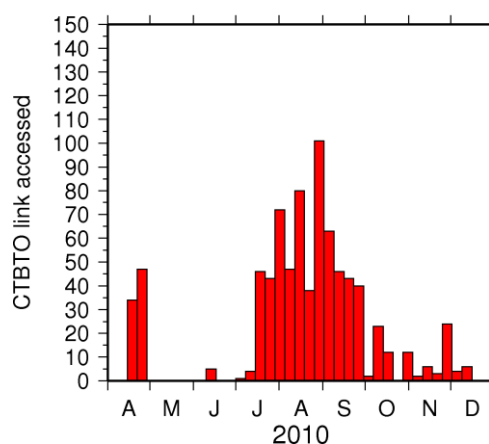


Figure 20. The link is provided to the NDCs through the IDC secure website. The figure shows the steady stream of activity on the Link.

Although it may appear that this project benefitted only the CTBTO, the ISC and its users also gained enormously from the experience. The ISC development staff have acquired skills during this project and further implemented in the traditional open facilities, through speedier access to the REB data and further increased possibilities of cooperation with this large and internationally based organization such as CTBTO that employs many seismologists from around the world.

It also has to be noted that although the software created under this project is open only to the monitoring community, the actual data used by them are exactly the same as used by all ISC users: the ISC Bulletin, GT List, EHB and International Seismograph Station Registry.

At the end of the 2010, a further 1-year contract was signed with PTS / CTBTO for the continued maintenance and further development of the Link.

IMPROVEMENTS to the ISC OFFICE BUILDING

Since 1986, the ISC was housed in the industrial type building in Thatcham in West Berkshire that was once converted from a warehouse to offices to accommodate a small group of ISC staff. The staff numbers have grown quite considerably in the last three years and office space became an issue.

A set of building projects during 2010 considerably improved working conditions for the ISC staff and brought the building to environmental and safety standards of the 21st century.

As a result of a painstaking procedure, the Planning Permission and Building Control consents were obtained from the West Berkshire Council and a local reputable contractor, Ashridge Construction Ltd, was able to build two new mezzanine offices under the existing roof of the ISC warehouse (fig. 21 and 22).



Figure 21. Large new mezzanine office where the work with historical station bulletins contributes to compilation of the Global Instrumental Catalogue (1900-2009).



Figure 22. All ISC staff members can now fit around the old renovated ISC tables for a staff meeting in the second large office.

In addition, modern roof insulation in the old part of the office was laid and double glazed windows and doors were installed to improve the ISC's carbon footprint and reduce the utility bills quite considerably in the coming years.

This investment into the ISC and comfort of its staff members and visitors became possible thanks to a multitude of additional projects that the ISC was engaged in during this year.

FINANCE

The detailed financial statements of the ISC for 2010 were audited by Griffins, Chartered Accountants (Newbury, UK) and approved by Prof. John Woodhouse, the representative of the hosting institution to the ISC Executive Committee. These statements present the state of ISC's financial affairs as at 31 December 2010.

INCOME

In 2010, the ISC had a total income of £ 629,290 from national contributions and a collection of grants for special projects totalling £139,715 itemised on page 8 of the accounts. Interest on ISC bank accounts plus the income from selling ISC publications is also included. The date for the ISC to claim the funding from NSF has been set back steadily over the past few years such that in 2010 it was decided to spread the amount received over the last half of 2010 and the first half of 2011, in accordance with the dates set by NSF. For this reason the budgeted amount of income is less than the actual amount stated. This system was also applied to some of the other grants where the work had yet to begin or was not scheduled until 2011.

The exchange rate between the UK £ and USA \$ steadily changed from £1=\$1.62 at the start of the year to £1=\$1.44 in the middle of the year and £1=\$1.56 at the end of December.

During 2010, INPRES from Argentina has re-joined as a Member-Institution, yet issues with correct payment are still being resolved. SOREQ, Israel paid in advance for 2011. At year-end, after 3 consecutive years the membership fees from GII, Israel were unpaid, but before this report was written we were delighted to receive one of the overdue payments.

EXPENDITURE

More than 73% of ISC expenditure in 2010 was committed to personnel costs some £75,783 more than in 2009. During the year we saw the departure of seismologist Shengzao Chen and welcomed the arrival of Domenico di Giacomo, Rosemary Wylie and Agne Baranauskaite who began working on the GEM project. After 4 years at ISC we were sad to lose Oriol Gaspà Rebull, seismologist/developer, but his replacement, Ben Dando, arrived soon after Oriol's departure. The ISC also hired Wayne Richardson to coordinate the ISC Bulletin Re-build project. The salary costs include salaries, pension contributions, and recruitment and repatriation of new and departing staff. The ISC salaries follow the UK academic salaries scales.

Building expenses were more than double the 2009 costs but at the time of writing the new offices for extra staff are fully occupied. Computer expenses rose by £17,036 and included extra data lines and replacement of some items as well as additional work stations for the new members of staff and purchase of a server for one of the special projects. Travel expenditure in 2010 was £14,561 greater than the previous year but once again, it should be noted that

much of this travel resulted in either additional data or additional funding and often both, as well as promotion of the ISC to new audiences.

RESERVES

The gain in income over expenditure for 2010 was £9,644. ISC total reserves, comprising the cash in the bank, building and land, the money owed to ISC (debtors) minus the money ISC owes (creditors and remaining mortgage on the building) increased during 2010 to £507,002. The Contingency Fund now stands at £30,000 in accordance with the wishes of the ISC Governing Council. The ISC General Reserve of £477,002 is equivalent to almost 9 month's operation of the ISC. This is well within British guidelines for charitable organizations.

CASH FLOW

The cash flow in Fig. 23 shows receipts and outlays using dates when transactions were recorded at the bank and the bank balances with US Dollars converted to Sterling using the exchange rate as of the end of each month.

