

INTERNATIONAL SEISMOLOGICAL CENTRE (ISC)

2011

Annual Director's Report



The year 2011 was another successful year for the ISC and its data users. As many as 20 members of staff worked at the Centre during the year as the ISC became involved in several major projects. Bulletin data for earthquakes and explosions in 2009-2011, as well as earthquake data in 1900-1970 were added to the ISC database. New earthquake locator has been put into operation. Historical station bulletin data from the ISC warehouse were put to good use as part of the GEM project. A Link between the computer facilities at CTBTO and the ISC database was further enhanced with assistance on relevant waveform retrieval. The ISC database and website mirror was set up and operated at the IRIS DMC. A large number of scientific articles indicate an extensive use of the ISC data by researchers worldwide.

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EXECUTIVE SUMMARY

2011 has been another successful year for the ISC.

- ❑ With the generous support from Member-Institutions and additional grants from US NSF, GEM Foundation, CTBTO and IUGG, the ISC finances stayed healthy, as many as 20 staff members worked during the year and essential improvements to the ISC services have been made.
- ❑ Parameters of 278 stations, including those from USArray, have been registered and modified in the International Seismograph Station Registry (IR).
- ❑ Current reviewed bulletin collection from 126 networks now stands at 12 months behind real time. The reviewed ISC Bulletin stands at 24-27 months. In addition, the ISC collects preliminary reviewed bulletin data from 26 data centres around the world. This information arrives within days and weeks after event occurrence and is being grouped and distributed with a few hours delay as part of the automatic preliminary ISC Bulletin.
- ❑ For data year 2009, ~54 thousand reviewed and ~280 thousand un-reviewed (small) events as well as ~10 million seismic arrivals were added to the ISC database.
- ❑ The ISC database size has increased by ~24% in just one calendar year and reached 93Gb 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 put in operation. It has improved the accuracy and error parameters of the ISC location and magnitude determination and reduced the load on the analysts reviewing the ISC Bulletin.
- ❑ We continued operating and improving the CTBTO Link to the ISC database with a healthy stream of queries from the NDCs and PTS being recorded.
- ❑ 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 historical station bulletins stored in the ISC warehouse are being entered into the database in an attempt to re-compute homogeneous locations and surface wave magnitudes of the large earthquakes during the 110 year period.
- ❑ The ISC database and the website mirror have been set up at IRIS DMC in Seattle in addition to existing database mirror at the ERI in Tokyo.
- ❑ The ISC now has as many as five members of staff in possession of a PhD. This 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

Thanks to a number of additional projects such as the GEM, CTBTO Link and the Bulletin Rebuild, as many as 20 members of staff worked at the ISC during 2011. During the year we saw the departure of seismologists Beatriz Vera and Juan Benjumea. New employees included Blessing Shumba from Zimbabwe to help with the Bulletin Analysis and Przemek Ozgo from Poland to assist with the system administration as well as four more data entry officers to work with historical station bulletins under the GEM project.

MANAGEMENT and ADMINISTRATION:



Dmitry Storchak, Ph.D.
Director
Russia/UK



Maureen Aspinwall
Administration Officer
UK

DATA and SYSTEMS MANAGEMENT:



James Harris
Systems & Database Admin
UK



John Eve, B.Sc.
Data Collection Officer
UK



Przemek Ozgo
Junior Systems Admin
Poland (started in October)

BULLETIN ANALYSIS TEAM:



Emily Delahaye, M.Sc.
Seismologist / Lead Analyst
Canada (promoted in September)



Beatriz Vera, M.Sc.
Seismologist / Senior Analyst
Colombia (left in August)



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



Blessing Shumba, M.Sc.
Seismologist / Analyst
Zimbabwe (started in February)

DEVELOPMENT:



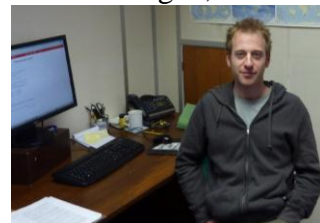
István Bondár, Ph.D.
Senior Seismologist, *Hungary*



Wayne Richardson, Ph.D.
Senior Seismologist, *New Zealand*

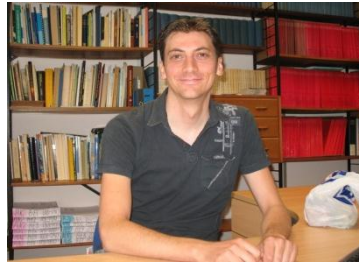


Juan Benjumea Cadavid, M.Sc.
Seismologist/Developer, *Colombia*
(left in May)



Ben Dando, Ph.D.
Seismologist/Developer, *UK*

HISTORICAL DATA OFFICE (GEM)



Domenico Di Giacomo, Ph.D.
Seismologist
Italy

Historical Data Entry Officers:



Rosemary Wylie,
M.Phys.Geog.,
UK



Rebecca Verney,
B.Sc.,
UK



Agne Baranauskaite,
B.Ed.,
Lithuania
(left in November)



Hepsi Simpson,
M.Econ.
Mexico
(left in August)



Natalia Safronova,
M.Eng.
Russia
(started in August)



Jessica Wilson,
B.Sc.
UK
(left in December)

OPERATIONS

INTERNATIONAL SEISMOGRAPH STATION REGISTRY (IR)

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 (fig.1). 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.

The unique IR codes are used by the international waveform data centres such as the IRIS DMC and ORFEUS for an appropriate waveform archival and distribution.

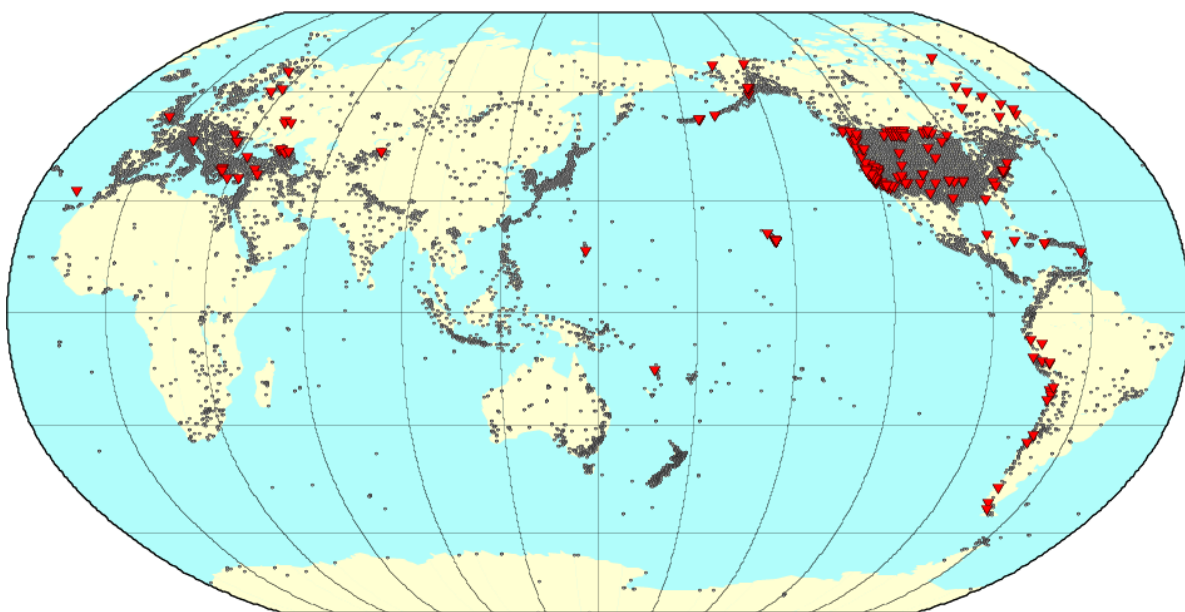


Figure 1. 16,629 stations, open or closed, were fully registered in the IR at the end of 2011 (in grey); parameters of 278 of those (in red) were either registered or modified during 2011. USArray is a prominent feature of the Registry in North America.

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 were initially reserved for future use without specifying exact coordinates. During the actual installation process sites are often shifted some in search of 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 that are 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.

COLLECTING PRELIMINARY NETWORK BULLETINS

In 2011 the ISC continued collecting preliminary bulletin data from a large number of networks and data centres. These data are expected to undergo at least a minimal review by local analysts. Typically the incoming data include a preliminary hypocentre location, magnitude estimates, moment tensor solution and station arrival data, though variations are large from agency to agency. 26 agencies reported preliminary data to the ISC during year 2011 (table 1), although contributions from the Council of Geosciences, South Africa were temporarily suspended, following an internal review of the data availability policy. There was also a temporary gap in preliminary reports from the Helwan and Hong Kong observatories. Two new agencies, Geoscience Australia and the National Nuclear Centre in Kazakhstan started contributing preliminary earthquake determinations to the ISC in 2011.

Table 1. As many as 26 agencies reported preliminary hypocentre determinations and corresponding arrival time data to the ISC in 2011.

Country	Reporting Agency
Armenia	National Survey of Seismic Protection
Australia	Geoscience Australia
Canada	National Earthquake Hazards Program
China	China Earthquake Administration
Cyprus	Cyprus Geological Survey Department
Czech Republic	Geophysical Institute, Academy of Sciences of the Czech Republic
Denmark	Geological Survey of Denmark and Greenland
France	European Mediterranean Seismological Centre
Germany	Landeserdbebendienst Baden-Wuerttemberg
Indonesia	Badan Meteorologi dan Geofisika
Iran	International Institute of Earthquake Engineering and Seismology
Israel	Geophysical Institute
Italy	Istituto Nazionale di Geofisica e Vulcanologia
Japan	Japan Meteorological Agency
Kazakhstan	National Nuclear Center
New Zealand	Institute of Geological and Nuclear Sciences
Norway	NORSAR
Russia	Geophysical Survey(GS), Russian Academy of Sciences (RAS)
Russia	Baykal Centre, GS, Siberian Branch, RAS
Russia	Kamchatka Regional Seismic Centre, GS, RAS
South Africa	Council for Geoscience
Spain	Instituto Geografico Nacional
Switzerland	ETH
Syria	National Syrian Seismological Center
UK	British Geological Survey
USA	National Earthquake Information Center, USGS

PRELIMINARY ISC BULLETIN

Preliminary hypocentre solutions and station arrivals are grouped in the ISC database with corresponding solutions from other agencies and made available through the standard ISC Bulletin search procedure within a few hours of receipt. 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. Earthquake headers include logo images of each reporting agency. By clicking on the logo, Preliminary ISC Bulletin users can get further information from each agency directly (fig. 2).

Almost all events with magnitude 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.

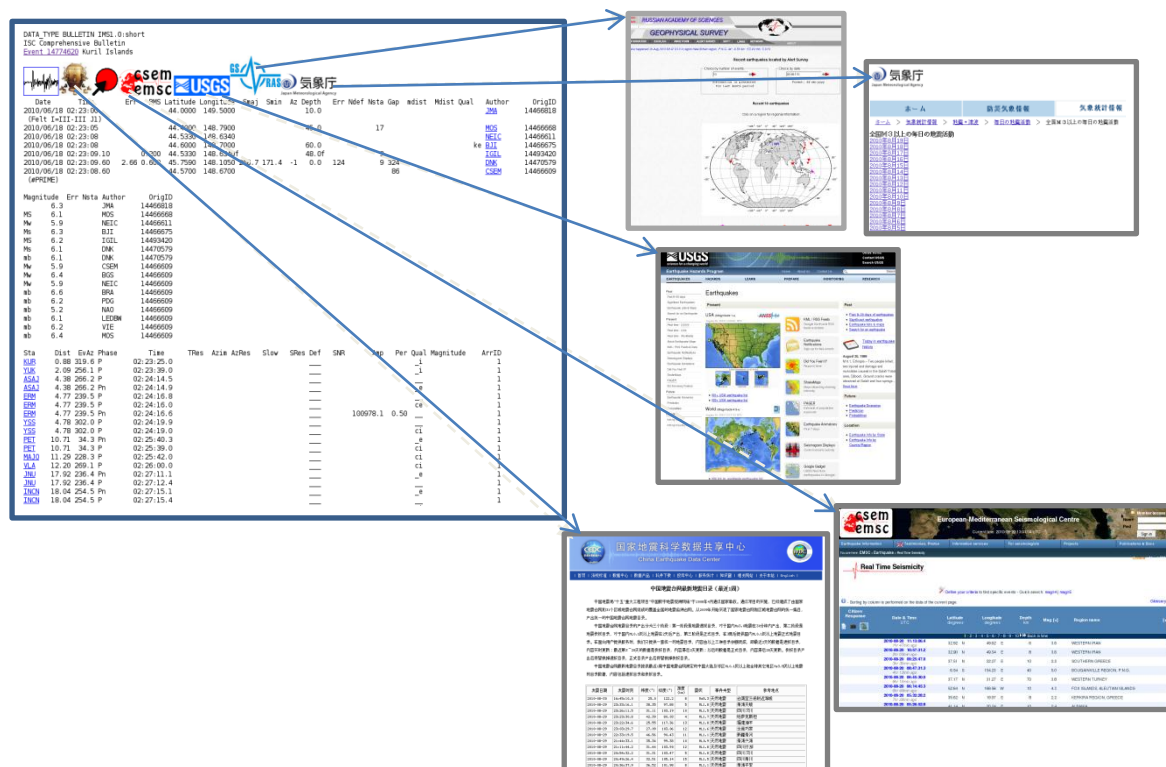


Figure 2. This figure illustrates the output of the standard ISC on-line Bulletin search when data for a very recent event are requested. Users can see a list of reporting agencies identified by their institutional logos, their hypocentre solutions, magnitude estimates and types as well as station arrival 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.