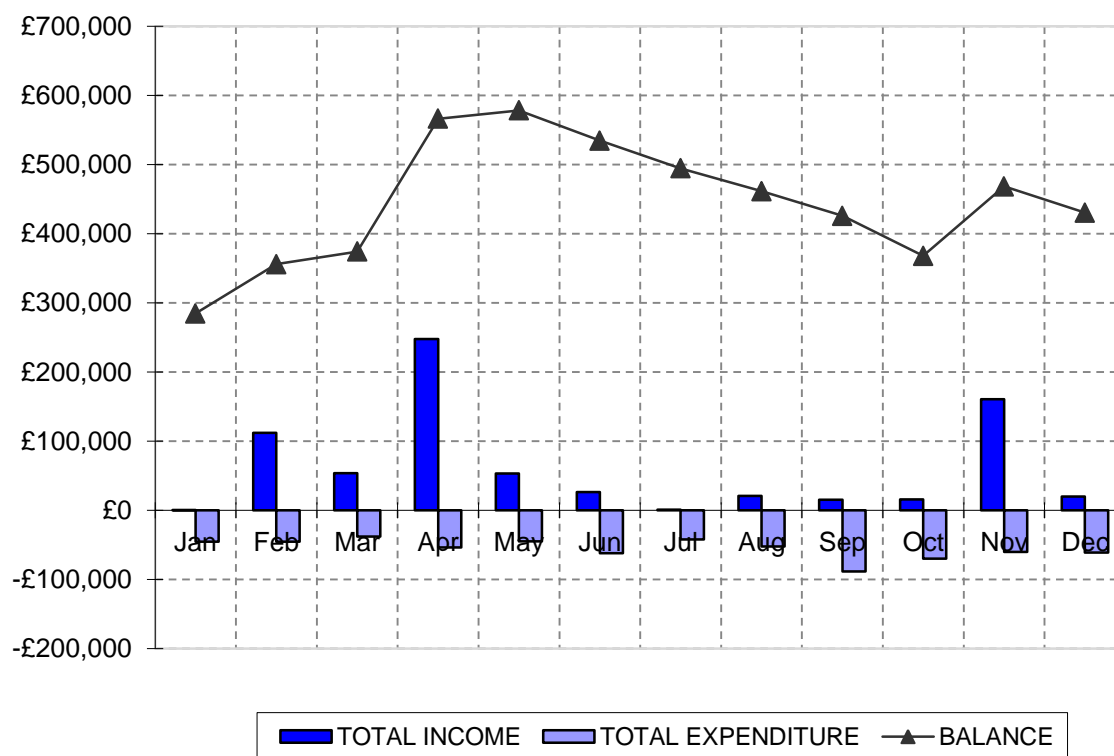


Figure 23. Income/Expenditure cash flow and cash balance

SCIENTIFIC LIAISONS

VISITORS to the ISC

The following geophysicists visited ISC premises in Thatcham during the year:

- Hiroshi Tsuruoka – Earthquake Research Institute, University of Tokyo, Japan
- Johannes Schweitzer – NOR SAR, Norway
- Roger Musson – British Geological Survey, U.K.
- Bob Engdahl – University of Colorado, Bolder, U.S.
- Antonio Villasenor – Jaume Almera Institute of Earth Sciences, Barcelona, Spain
- Peter Bormann – GFZ, Potsdam, Germany
- Qi-Fu Chen – China Earthquake Administration
- Gary Gibson – SRC and Melbourne University, Australia
- John Adams – Geological Survey of Canada
- Guy Masters – Scripps Institution of Oceanography, UC San Diego, U.S.
- John Woodhouse – Oxford University, U.K.
- Domenico Di Giacomo – GFZ, Potsdam, Germany
- Anastasia Chebrova – Kamchatka Branch, Geophysical Survey RAS, Russia
- Rémy Bossu – EMSC, Bruyeres-le-Chatel, France
- Stephanie Godey – EMSC, Bruyeres-le-Chatel, France
- Stuart Sipkin – NEIC/USGS, Golden, U.S.
- David Ketchum – NEIC/USGS, Golden, U.S.
- Paul Earle - NEIC/USGS, Golden, U.S
- Eric Bergman – University of Colorado, Bolder, U.S.

CONFERENCES, MEETINGS, WORKSHOPS

Members of the ISC staff gave talks or presented posters at the following conferences, meetings and workshops:

- Gulf Seismic Forum, Abu-Dhabi, UAE
- GEM Progress Review Meeting, Pavia, Italy
- CTBTO Evaluation Workshop, Nairobi, Kenya
- SSA, Portland, U.S.A. (ISC poster delivered by the former ISC member of staff)
- GEM Outreach, Washington DC, U.S. (ISC talk delivered by the Governing Council Chair)
- AGU Meeting of Americas, Iguassu, Brazil
- CTBTO WGB35, Vienna, Austria
- ESC, Montpellier, France
- CTBTO Machine Learning Workshop, Montpellier, France
- Nordic Seminar on Detection Seismology, Aarhus, Denmark
- International Seismology School, GS RAS, Vladikavkaz, Russia

- Monitoring Research Review, Orlando, U.S.
- ASC, Hanoi, Vietnam
- GEM Progress Review Meeting, Singapore
- AGU, San Francisco, U.S.

ISC STAFF VISITING other INSTITUTIONS

Often with the help of the hosting institution, the members of the ISC staff visited and, where appropriate, gave a presentation to members of staff of:

- International Data Centre, CTBTO, Vienna, Austria
- China Earthquake Networks Center, CEA, Beijing, China
- Institute of Earthquake Science, CEA, Beijing, China
- Institute of Geophysics, Beijing, China
- EUCENTRE, Pavia, Italy
- North Ossetia Branch, GS RAS, Russia
- Earth Observatory of Singapore
- National Environment Agency, Singapore
- Blacknest, AWE, United Kingdom
- SECED, London, United Kingdom
- Royal Society, London, United Kingdom
- Institute of Geophysics, VAST, Vietnam

ISC STAFF TRAINING

The UK Atomic Weapons Establishment (AWE) facility charged with researching techniques to distinguish the seismic signals generated by underground nuclear explosions worldwide from those generated by earthquakes. Almost entire ISC staff went to learn about the operations at this nearby facility.

STUDENTS at the ISC

At the end of September Ms Anna Hendry, a final year undergraduate Natural Science student from the University of Durham, spent a week of work placement at the ISC. Anna discovered details of the ISC operations by learning from virtually every member of the ISC staff. In addition she made her own input to the GEM works by entering data from historical station bulletins under the supervision of the ISC seismologists.

Louisa Tsang, PhD student from the Department of Earth Sciences at the University of Hong Kong is currently working on the neotectonics of Tibet. In July she has spent a few weeks at the ISC, gaining work experience and assisting with the current ISC development. Louisa collaborated with the ISC Senior Seismologist on the validation of the new ISC seismic event Locator. She investigated the impact of using large concentration of seismic stations, such as

the USArray, on the earthquake location results in South America by comparing the old and new ISC location techniques.

ISC PRIZE for OXFORD UNIVERSITY STUDENTS

A few years ago the ISC established a small annual Prize in Mathematics and Geophysics for a best first year student at the Earth Science Department of its home institution – the University of Oxford. The prize is given to the student with the best exam results in geophysics and mathematics. This year, Ms Jen Truby was nominated to receive the prize - the annual ISC Bulletin CD-ROM and a cheque for £200. In the past, a precedent was set up when an Oxford University student positively contributed to the ISC operations. By setting this prize the ISC hopes to attract Oxford University students to take note of the ISC services right from the first year, support the ISC in the future and perhaps even help the ISC in fulfilling its mission.

PAPERS PUBLISHED by the ISC STAFF

Coppola J.M., L.X. Cowan, G.L. Downes, K.F. Fenaughty, P.D. Grimwood, P. Leach and **E. de J. Robertson**, 2010. Felt Earthquake Reporting via the Internet in New Zealand, *Seism. Res. Lett.*, 81, 6. [doi:10.1785/gssrl.81.6.984](https://doi.org/10.1785/gssrl.81.6.984)

Oth A., D. Bindi, S. Parolai, and **D. Di Giacomo**, 2010. Earthquake scaling characteristics and the scale-(in)dependence of seismic energy-to-moment ratio: Insights from KiK-net data in Japan, 2010. *Geophys. Res. Lett.*, 37, L19304. [doi:10.1029/2010GL044572](https://doi.org/10.1029/2010GL044572).

Bennett, T.J., V. Oancea, B.W. Barker, Y-L. Kung, M. Bahavar, B.C. Kohl, J.R. Murphy and **I.K. Bondár**, The Nuclear Explosion Database (NEDB): A new database and web site for accessing nuclear explosion source information and waveforms, 2010. *Seism. Res. Lett.*, 81, 12-25.

PAPERS PUBLISHED in 2010 that USE the ISC DATA

This list is a result of a special effort to put together a collection of scientific papers that used ISC or EHB data in 2010. The list is by no means complete. The ISC has become such a household name that many researchers unfortunately fail to reference the ISC when using the ISC data.