This process is there 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 the 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.

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

COLLECTING REVISED BULLETINS from NETWORKS

The standard ISC data collection is the collection of revised bulletin data from many agencies (network data centres and single observatories) around the world up to 12 months behind real time. With a few exceptions, this delay gives the data contributors enough time for reviewing and finalising their bulletin data before submission to the ISC. Figure 3 shows 123 agencies that routinely report final reviewed bulletin data directly to the ISC. In addition, a few tens of

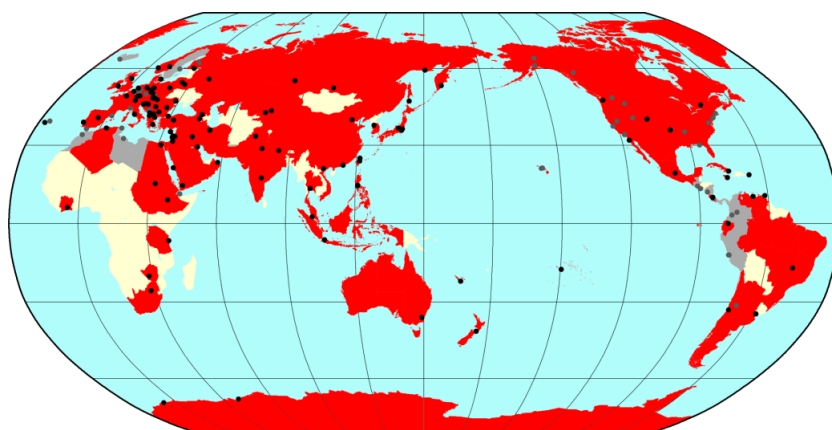


Figure 3. 123 agencies around the world (black dots) report bulletin data directly to the ISC. Dry land territories covered by these reports are in red. Grey areas and grey dots indicate those territories and agencies that are covered indirectly via reports from NEIC, EMSC and CASC. Light colour indicates areas that are not covered by local network operator reports.

agencies report to the ISC via regional data concentrating centres such as the National Earthquake Information Center (NEIC), the European Mediterranean Seismological Centre (EMSC) and the Central American Seismological centre (CASC). Large events with magnitude 4.5-5.0 and above in Africa and on mid-oceanic ridges are reported by the NEIC, International Data Centre of CTBTO, Geophysical

Survey of Russian Academy of Sciences (GS RAS) and China Earthquake Networks Center (CENC). Despite recent successful new dataset acquisitions, 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 2011 we recovered previously stopped reports from the Saudi Geological Survey yet the Geological Research Authority of Sudan has never resumed its participation due to

downscaling of seismic monitoring in the country. We have lost bulletin contribution from the Kuwait Institute of Scientific Research (KISR), but fortunately we began receiving data from:

- Goetz Observatory in Bulawayo, Zimbabwe;
- Department of Regional Geology, Maputo, Mozambique;
- The Geological Survey of Namibia, Ministry of Mines and Energy, Windhoek, Namibia;
- Department of Physics, University of Dar es Salaam, Tanzania
- Geological Survey Department, Lusaka, Zambia
- Instituto Nacional de Prevencion Sismica (INPRES), San Juan, Argentina

The ISC is grateful to one of its new analysts whose networking experience in Africa Array and the Eastern and Southern Africa Regional Seismological Working Group (ESARSWG) has helped a great deal in acquiring these sometimes sporadic yet new data. This example alone proves the need to continue with the practice of employing analysts from different parts of the world.

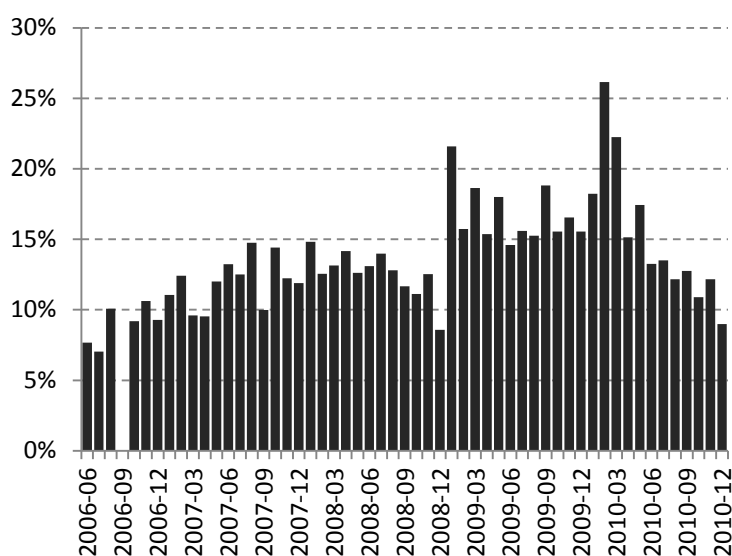


Figure 4. Fraction of arrival picks reported by USArray network facility as compared to the total number of arrivals associated to events in the ISC Bulletin with magnitude in excess of 4.5.

During 2011, the IRIS DMC continued its contribution of station arrival times that were picked and reviewed by the USArray Array Network Facility in the Institute of Geophysics and Planetary Physics (IGPP) of the Scripps Institution of Oceanography, UCSD. 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. 4). Whilst being a major source of highly useful data for

tomographic research, this data set presented a major challenge to the ISC in the past since the large concentration of stations generally biased the ISC solutions. This is no longer the case from data year 2009 as the new ISC Locator now takes correlated travel-time error structure into consideration. Nevertheless, the increased numbers of stations, reporting the same event, continue to create a major overload for the ISC Analysts.