We have searched Google Scholar for scientific papers that refer to ISC data. We used the exact phrases “International Seismological Centre”, and “International Seismological Center” and “EHB”+ “seismic” for papers appearing in 2010. These searches revealed almost 250 items, a selection of which appears below. No doubt many more references can be found by using different search phrases.

[Contrasting décollement and prism properties over the Sumatra 2004–2005 earthquake rupture boundary](#) SM Dean, LC McNeill, TJ Henstock, JM Bull... - *Science*, 2010 - ... occurred beneath the forearc basin and islands, with

limited extent further seaward (2, 3). Finally, the aftershock distribution changes, consistent with the mainshock slip (1–3); aftershocks for the 2004 and 2005 events from the International Seismological Centre (ISC) catalog (11 ...

[Geo-environmental hazards assessment of the north western Gulf of Suez, Egypt](#) MO Arnous, HA Aboulela... - Journal of Coastal Conservation, 2010 – Springer ... The seismicity distribution for the study area during the period 1904–2005 was obtained from the National Earthquake Information Centre (NEIS), the International Seismological Centre (ISC) and the Egyptian National Seismic Network (ENSN). Geo-environmental hazards ...

[Structure of the upper mantle and transition zone beneath Southeast Asia from traveltimes tomography](#) C Li... - 2010 - dspace.mit.edu ... Two decades ago tomography with P-wave data from the International Seismological Centre revealed the presence of stagnant slabs in the mantle transition zone beneath the Japan Sea, the northern part of the Philippine Sea, and East China, with slabs penetrating to larger ...

[Sensitivity Analysis of Wave-equation Tomography: A Multi-scale Approach](#) V Brytik, MV De Hoop... - J. Fourier Anal. Appl, 2010 – Springer ... For instance, tomographic inversions of vast amounts of routinely processed travel time residuals from international data centers, such as the International Seismological Centre, have been used to delineate three-dimensional heterogeneity in rather spectacular detail [1, 13, 29

[Comment on" A Homogenous and Complete Earthquake Catalog for Northeast India and the Adjoining Region" by RBS Yadav, P. Bormann, BK Rastogi, MC Das, and ...](#) R Das... - Seismological Research Letters, 2010 - ... (1986). Yadav et al. (2009) adopted this catalog and considered these unspecified magnitudes equivalent to M S values of the International Seismological Centre (ISC) for calculating proxy M w ,HRVD values using the regression relation (Equation 3 of Yadav et al. 2009): (1). ...

[Seismic activity at Cadamosto seamount near Fogo Island, Cape Verdes—formation of a new ocean island?](#) I Grevemeyer, G Helffrich, B Faria... - Geophysical ..., 2010 - Wiley Online Library ... The first event occurred on 1998 September 18. The International Seismological Centre (ISC) provides a magnitude of $m_b = 4.9$ for the earthquake. Most of the traveltimes reported by the ISC have been provided by North American stations. ...

[Comment on" Estimation of Seismicity Parameters for India" by STG Raghukanth](#) SK Nath, KKS Thingbaijam - Seismological Research ..., 2010 - srl.geoscienceworld.org ... Figure 1 View larger version (15K): [in this window] [in a new window], Figure 1. Comparison between A) body wave magnitudes derived from the global catalogs of the International Seismological Centre (ISC) denoted by m_b ,ISC and the US Geological Survey (USGS) denoted ...

[Earthquakes and civilizations of the indus valley: a challenge for archaeoseismology](#) RL Kovach, K Grijalva... - Ancient Earthquakes, 2010 - books.google.com ... International Seismological Centre, 2006, International Seismological Centre Bulletin Thatcham, United Kingdom: <http://www.isc.ac.uk/>(accessed 14 July 2010). Jarrett, M., HS, 1881, History of the Caliphs by Jalalu'ddin A's Suyuti: Cal- cutta, Asiatic Society, p. 387–388. ...

[Seismicity Map of Eastern Russia, 1960-2010](#) 7KG Mackey, K Fujita, HE Hartse... - Seismological ..., 2010 -

171.66.125.217 ... Figure 4 shows data available from the International Seismological Centre (ISC) Bulletin (1960–2006); some regional network data for larger events from eastern Russia have been contributed to the ISC since the mid-1990s (see electronic supplement). ...

[Preliminary analysis of the 21 february 2008 svalbard \(norway\) seismic sequence](#) M Pirl, J Schweitzer, L Ottemoller... - Seismological ..., 2010 - 171.66.125.217 ... by the Knipovich ridge (eg, Engen et al. 2003; International Seismological Centre (2001), which, as a spreading plate boundary, is the structure that dominates the regional stress field. Most of the seismic activity (Figure 1) is ...

[First global positioning system results in northern Myanmar: Constant and localized slip rate along the Sagaing fault](#) T Maurin, F Masson, C Rangin, U Min... - Geology, 2010 - ... 5). Furthermore, historical seismicity from the International Seismological Centre catalogue (<http://www.isc.ac.uk>) shows large earthquakes ($M_w > 7$) along this segment of the fault in 1906 (M_w 7.0), 1908 (M_w 7.5), and 1931 (M_w 7.6)

[Lg attenuation in a region with both continental and oceanic environments](#) TK Hong - Bulletin of the Seismological Society of America, 2010 - Seismol Soc America ... Event information was collected from event catalogues of local seismological institutions (Korea Institute of Geoscience and Mineral Resources [KIGAM], Korean Meteorological Administration [KMA]) and the International Seismological Centre (ISC). ...

[A seismotectonic study of the Southeastern Alaska Region](#) DI Doser... - Tectonophysics, 2010 – Elsevier ... Unlike the previous work of Doser and Lomas (2000), we relocated all earthquakes, regardless of magnitude, that had phase data listed in either the bulletins of the International Seismological Summary (1919-1963) or the International Seismological Centre (1964-1972). ...

[Fast P-and S-wave velocities associated with the the "cold" stagnant slab beneath the northern Philippine Sea](#) H Sugioka, D Suetsugu, M Obayashi... - Physics of the Earth and ..., 2010 – Elsevier ... and Tonga-Kermadec. Use of a vast amount of first arrival data mainly from the International Seismological Centre (ISC) Bulletin has made it possible to resolve the geometry and location of the stagnant slab. Its presence has ...

[Development of spectral hazard maps for a proposed revision of the Indonesian Seismic Building Code](#) M Irsyam, M Asrurifak, B Budiono... - Geomechanics and ..., 2010 - informaworld.com ... International Institutions, such as the Bureau of Meteorology and Geophysics (BMG), the Preliminary Determination of Epicenters (PDE) catalogs of the US Geological Survey (USGS), the International Seismological Centre (ISC) catalog, The Advanced National Seismic System ...

[Correlation between Pc1 electromagnetic activity and earthquakes](#) AV Guglielmi... - Izvestiya Physics of the Solid Earth, 2010 – Springer ... Physics" collection. Electronic files of the entire catalogue were provided by AS Potapov and TP Polyushkina. 3. The International Seismological Centre's (ISC) catalogue of earthquakes for 1964–2006, <http://www.isc.ac.uk>. 4. The ...

[Ground-motion attenuation relationship for the Sumatran megathrust earthquakes](#) K Megawati... - Earthquake Engineering & Structural ..., 2010 - Wiley Online Library ... 12 13 Sep 2007 03:35:29 2.130°S 99.627°E 22.0 7.0 602 Note: The information for Events 1–9 is compiled from the Bulletin of the International Seismological Centre (ISC), and that for Events 10–12 is from USGS National Earthquake Information Center (NEIC). ...