ISC BULLETIN REVIEW

The ISC seismologists/analysts review ~24% of all events formed in the ISC database by the automatic procedures that compile and update the automatic ISC Bulletin as the data from agencies arrive to the ISC. This is the 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's worth of data is pulled into separate database 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 limiting 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 three to four analysts reviewed 12 months of the ISC Bulletin (Jan-Dec 2009) during the calendar year 2011. Mr Blessing Shumba from Zimbabwe has joined the Analysis team in February and remained under training for most of the year. The ISC Senior Analyst, Beatriz Vera, left the ISC in August to take an appointment at CTBTO. Arrangements have been made to fill the vacant analyst post with an appropriate professional in early January 2012.

Ms Emily Delahaye was promoted to serve as the Lead Analyst. Helped by the Director, Ms Delahaye has led the re-appraisal of the analysis procedures, set the expected analysis schedule and developed guidelines and standards for the entire team. She also initiated a series of development improvements that were discussed and implemented with the help of the entire Data Management and Development teams. A good number of deficiencies and inconsistencies were eliminated in the existing Bulletin analysis software as well as in the software used to parse incoming network bulletins into the ISC database. These measures helped to minimise typical bulletin month processing times.

The team was also helped by the Director during the final steps in the analysis procedure as well as by Dr. Wayne Richardson, a Senior Seismologist, whose experience of editing the ISC Bulletin was useful during the training as well as in solving difficult cases.

During 2011 the ISC Reviewed Bulletin was made available between 24 and 27 months behind real time.

Due to an unfortunate mistake, the majority of USArray arrival picks for four data months between May and August 2009 were not sent to the ISC in time for routine analysis. The

USArray arrival picks contribute to locations of many large events and therefore had to be processed, merged and reviewed as a special case for continuity reasons well after the normal Bulletin analysis was complete. This work was performed by the ISC Database Administrator and the former ISC Senior Analyst, Beatriz Vera, whilst on leave from CTBTO for two weeks in November/December.

NEW EARTHQUAKE LOCATOR in OPERATIONS

From January 2011 (data year 2009) the new earthquake Locator (written by István Bondár, an ISC Senior Seismologist) was put into operation. This was a rather challenging time for the ISC Analyst's Team trying to adapt to changes in editing requirements as well as seeking out remaining bugs and inconsistencies that inevitably arise when large volumes of previously unused data are processed. A moderate delay in the ISC Bulletin distribution was caused by further need to adapt most of the ISC distribution software to changes in the structure of the results achieved during the Bulletin review, as well as to a more comprehensive account of results provided by the Locator itself. As a payback, the general load on the ISC analysts was reduced in the long run as some of the routine tasks have now been automated and phase identification improved.

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. The paper describing the new ISC location algorithm has been published in the *Geophysical Journal International* (Bondár and Storchak, 2011).

The new algorithm has proven to improve the accuracy of the ISC location, magnitudes and error estimates. The ISC now produces the magnitude error estimates and retains a record of which station amplitudes were used to compute it. It addressed previous bias created by large concentrations of stations in certain regions of the world and sparse networks in others.

The Locator's code was made openly available from the ISC website. Nevertheless, the ISC will not, under normal circumstances, be able to offer assistance in either installation or maintenance of this code. A manual was also produced to address any possible user queries.

We continued computing the second set of locations (ISCJB) based on the Jeffreys-Bullen travel times and the old ISC locator. These locations are automatic and only those substantially deviating from the *ak135* locations are reviewed and revised by the ISC analysts. This service will cease to exist once the entire ISC Bulletin is recomputed using the *ak135* velocity model by mid-2014 under the Rebuild project described below.

WORK on the IBAS

The issue of the constantly 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. An introduction of the Interactive Bulletin Analysis System (IBAS) in place of the existing paper-scanner-screen based batch-type analysis is planned. The IBAS would allow the ISC analysts to concentrate on the review of outliers instead of reviewing all data. Following the ISC Executive Committee decision the relevant staff of the Centre continued working on the IBAS design.

We also continued our search for appropriate ways to fund the project and attract professional support in the area of computer-human interaction that the ISC staff is clearly missing. An outcome of preliminary enquiries made in 2010 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. Hence, during 2011 we continued working with the Dr James Anderson from the Computer Department at nearby Reading University. Our goal was to have a student from Reading University working on the IBAS at the ISC under a supervision of the Reading University specialists. Helped by Anna Price, Business Development Manager of the University's Knowledge Transfer Centre, and in partnership with James Anderson we prepared and submitted a formal pre-proposal to the current UK Government Program of Knowledge Transfer Partnerships (KTP). The Program is designed to contribute joint funds of several UK Government funding bodies towards those projects that implement University research results into successful business environment and give recent graduates a chance to work in UK companies. Contrary to all initial indications, the ISC/Reading University application did not receive the support of the KTP Regional Adviser as it did not involve a "cutting-edge" science neither was it guaranteeing a "substantial increase in profits". The other, perhaps more profound reason for this failure to attract funding was that the KTP programme's funding had been drastically scaled down several fold in the weeks preceding the ISC application.

Despite the disappointing application result we continued working on the IBAS vision document. A number of brain-storming meetings at the ISC generated quite a few useful ideas and suggestions that moved us forward.

In the meantime, a number of additional projects run by the ISC have produced a necessary funding surplus to be used for hiring a computer programmer to implement the IBAS design once it is ready.

GENERAL STATISTICS of the ISC BULLETIN

The ISC Bulletin and the ISC database grow by the day in both seismic event (earthquake or explosion) numbers and reported seismic wave arrival times and amplitudes at stations registered in IR (fig. 5a,b). During the year 2011, over 54,000 reviewed (by the ISC analysts) events and almost 280,000 unreviewed (small) events were added to the ISC Bulletin. At the

same time ~5 million arrivals were associated to reviewed events and further ~4.6 million seismic arrivals were associated to the unreviewed (small) events. A further ~750 thousand arrivals from unknown events were added to the ISC database during 2011.