[Global Instrumental Seismic Catalog: earthquake relocations for 1900-present](#) A Villasenor, E Engdahl... - AGU Fall Meeting ..., 2010 - adsabs.harvard.edu ... Affiliation: AA(Inst Cien Tierra Jaume Almera, Barcelona, Spain;), AB(Department of Physics, University of Colorado, Boulder, CO, USA;), AC(International Seismological Centre, Thatcham, United Kingdom;), AD(International Seismological Centre, Thatcham, United Kingdom ...

[Probabilistic seismic hazard analysis in Thailand and adjacent areas by using regional seismic](#) S Pailoplee, Y Sugiyama... - 2010 - tao.cgu.org.tw ... (1997) for shallow crustal earthquakes. Seismic source potentials were evaluated based on composite earthquake catalogues reported by the US Geological Survey (USGS), International Seismological Centre (ISC), and the Thai Meteorological Department (TMD). ...

[A review of earthquake occurrences and observations in Nigeria](#) OU Akpan... - Earthquake Science, 2010 – Springer ... event was recorded and located by four international organizations, the National Earthquake Information Centre (NEIC) of the United States Geological Survey (USGS), the International Data Centre (IDC), Vienna, Austria, the International Seismological Centre (ISC), United ...

[Inge Lehmann's work materials and seismological epistolary archive](#) E Hjørttenberg - Annals of Geophysics, 2010 - annalsofgeophysics.eu ... A short biography is given. After her retirement in 1953 she worked at home in Denmark, and abroad in USA and in Canada. She took part in the creation of the European Seismological Commission in 1951, and in the creation of the International Seismological Centre in 1964. ...

[Reply to" Comment onA Homogeneous and Complete Earthquake Catalog for Northeast India and the Adjoining Region"by RBS Yadav, P. Bormann, BK Rastogi, MC ...](#) P Bormann... - Seismological Research Letters, 2010 - 171.66.125.217 ... For comparison, we choose the most comprehensive study by Scordilis (2006), which is based on tens of thousands of magnitude data published in the International Seismological Centre (ISC), the National Earthquake Information Center (NEIC) of the US Geological Survey ...

[Focal Mechanism of Earthquakes in the North of Central Iran](#) F Javadian, M Qorashi... - 2010 - All recorded earthquakes with magnitude of 5 and higher, occurred in the area between 34°30' - 37°00' N and 48°00' - 52°30' E, have been studied. The seismological data were taken from the International Seismological Centre (ISC) bulletin. ...

[A New View on the Space-Time Pattern of Great or Large Earthquakes along the Northern Japan to Southern Kurile Trenches](#) T Harada, K Satake... - AGU Fall Meeting

Abstracts, 2010 - adsabs.harvard.edu ... The arrival-time data are obtained from the ISC (International Seismological Centre), ISS (International Seismological Summary), and BCIS (Bureau Central International de Sismologie) bulletins. The results in this study are summarized as follows. ...

[Active spreading processes at ultraslow-spreading ridges: Relocalization and analysis of the 1999 earthquake swarm at Gakkel Ridge, Arctic Ocean, European ...](#) E Korger, V Schindwein... - Home| About ePIC| Impressum| ..., 2010 - epic.awi.de ... volcanic centre. As these analyses were based on preliminary datasets it seemed indicated to relocalize the earthquakes when the reviewed bulletin of the International Seismological Centre was released. This relocalization ...

[Seismic event of January 22, 2010 near Belchatów, Poland](#) P Węjacz... - Acta Geophysica, 2010 – Springer ... mic stations in Europe. In all, the event has been reported to the International Seismological Centre by 69 stations; this is however only the number of stations that have considered the event big enough to report it. Of the 10 ...

[a unified catalog of main earthquakes for northern algeria from ad 856 to 2008](#) M Hamdache, JA Pelaez, A Talbi... - Seismological ..., 2010 2003; Yelles Chauche et al. 2007), the completeness of this Algerian database is strongly time-dependent. International Seismological Centre (ISC) catalog (ISC 2009). ... ISC (2009). International Seismological Centre, online bulletin; [http://www.isc.ac.uk/Bull. ...](http://www.isc.ac.uk/Bull.)

[Active spreading processes at ultraslow-spreading ridges: Relocalization and analysis of the 1999 earthquake swarm at Gakkel Ridge, Arctic Ocean](#) E Korger, V Schindwein... - Arctic Ocean, European ..., 2010 - epic.awi.de ... volcanic centre. As these analyses were based on preliminary datasets it seemed indicated to relocalize the earthquakes when the reviewed bulletin of the International Seismological Centre was released. This relocalization ...

[model update January 2010: upper mantle Heterogeneity beneath north america from traveltimes tomography with global and usarray transportable array data](#) S Burdick, RD van der Hilst, FL Vernon... - Seismological ..., 2010 - 171.66.125.217 ... The data included in the inversion consist of 10 million P-wave residuals from the International Seismological Centre and the National Earthquake Information Center processed using the algorithms developed by Engdahl et al. ...

[The Nuclear Explosion Database \(NEDB\): A New Database and Web Site for Accessing Nuclear Explosion Source Information and Waveforms](#) TJ Bennett, V Oancea, BW Barker... - Seismological ..., 2010 - srl.geoscienceworld.org ... and Development Support Services (RDSS) project home page (<http://www.rdss.info/>) using Google Maps interaction, which enables comparisons between events or subsets of events, review of alternative source locations (eg, International Seismological Centre [ISC] or other ...

[Segmentation of the eastern North Greenland oblique-shear margin--Regional plate tectonic implications](#) A Døssing, L Stemmerik, T Dahl-Jensen... - Earth and Planetary ..., 2010 – Elsevier ... Jakobsson et al., 2008). Black circle outlines the eastern North Greenland oblique-shear margin. Red stars show recorded, 1964–2008 seismicity along the

margin (International Seismological Centre). Note that location of individual ...

[Analysis and repair of bias in existing teleseismic travel time databases](#) AB Medhus, BH Jacobsen, P Voss, B Paulsen... - 2010 - meetingorganizer.copernicus.org ... We compare travel time identifications from the International Seismological Centre (ISC) with high quality picks on seismological stations in our study area of Southern Scandinavia. We find bias differences amounting to more than 1 second among ISC stations. ...

[The 2009 Bhutan and Assam felt earthquakes \(M w 6.3 and 5.1\) at the Kopili fault in the northeast Himalaya region](#) JR Kayal, SS Arefiev, S Baruah... - ... Natural Hazards and ..., 2010 - informaworld.com ... The recent seismicity of the Bhutan Himalaya during the last 100 years, as reported in the International Seismological Centre (ISC; <http://www.isc.ac.uk>) catalogue is, however, low compared to its adjoining Himalayan segments in the west. ...

[Some characteristics of the seismicity of the Tyrrhenian Sea Region](#) S Meszaros... - Annals of Geophysics, 2010 - annalsofgeophysics.eu ... the end of 1965. Data of shocks, took place between 1966.01.01 and 1970.12.31 are to be found in the volumes of Regional Catalogue of Earthquakes, issued by the International Seismological Centre, Edinburgh. We wish to ...

[Local relations for converting ML to MW in Southern-Western Balkan region](#) L Duni, S Kuka... - Acta Geodaetica et Geophysica ..., 2010 - akademiai.com ... we utilized all the available information for the damaged earthquakes of the region, such as the earthquake catalogues of Albania, Montenegro, Croatia, Serbia, Macedonia, Greece (Thessaloniki), as well as the earthquake bulletins of the International Seismological Centre (ISC ...