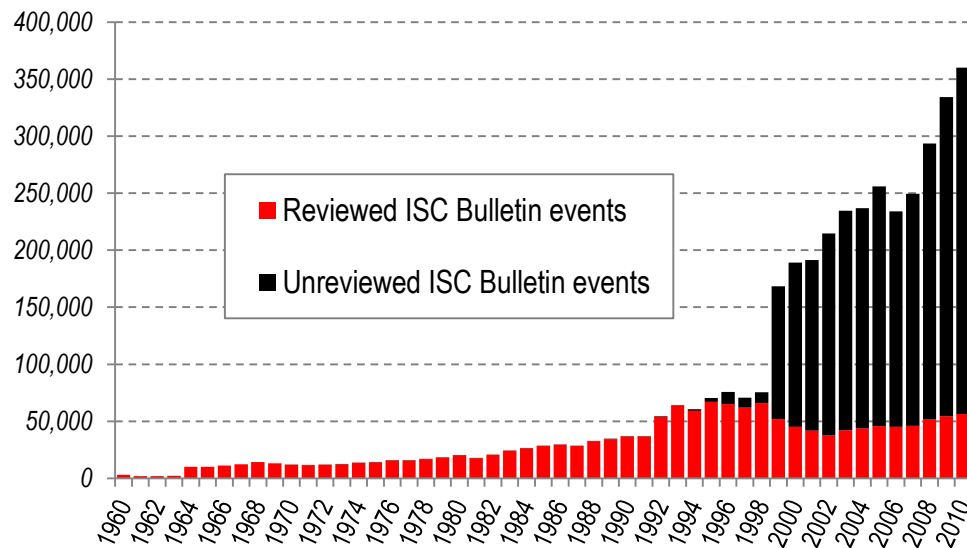


Figure 5a. Timeline of the annual number of reviewed and unreviewed (small) events in the ISC Bulletin. The total height of each column represents the annual number of all seismic events in the ISC Bulletin.

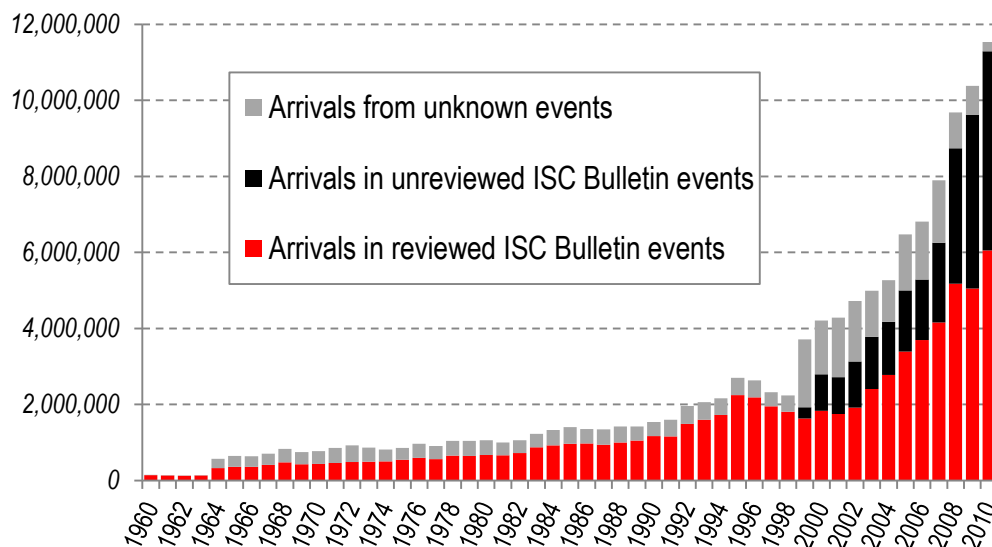


Figure 5b. Timeline of the annual number of seismic arrivals associated with both reviewed (red) and unreviewed (black) events in the ISC Bulletin, as well as those arrivals in the ISC database that are not associated to any known events (grey). The total height of each column represents the annual number of all seismic arrivals in the ISC database.

Figure 6 demonstrates a comparative magnitude completeness of the ISC Bulletin and bulletins 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. The NEIC has adopted its new global magnitude cut-off threshold of 4.5 which means that the ISC Bulletin will always be more complete by definition. The IDC is unlikely to use many more seismic sites than they use at present due to exact IMS network station positions written in the Comprehensive Test Ban Treaty. Hence, it is likely that there will be even more seismic events in the future that will be unique to the ISC Bulletin.

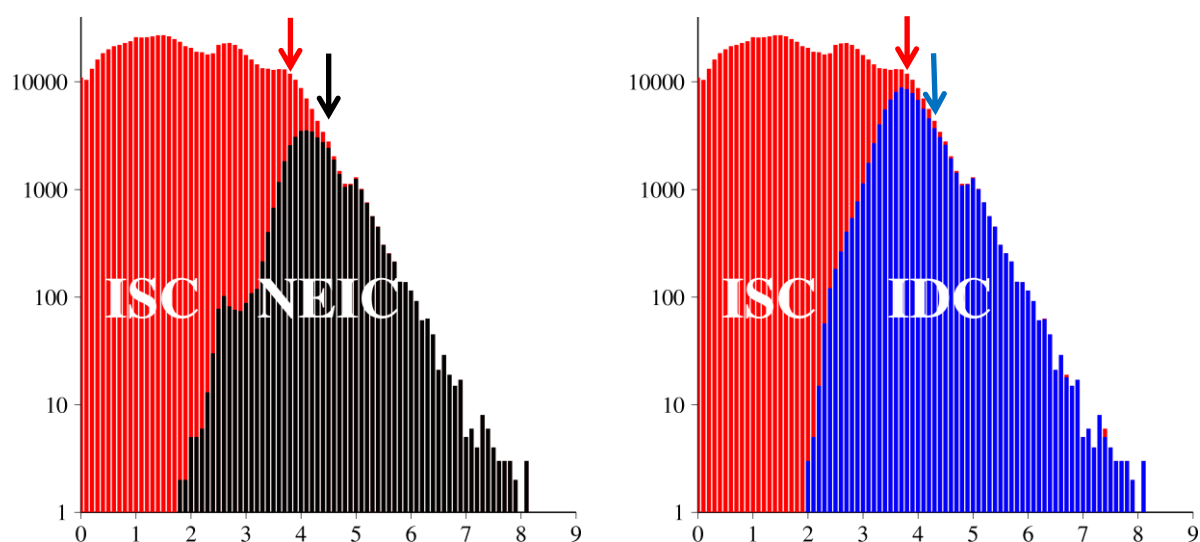


Figure 6. Comparative global magnitude completeness of the ISC, NEIC/USGS and IDC/CTBTO (REB) bulletins (2007-2009). The ISC appears to be more complete than any of NEIC or IDC Bulletins by at least half a unit of magnitude.

ISC DATABASE

The ISC holds its entire collection of data in the relational Postgre database on a Linux server with a RAID Array. In 2011 this database has grown by 24% and reached the volume of 93Gb, thanks to a steady increase in the number of seismic arrival picks reported for the ever growing number of seismic events as described above.