[Seismic cycle stress change in western Taiwan over the last 270 years](#) M Mouyen, R Cattin... - Geophysical Research Letters, 2010 - L03306 1 of 5 Page 2. is a key-parameter unknown for many earthquakes. We determine it from International Seismological Centre data and according to tectonic context. For unregistered events, focal mechanisms are estimated considering the tectonic context only. ...

[Heterogeneous Coupling on the Sumatran Megathrust and the Nature of Triggering of Seismicity in the Inter-seismic Period](#) M Nic Bhloscaidh, J McCloskey... - AGU Fall Meeting ..., 2010 - adsabs.harvard.edu ... A study of the distribution with respect to the coupling field of hypocentre locations (as published in the Bulletin of the International Seismological Centre) of Sumatran inter-seismic seismicity is presented, where the statistical parameterisation of the earthquake catalogue with ...

[Double seismic zone in the North Mariana region revealed by long-term ocean bottom array observation](#) H Shiobara, H Sugioka, K Mochizuki... - Geophysical ..., 2010 - Wiley Online Library ... The number of earthquakes on the PDE list in this observation period was 59, as already mentioned. In another catalogue, the International Seismological Centre's one (EHB), it was 56 in the same period. ... International Seismological Centre (ISC), 2009. ...

[A dominant shear zone and other modes of deformation in the deep Tonga slab](#) R Gesserman... - AGU Fall Meeting

Abstracts, 2010 - adsabs.harvard.edu ... Combining arrival times from the International Seismological Centre between 1976 and 2008 with local data from the South Pacific Seismic Experiment between 1993 and 1995 provides more accurate event depths in the region of interest. ...

[The Kupa Valley \(Croatia\) Earthquake of 8 October 1909--100 Years Later](#) [D Herak... - Seismological Research Letters, 2010 - srl.geoscienceworld.org ... These rules are different than those adopted by, eg, the International Seismological Centre (ISC) or the National Earthquake Information Center (NEIC), as no limits are imposed a priori to the period at which measurements are taken (see also Bormann et al. 2009). ...

[Studies of earthquakes stress drops, seismic scattering, and dynamic triggering in North America](#) E Ayala... - 2010 - digitalcommons.utep.edu ... stresses effects at teleseismic distances. I use the Bulletin of the International Seismological Centre Catalog (ISC-CD) published by the Incorporated Research Institutions for Seismology (IRIS). To identify MASZ seismicity changes ...

[Characteristics of seismic activity in the Western, Central and Eastern parts of the North Anatolian Fault Zone, Turkey: Temporal and spatial analysis](#) S Öztürk - Acta Geophysica, 2010 - Springer ... For this purpose, he used the catalogue data from the website of the International Seismological Centre (ISC) for the time period from 1970 to 1973 and Bogazici University, Kandilli Observatory and Research Institute (KOERI) for the time interval 1974 and 2005. ...

[Seismicity of the Baikal rift zone for the digital recording period of earthquake observation \(2001–2006\)](#) VI Mel'nikova, NA Gileva, NA Radziminovich... - Seismic ..., 2010 - Springer Page 1. ISSN 0747 9239, Seismic Instruments, 2010, Vol. 46, No. 2, pp. 193–206. 2010. Original Russian Text © VI Mel'nikova, NA Gileva, NA Radziminovich, OK Masal'skii, VV Chechel'nitskii, 2010, published ...

[Connecting the African Superplume to the Anomalous Upper Mantle beneath East Africa and Western Arabia: Results from Adaptively Parameterized P-wave ...](#) SE Hansen, A Nyblade, MH Benoit... - AGU Fall Meeting ..., 2010 - adsabs.harvard.edu ... We assess the competing plume models by combining P-wave arrival time data from many new permanent and temporary seismic stations throughout Africa with reprocessed data from the International Seismological Centre. ...

[Dynamic triggering of low magnitude earthquakes in the Middle American Subduction Zone](#) CR Escudero... - AGU Fall Meeting Abstracts, 2010 - adsabs.harvard.edu ... stresses effects at teleseismic distances. We use the Bulletin of the International Seismological Centre Catalog (ISCCD) published by the Incorporated Research Institutions for Seismology (IRIS). To identify MASZ seismicity ...

[Seismicity and vulnerability in Himalayas: the case of Himachal Pradesh, India](#) VBS Chandel... - Geomatics, Natural Hazards and Risk, 2010 - informaworld.com ... 21 1963 11 12 4.6 Kinnaur 74 VBS Chandel and KK Brar Page 7. 1.3.4 Modern scientific seismological era (AD 1964–

2005). In 1964, for the first time, International Seismological Centre (ISC) published high-quality instrumental database on earthquake locations. ...

[The relationship between the body wave and the local magnitudes for Himalayan earthquakes](#) MP Chhabra, RKS Chauhan... - *Annals of ...*, 2010 - [annalsofgeophysics.eu](#) ... both could be determined for 52 earthquakes only. Although the focal depth determination were available only up to 1973 from the Bulletin of the International Seismological Centre, we have included those earth- Page 3. Page 4. ...

[Geological and macroseismic effects of the Muya, 1957 earthquake and palaeoearthquakes in Baikal region](#) RE Tatevossian, NG Mokrushina... - *Seismic ...*, 2010 - Springer Page 1. *Seismic Instruments*, 2010, Vol. 46, No. 2, pp. 152–176. . Published in Russian in *Voprosy Inzhenernoy Seismologii*, 2010, pp. 72–97. 152 1 INTRODUCTION Palaeoseismological ...

[A General Method to Estimate Earthquake Moment and Magnitude Using Regional Phase Amplitudes](#) ME Pasyanos - *Bulletin of the Seismological Society of America*, 2010 - [bssaonline.org](#) ... From the International Seismological Centre (ISC) bulletin, we determined an average standard deviation of 0.36 for m_b . From the National Earthquake Information Center (NEIC) Earthquake Data Report (EDR), the deviation of m_b is 0.41. ...

[Felt earthquake reporting via the Internet in New Zealand](#) JM Coppola, LX Cowan, GL Downes... - *Seismological ...*, 2010 - 171.66.125.217 ... TABLE 1 Building Damage Classes. 1 GNS Science, Lower Hutt, New Zealand 2 (deceased) 3 (retired) 4 Liip AG, Fribourg, Switzerland 5 International Seismological Centre, Thatcham, UK

[Estimation of seismicity parameters for India](#) STG Raghukanth - *Seismological Research Letters*, 2010 - 171.66.125.217 ... Rao and Rao (1984) reported 295 events in PI from AD 1340 to 1983. Chandra (1992) compiled 711 earthquakes in the Himalayan region from 1505 to 1986. The International Seismological Centre (ISC) bulletins were used to construct the 1964–86 catalog in Chandra (1992). ...

[Multiple episodes of continental subduction during India/Asia convergence: Insight from seismic tomography and tectonic reconstruction](#) A Replumaz, AM Negrodo, S Guillot... - *Tectonophysics*, 2010 - Elsevier ... (1998). This model has been updated by Villaseñor et al. (2003) by including arrival times of earthquakes from 1995 to 2002 listed in the bulletins of the International Seismological Centre and reprocessed using the EHB methodology (Engdahl et al., 1998). ...

[Tectonic implication of drainage set-up in the Sub-Himalaya: A case study of Papumpare district, Arunachal Himalaya, India](#) RK Devi, SS Bhakuni... - *Geomorphology*, 2010 - Elsevier ... The highly seismic nature of the northeastern region is observed from the epicentral plots of the International Seismological Centre (ISC), UK and United States Geological Survey (USGS), USA (1964-early 2010) database with magnitude ranging from 4 to 6.6 whereas ...

[The GEOSCOPE Program: Progress and challenges during the past 30 years](#) G Roult, JP Montagner... - *Seismological ...*, 2010 - [srl.geoscienceworld.org](#) ... Earthquake catalogs (such as the International Seismological Centre [ISC]

catalog or USGS Preliminary Determination of Epicenters [PDE] catalog) are more and more complete because of the increasing number of stations installed worldwide in the last decades-even in ...

[Seismic Ambient Noise Characterization of a New Permanent Broadband Ocean Bottom Seismometer Site offshore Catalonia \(Northeastern Iberian Peninsula\)](#) T Frontera, A Ugalde, C Olivera... - *Seismological ...*, 2010 - 171.66.125.217 ... data center in Barcelona. The station, with geographical coordinates 40.71°N and 1.36°E, has the code COBS at the International Registry of Seismograph Stations of the International Seismological Centre. The project was

[Seismic event identification](#) DN Anderson, GE Randall... - *Wiley ...*, 2010 - *Wiley Online Library*... The individual discriminants are illustrated with seismic event data acquired from the International Seismological Centre (ISC), the AWE Blacknest Seismological Centre (BSC), Lawrence Livermore National Laboratory (LLNL), and Los Alamos National Laboratory (LANL). ...

[The Scotia-Antarctica plate boundary from 35° W to 45° W](#) E Lodolo, D Civile, A Vuan, A Tassone... - *Earth and Planetary ...*, 2010 - Elsevier ... Although uncertainties could be large, discrepancies observed by comparing bulletins from different agencies, having different seismic stations patterns (NEIC, IDC, ISC, EHB, etc...), are limited horizontally to 10–20 km (International Seismological Centre, 2009). ...

[A Database on Submarine Landslides of the Mediterranean Sea](#) A Camerlenghi, R Urgeles... - *Submarine Mass Movements and ...*, 2010 - Springer ... From Vannucci et al. (2004) (permission requested from the publisher). ISC: International Seismological Centre; Mw: Moment Magnitude. Blue bands: Main active deformation areas 10W 10E 20E 30E 40E 50N 45N 40N 35N 30N 0 Page 4. 506 A. Camerlenghi et al. ...

[Regional seismicity of the Mid-Atlantic Ridge: observations from autonomous hydrophone arrays](#) N Simão, J Escartín, J Goslin... - *Geophysical ...*, 2010 - *Wiley Online Library* ... With a declustered data set it was then possible to compare the different temporal recordings of the various arrays deployed in the MAR during the nine-year AuH experiment and compare them to the 40-year span International Seismological Centre (2007) catalogue obtained

[Italian strong motion database relative to the period 1972–2004: motivations and aims](#) L Luzi, F Sabetta, F Mele... - *Bulletin of Earthquake Engineering*, 2010 - Springer ... catalogues by International Seismological Centre (ISC), European-Mediterranean Seismological Centre (EMSC), National Earthquake Information Center (NEIC), among others. Each seismic event was associated to different types of magnitude. ...

[Probabilistic Assessment of Earthquake Recurrence in Northeast India and Adjoining Regions](#) RBS Yadav, JN Tripathi, BK Rastogi... - *Pure and Applied ...*, 2010 - Springer ... The sources of the modern seismicity database are the India Meteorological Department (IMD), New Delhi, India; Geological Survey of India (GSI), India; National

Earthquake Information Center (NEIC) of USGS, International Seismological Centre ...

[Routine Regional Moment Tensor Inversion for Earthquakes in the Greek Region: The National Observatory of Athens \(NOA\) Database \(2001-2006\)](#) KI Konstantinou, NS Melis... - Seismological ..., 2010 - srl.geoscienceworld.org ... al. 2008). Figure 1B shows the epicenters of earthquakes in the Greek region for the period 1964–2005 as relocated by Engdahl et al. (1998) using travel times compiled by the International Seismological Centre (ISC). It can ...

[Occurrence of pockmarks on the Ortegá Spur continental margin, Northwestern Iberian Peninsula](#) G Jané, A Maestro, G Ercilla... - Marine and Petroleum ..., 2010 – Elsevier ... (1989). Bathymetric map derived from satellite and ship track data (Smith and Sandwell, 1997). Regional seismicity (earthquake epicentres) from the International Seismological Centre (2001) (<http://www.isc.ac.uk>). The size of the circle is related to the magnitude of the event. ...

[Application of array-based waveform cross-correlation techniques to aftershock sequences: the 2003 Lefkada Island, Greece, case](#) M Pirli, SJ Gibbons... - Journal of Seismology, 2010 – Springer ... Geophys J Int 165:149–166 International Seismological Centre (2001) On-line Bulletin <http://www.isc.ac.uk>, Int Seism Centre, Thatcham, United Kingdom Karakostas VG, Papadimitriou EE, Papazachos CB (2004) Properties of the 2003 Lefkada, Ionian Islands, Greece ...

[The 2010 Maule, Chile earth-quake: Dwindip rupture limit revealed by space geodesy](#) Geo-phys X Tong - Res. Lett, 2010 - ceri.memphis.edu ... Moreover, the 12° dipping fault plane lies shallower than both the hypocenter and the M > 4 background seismicity from 1960–2007, whose depths are well con- strained in the EHB bulletin [International Seismological Centre, 2009] (Figure S2d). ...

[Teleseismic magnitude relations](#) M Báth - Annals of Geophysics, 2010 - annalsofgeophysics.eu... h) calibrating function for m; T wave period, sec; x,y Cartesian coordinates; Y yield of underground nuclear explosion, kt; α angle between abscissa and normal to straight line; γ seismic efficiency; Δ epicentral distance, degrees; ISC International Seismological Centre; KIR Kiruna ...

[Seismic response to slab rupture and variation in lithospheric structure beneath the Savu Sea, Indonesia](#) KS Ely... - Tectonophysics, 2010 – Elsevier ... detail of seismic activity in the Sunda–Banda region was presented in studies focussed on intermediate and deep seismicity by Schoffel and Das ([Schoffel and Das, 1999] and [Das, 2004]) These authors relocated events from the International Seismological Centre (ISC) and ...

[Extension on the Tibetan plateau: recent normal faulting measured by InSAR and body wave seismology](#) JR Elliott, RJ Walters, PC England... - Geophysical ..., 2010 - Wiley Online Library ... Body wave solutions for the two earthquakes are coloured cyan and labelled BW with the year of the earthquake. GCMT centroid, USGS Preliminary Determination of Epicentres (PDE), International Seismological Centre (ISC) and EHB (Engdahl et al. ...

[Intensity, magnitude, location, and attenuation in India for felt earthquakes since 1762](#) W Szeliga, S Hough, S

Martin... - Bulletin of the ..., 2010 - Seismol Soc America ... If an event is not listed in the Centennial Catalog, we use hypocentral estimates from the Bulletin of the International Seismological Centre (ISC) and thereafter, the USGS National Earthquake Information Center Monthly Hypocenter Data File (MHDF). ...

[A strong-motion database from the Peru–Chile subduction zone](#) MC Arango, FO Strasser, JJ Bommer... - Journal of ..., 2010 – Springer ... Seismicity corresponds to that reported in the EHB Bulletin (Engdahl et al. 1998) for the period 1960–2006 (International Seismological Centre 2009). The width and direction of the cross-sections of seismicity are indicated by the rectangles on the map ...