IASPEI GT LIST

The International Seismological Centre maintains the IASPEI database of Reference Events (earthquakes and explosions, including nuclear) 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 is coordinated by the CoSOI/IASPEI working group on Reference Events for Improved Location chaired by Bob Engdahl and Eric Bergman. This database of 7,410 reference events (1962-2008) and approximately 500,000 station arrivals facilitates better

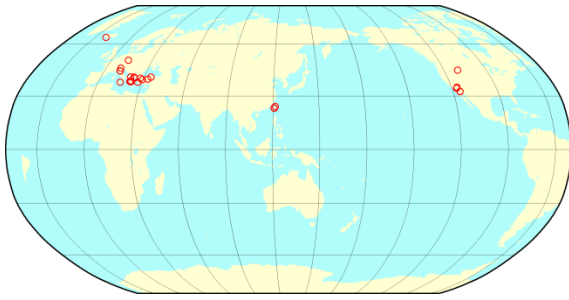


Figure 7. 57 events (all in Northern hemisphere) have been added to the IASPEI list of Reference earthquakes and explosions for data year 2008.

magnitudes from 3 to 5 have been added to the List (fig. 7). Members of the CoSOI/IASPEI working group had a chance to review both the criteria and individual events. There were no reference events identified in southern hemisphere which reflects the sparse permanent station distribution in this part of the world.

EHB

The EHB (Groomed ISC Bulletin) (E.R. Engdahl, R.D. van der Hilst, R. Buland ,1998) 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 made by the ISS, ISC and NEIC/PDE.

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 141,478 events between 1960 and 2008 accompanied with ~25 million 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 the convenience of the ISC users.

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.

At the end of each data year analysis, we add new events to the Reference Event List. For data year 2008, 57 new events with

With the new ISC Location algorithm finally in the ISC routine operations and planned relocation and enrichment of the entire ISC Bulletin with the new and missing bulletin data already taking place, it is expected that further production of the EHB bulletin, that made such a great contribution towards the global tomographic studies, will finally be discontinued.

ISC WEB and FTP SERVICES

The ISC web-site as a whole and the ISC Bulletin search in particular continued to grow in popularity during 2011 (fig. 8a,b). The number of hits reached ~5.4 million, having increased 5% compared with 2010. Both the number of the ISC Bulletin searches and the number of searches through the station registry (IR) in 2011 have doubled since 2010.

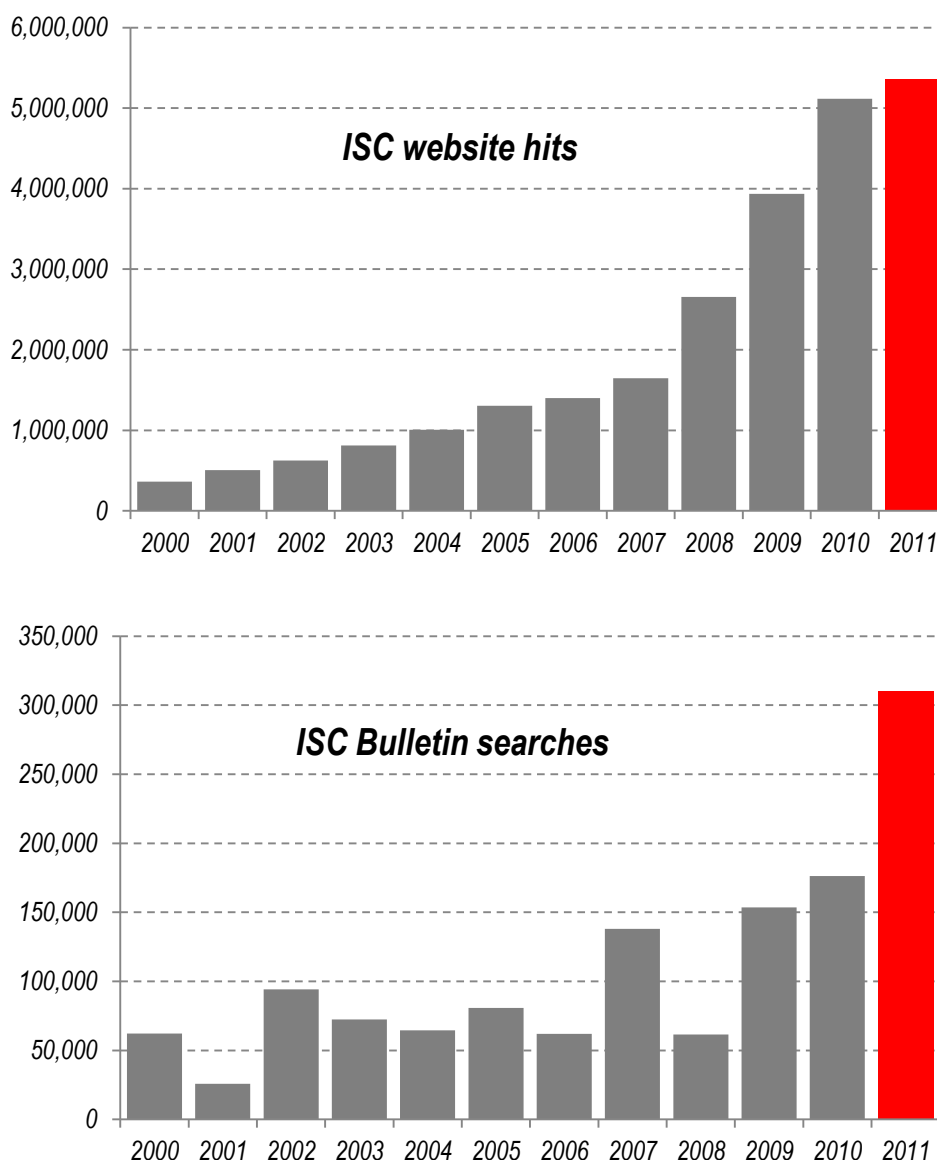


Figure 8a,b. Annual numbers of the ISC website hits (a) and the Bulletin searches (b).

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

- International Station Registry (407K, 100% increase compared with 2010),
- ISC Bulletin search (310K, 100% increase compared with 2010),
- Bulletin map (10K)
- Search of original data contributed to the ISC (6.7K),
- Links to agencies providing real time data (6.4K),
- Bibliography search (2.5K)
- EHB (1.6K)
- GT (0.35K)

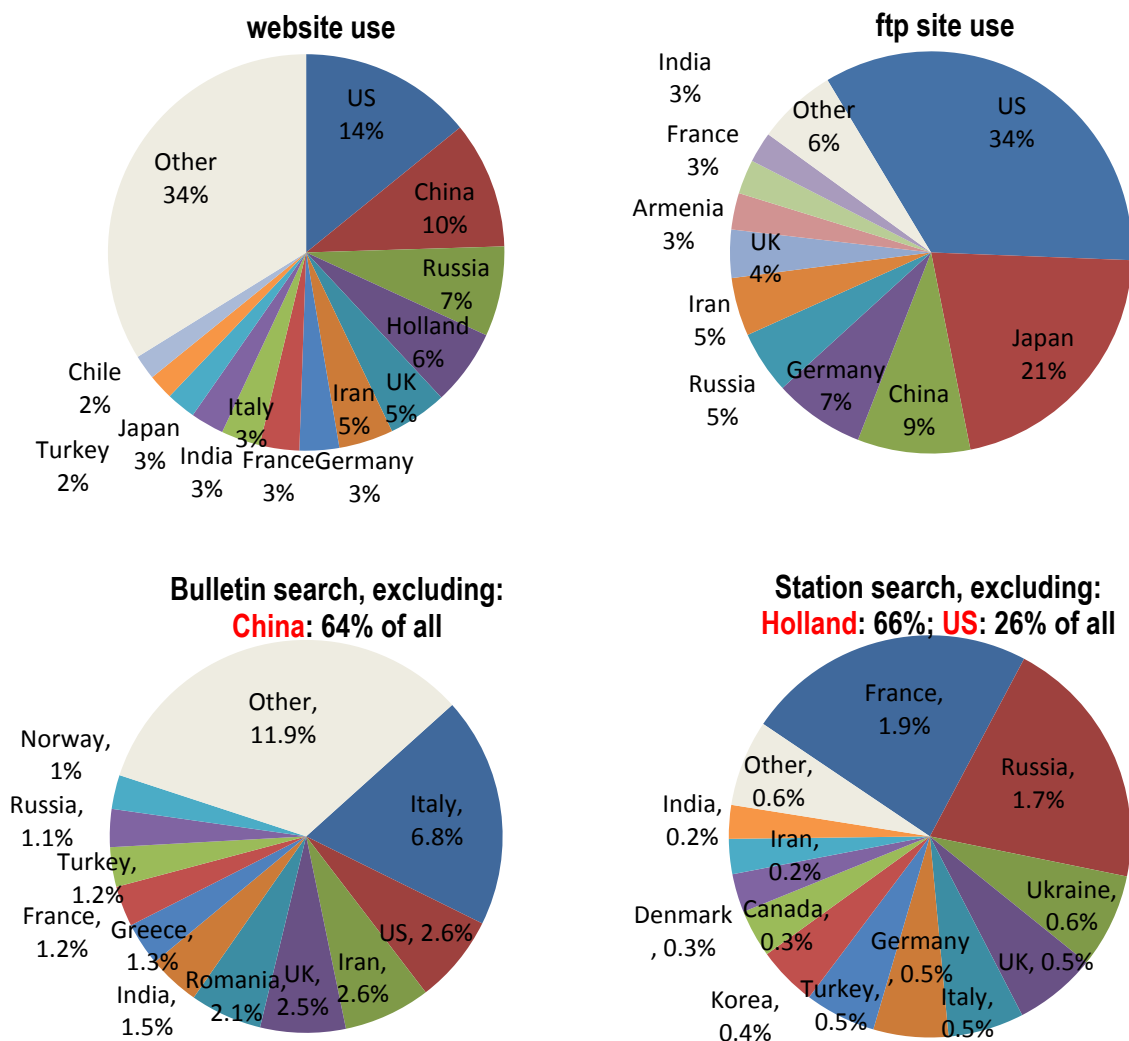


Figure 9. Per country statistics of the ISC web and ftp site use, Bulletin and IR searches.

General usage of the ISC web and ftp services, with Bulletin and Station Registry searches in particular are described on Figure 9. Clearly the US, China, Holland, Japan are in the lead. Unusually high amount of searches to the station registry is dominated by the LLNL in US and the ORFEUS in Holland. We are not aware of a single institution in China that is responsible for the abnormally high number of the Bulletin searches this year.

DEVELOPMENT PROJECTS

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-month 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 a team of observers on behalf of the IASPEI: Roger Musson (BGS, *UK*), Johannes Schweitzer (NORSAR, *Norway*), Göran Ekström (Columbia Uni, *US*) and 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 same technique combining 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 moments from GCMT and individual credible earthquake studies where possible and M_W proxy values in other cases using appropriate empirical relationships between M_S /mb/mB and M_W .
- ✓ 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 have been recovered from the historical collections at USGS/Berkeley.

Many of seismic wave amplitudes, especially surface wave amplitudes, as well as depth sensitive secondary seismic arrivals, currently being extracted from these bulletins, have never been part of global bulletins before (table 2). 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 but this collection has considerable gaps. 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.

Table 2. Electronic data availability (black as opposed to grey) prior to project start;

Period	1900-1959	1960-1970	1971-1977	1978-2009
Body wave arrival times	Grey	Black	Black	Black
Surface wave amplitudes	Grey	Grey	Black	Black

The surface wave amplitudes and secondary depth sensitive phases from a number of quality stations that operated for long periods of time proved 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 the majority of cases. Hence as many as five full-time data entry officers were employed at any single time during 2011 to perform efficient and thoughtful manual entry of data from historical publications into the database (fig. 10a,b). The quality and suitability of the incoming data were constantly monitored by the GEM Seismologist.

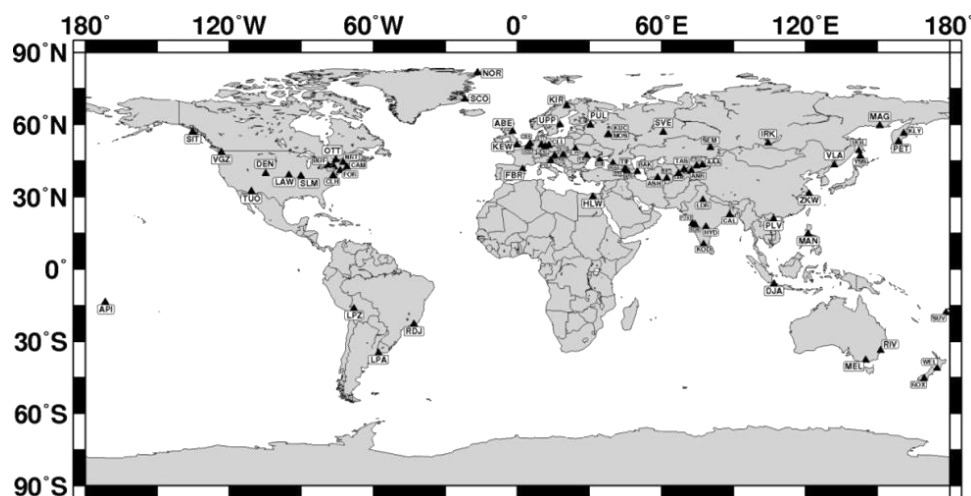


Figure 10a. Arrival times, amplitudes and periods are obtained from historical bulletins of the high quality long-serving seismic observatories.