[Seismic Tomography of the Arabian-Eurasian Collision Zone and Surrounding Areas](#) MN Toksoz - 2010 - DTIC Document ... S-wave arrival times from local, regional and global stations come from four sources: (1) phase readings from many countries in the study region; (2) EHB (Engdahl, van der Hilst, and Buland, 1998) data reprocessed from the International Seismological Centre (ISC) bulletins ...

[New constraints on the intraplate stress field of the Amurian plate deduced from light earthquake focal mechanisms](#) A Barth... - Tectonophysics, 2010 – Elsevier ... available (Engdahl et al., 1998; Engdahl pers. communication). Additionally, we use bulletins of the International Seismological Centre (ISC), the NEIC, and local bulletins for event locations. We restrict our data selection to events ...

[Beyond the Motagua and Polochic faults: Active strike-slip faulting along the Western North America-Caribbean plate boundary zone](#) M Guzmán-Speziale - Tectonophysics, 2010 – Elsevier ... (1998) (EHB), in the period 1964–2007. Events in the EHB catalog are carefully relocated hypocenters originally reported by the International Seismological Centre (ISC) and/or by the National Earthquake Information Center (NEIC). ...

[Aftershock Characteristics as a Means of Discriminating Explosions from Earthquakes](#) SR Ford... - Bulletin of the Seismological Society of ..., 2010 - bssaonline.org ... Unfortunately the M c of the International Data Center (IDC) and PDE catalogs in the region was a little less than 4 and the M c of the International Seismological Centre (ISC) catalog in the same region is a little more than 4 (Woessner and Wiemer, 2005). ...

[Geophysical and geological imprints of southern Neotethyan subduction between Cyprus and the Isparta Angle; SW Turkey](#) UY Kalyoncuoglu, O Elitok, MN Dolmaz... - Journal of ..., 2010 – Elsevier ... Because of these criteria, the data used in this study have been compiled from two sources. Earthquake data were selected between 1964 and 2010, with magnitudes of Mb 3.5 and Ms 3, from the International Seismological Centre (ISC) catalogue. ...

[Structure of the Earth's crust and upper mantle of the West- and East-Black Sea Basins revealed from geophysical data and its tectonic implications](#) T Yegorova... - Geological Society, London, ..., 2010 - specpubgsl.highwire.org ... The data were taken not only from International Seismological Centre (ISC) Bulletins, but also from bulletins of the regional network of Crimea seismic stations (Pustovitenko 1991,

2005), internet databases (<http://www.isc.ac.uk>, <http://www.sismo.deprem.gov.tr>) and other ...

[Earthquake deformation in the northwestern Sierras Pampeanas of Argentina based on seismic waveform modelling](#) P Alvarado... - Journal of Geodynamics, 2010 – Elsevier ... We believe that the smaller differences observed 25 for the events that occurred before 1989 is due to their focal depths are based on depth 26 phase determinations calculated by the International Seismological Centre-ISC which, were 27 then used by the regional modelling ...

[New Seismic Hazard Maps for Puerto Rico and the US Virgin Islands](#) C Mueller, A Frankel, M Petersen... - Earthquake Spectra, 2010 -... uniform catalog is constructed from four sources: 1) a compilation by of large global earthquakes, many carefully relocated (called EV, downloaded from ftp site ciei.colorado.edu/pub/user/engdahl/Handbook/CENT.CAT); 2) the International Seismological Centre global catalog ...

[Site Effects Assessment in Bishkek \(Kyrgyzstan\) Using Earthquake and Noise Recording Data](#) S Parolai, S Orunbaev, D Bindi... - Bulletin of the ..., 2010 - Seismol Soc America ; the Global Earthquake Model program Generic Mapping Tool and the International Seismological Centre catalog...

[Himalayan tectonic model and the great earthquakes: an appraisal](#) JR Kayal - Geomatics, Natural Hazards and Risk, 2010 - ... The errors of hypocentre locations are large and most of the earthquakes, as recorded in the catalogues of the US Geological Survey (USGS) and in the International Seismological Centre (ISC) bulletins, are assigned to a fixed depth (33 km) based on the global seismic stations ...

[Probabilities for the occurrences of medium to large earthquakes in northeast India and adjoining region](#) RBS Yadav, JN Tripathi, D Shanker, BK Rastogi... - Natural Hazards, 2010 – Springer ... The latter are the International Seismological Centre in the United Kingdom (ISC, since 1964; <http://www.isc.ac.uk/search/bulletin>), the NEIC (since 1963; <http://neic.usgs.gov/neis/epic/epic-global.htm>), and the HRVD (since 1976; now operated as the Global Centroid-Moment ...

[Timing of earthquake ruptures at the Al Harif Roman aqueduct \(Dead Sea fault, Syria\) from archaeoseismology and paleoseismology](#) MR Sbeinati, M Meghraoui, G Suleyman... - Ancient...2010 - ... ruptures at the Al Harif Roman aqueduct (Dead Sea fault, Syria) 245 Figure 1.(on this and following page).(A) Seismic- ity (historical before 1900 and instrumental until 2004) along the Dead Sea fault (data from merged ISC [International Seismological Centre], [Searching for an Earthquake Precursor—A Case Study of Precursory Swarm as a Real Seismic Pattern Before Major Shocks](#) D Shanker, HN Singh, H Paudyal, A Kumar... - Pure and Applied ..., 2010 – Springer ... The earthquake catalogues published by the International Seismological Centre (ISC, 1963–1988) and PDE, 1963–1988 catalogue (preliminary determination of epicenters) of the United States Geological Survey (USGS) have been considered for the period from 1963 to 1988 ...

[Joint inversion of the differential satellite interferometry and GPS data: A case study of Altai \(Chuia\) Earthquake of September 27, 2003](#) VO Mikhailov, AN Nazaryan, VB Smirnov... - Izvestiya Physics of the ..., 2010 – Springer Page 1. ISSN 1069 3513, Izvestiya, Physics of the Solid Earth, 2010, Vol. 46, No. 2, pp. 91–103. © Pleiades Publishing, Ltd., 2010. Original Russian Text © VO Mikhailov, AN Nazaryan, VB Smirnov, M. Diamant, N. Shapiro, EA ...

[Present patterns of decelerating–accelerating seismic strain in South Japan](#) BC Papazachos, GF Karakaisis, EM Scordilis... - Journal of ..., 2010 – Springer ... The data sources that were used for this purpose are the bulletins of the International Seismological Centre (ISC 2007) and the National Earthquake Information Centre (NEIC 2007) of the United States Geological Survey (USGS), as well as the online CMT catalogue of Harvard ...

[Jordskælvet i Pakistan-området med voldsom tektonik](#) TB Larsen - GeologiskNyt, 2010 - ojs.statsbiblioteket.dk ... Referencer: International Seismological Centre, <http://www.isc.ac.uk/> European Mediterranean Seismological Centre, <http://www.emsc-csem.org/> National Earthquake Information Center, USGS, <http://www.neic.cr.usgs.gov/> Af Jan Thøgersen, Kemisk Institut, Aarhus Universitet ...

[МОДЕЛЬ ОЧАГА И МАКРОСЕЙСМИЧЕСКИЙ ЭФФЕКТ РАЧИНСКОГО ЗЕМЛЕТРЯСЕНИЯ 1991 Г.](#) РЭ ТАТЕВОСЯН... - Вопросы инженерной сейсмологии, 2010 - ifz.ru ... Файл получен в ноябре 2009 г. Graizer V., Kalkan E. Prediction of spectral acceleration response ordinate based on PGA at- tenuation // Earthquake Spectra. 2009. V. 25, N 1. P. 39–69. International Seismological Centre. On-line Bulletin, ...

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[The distribution of earthquake multiplets beneath the southwest Pacific](#) R Myhill, D McKenzie... - Earth and Planetary Science Letters, 2010 - Elsevier ... Fig. 7. Map of the study region. Shaded locations correspond to the EHB centroids of groups of events with waveforms recorded at WRAB (see inset for location) which cluster above a similarity value of 0.85. ... These are superimposed on the overall seismicity for the.

[Sharpening the tomographic image of the subducting slab below Sumatra, the Andaman Islands and Burma](#) JD Pesicek, CH Thurber... - Geophysical ..., 2010 - Wiley Online Library ... Taking advantage of the increased ray

coverage due to seismicity following the 2004 ... how source mislocation affects our solution, we have relocated the initial EHB earthquake locations ... precise relative local and regional earthquake locations within many seismic networks (eg ...

[Tears or thinning? Subduction structures in the Pacific plate beneath the Japanese Islands](#) BLN Kennett... - Physics of the Earth and Planetary Interiors, 2010 - Elsevier ... Recent seismicity is concentrated along the crease line, and in a further linear trend slightly ... We build on the regional seismic tomography of Gorbatov and Kennett (2003) with joint ... The arrival times were extracted from an updated version of the EHB catalogue (Engdahl et al ...

[Midperiod Rayleigh wave attenuation model for Asia](#) AL Levshin, X Yang, MP Barmin... - 2010 - ciei.colorado.edu ... Altogether, more than 9000 records from 135 seismic stations were selected for measurements. The moment tensor solutions of selected events are taken from the CMT catalog [Dziewonski et al., 1981], and the hypocenter information is from the catalog EHB by Engdahl et al. ...

[Quantifying potential tsunami hazard in the Puysegur subduction zone, south of New Zealand](#) GP Hayes... - Geophysical Journal International, 2010 - Wiley Online Library ... represent earthquake locations for events between 1973 and the present from the EHB and PDE ... or the sampled period was too short to capture the characteristic seismic behaviour of ... ratio more likely means that we have not sampled a selection of seismicity representative of ...

[The crustal and mantle velocity structure in central Asia from 3D travelttime tomography](#) Y Sun, RV Martin, MN Toksoz... - AGU Fall Meeting ..., 2010 - adsabs.harvard.edu ... to relocate events and to invert for seismic structures simultaneously. Our results provide accurate locations of earthquakes and high resolution crustal structure in this region. To extend the model deeper into the mantle through the upper mantle transition zone, ISC/EHB data for ...

[Contrasted seismogenic and rheological behaviours from shallow and deep earthquake sequences in the North Tanzanian Divergence, East Africa](#) J Albaric, J Perrot, J Déverchère... - Journal of African Earth ..., 2010 - Elsevier ... Structural sketch map of the NTD (modified from Le Gall et al., 2008) with SEISMO-TANZ' 07 network and seismicity (blue circles ... Seismological setting. ... A general view on the overall seismic activity is provided by global catalogues, as the updated EHB catalogue which shows the ...

[Upper mantle S-velocity structure and Moho depth variations across Zagros belt, Arabian-Eurasian plate boundary](#) NS Manaman... - Physics of the Earth and Planetary Interiors, 2010 - Elsevier ... Baker et al., 1993], [Maggi et al., 2000] and [Talebian and Jackson, 2004]) suggest that seismicity in Zagros ... with a magnitude between 5.5 and 7.7 recorded by two sources: 1. A temporary seismological network along ... 2. Iranian Seismic Network (INSN) around the Zagros profile. ...

[Locations and magnitudes of historical earthquakes in the Sierra of Ecuador \(1587–1996\)](#) C Beauval, H Yepes, WH Bakun... - Geophysical ..., 2010 - Wiley Online Library ...

Seismicity and tectonics; Seismic attenuation; South America. ... The Ecuadorian seismic network (RENSIG), maintained by the Geophysical Institute in Quito (IG ... catalogues can provide instrumental solutions for earthquakes with significant magnitude (EHB Centennial catalogue ...

[Improved Characterization of Far-Regional and Near-Teleseismic Phases Observed in Central Asia](#) A Ferris - 2010 - Figure 4: Far-regional seismicity (14 - 18°) from the KKAR (red circles) and MKAR (blue circles) arrays. Other seismicity is shown in yellow. The seismic zones discussed in the text are outlined and numbered. Epicenter locations are from the EHB catalog of Engdahl et al. (1998). ...

[Lithospheric structure of the Chinese mainland determined from joint inversion of regional and teleseismic Rayleigh-wave group velocities](#) M Feng... - J. Geophys. Res, 2010 - seismolab.org ... The seismic stations and events used in this study are shown in Figure 2a as triangles and circles, respectively. ... Epicenters and event origin time data, as

required by group velocity calculations, are taken from the Engdahl Hilst Buland (EHB) catalog [Engdahl et al., 1998]. ...

[Full-wave Moment Tensor and Tomographic Inversions Based on 3D Strain Green Tensor](#) Y Shen - 2010 - It is also one of the most widely used numerical methods in seismological studies. ... systematically developed a finite-difference method to accurately and efficiently simulate seismic wave propagation ... The cross marks the FDSGT location, the square the EHB location (ER Engdahl ...

[Earthquake mechanisms and active tectonics of the Hellenic subduction zone](#) B Shaw... - Geophysical Journal International, 2010 - Wiley Online Library ... (2001) use wide-angle seismic data to ... The along-strike distribution of seismicity round the arc is patchy, with dense groups of earthquakes separated by areas without ... In this region hypocentral depths from the EHB catalogue, while unlikely to be reliable to better than ± 15 km ...

SUMMARY OF ACHIEVEMENTS

- Through sustained great support from Member-Institutions and additional grants the ISC's finances stayed healthy, staff numbers increased and essential improvements to the ISC building have been made.
- Current reviewed bulletin collection from networks now stands at 12 months behind real time. The final ISC Bulletin analysis stands at 24-25 months.
- Reviewed preliminary data are collected within days and weeks after event occurrence, grouped and distributed as part of the automatic preliminary ISC Bulletin.
- The ISC Bulletin is more complete by at least half a unit of magnitude than the bulletins of either the NEIC/USGS or the IDC/CTBTO.
- For data year 2008, ~52 thousand reviewed and ~240 thousand un-reviewed (small) events were added to the ISC database.
- The new ISC seismic event location program was designed, tested and validated using the IASPEI Reference Event List that the ISC maintains. It is ready to be put into operations to increase the accuracy of the ISC locations and its uncertainties and further reduce the load on the ISC analysts.
- CTBTO Link to the ISC database has been put into operation.
- The ISC is leading an international team in compilation of the GEM Global Reference Instrumental Earthquake Catalogue (1900-2009).
- As part of the GEM project, the data from printed historical station bulletins from the ISC collection are being entered into the database in an attempt to compute homogeneous surface wave magnitudes for the largest events of the first three quarters of the 20th century.
- The Centre received good publicity throughout the year.
- A large number of scientific articles indicate a continued wide-range use of the ISC Bulletin data by many researchers worldwide.

Signed, June 20, 2011

A handwritten signature in black ink, appearing to read 'Dmitry Storchak', written in a cursive style.

Dr Dmitry A Storchak

Director