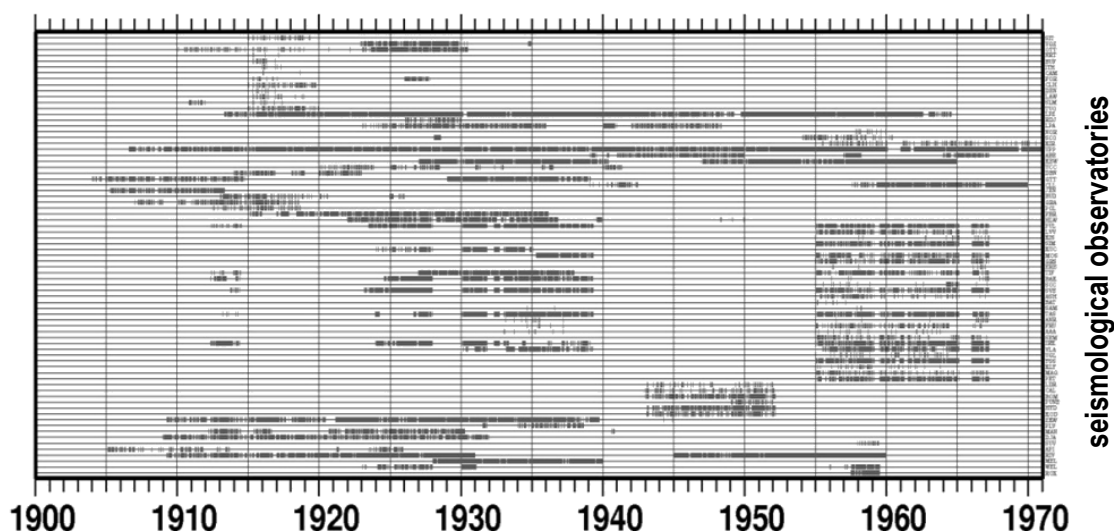


Figure 10b. Time line of station data availability. When selecting observatories, due regard is given to the time period they jointly cover. World War I and II caused major gaps in data availability of many stations.

As the data entry work continues, techniques of relocating historical seismic events are being reviewed and tested using a more recent period of time, where the original ISC locations are already available. Figure 11 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.

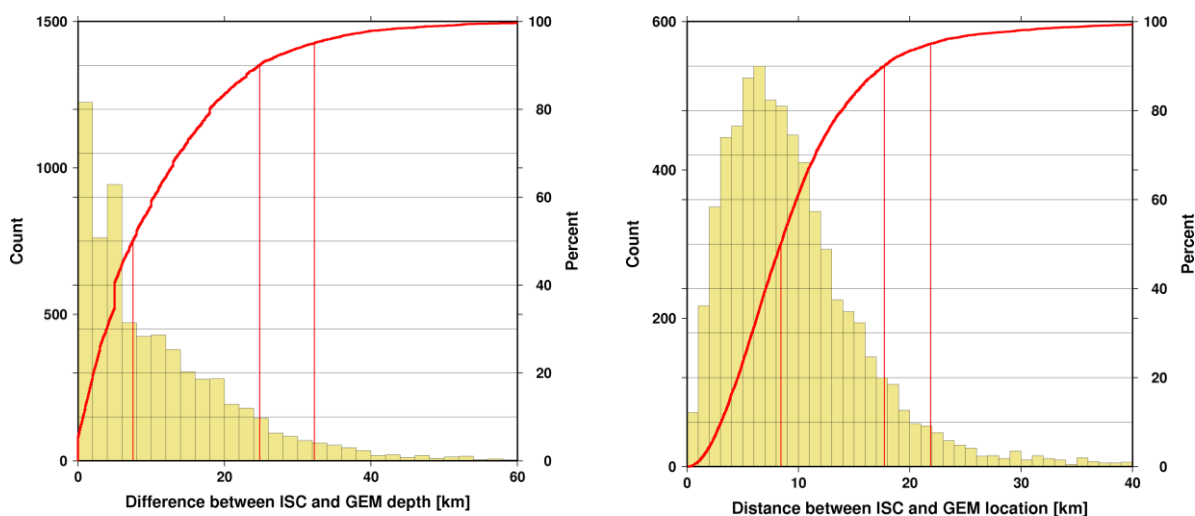


Figure 11. 6601 earthquakes with $M_S > 5.5$ were relocated for the period of 1978-1999. Differences between the original ISC and GEM (new ISC) locations and depths are shown.

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 from 1900 to the present.

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 funding with GEUS (Denmark), NORSAR (Norway), FOI (Sweden) and University of Helsinki (Finland) complementing it with 2.5% each. Starting from April 2011, the funding of the project was taken over by the CTBTO for one year with an intention to continue on an annual basis.

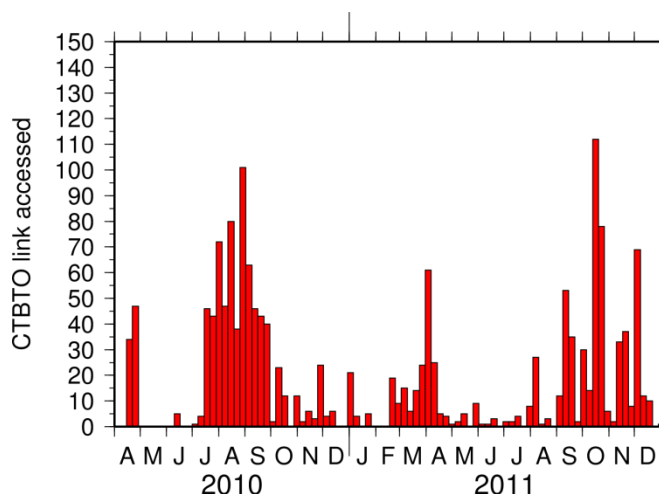


Figure 12. *The Link to the ISC database mirror is provided to the NDCs through the IDC secure website. The figure shows the healthy stream of user activity.*

CTBTO to query the ISC database in ways specific to the explosion monitoring community. This dedicated software package included 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 perform various types of analysis such as:

- assessing the historical seismicity in a specific region;
- putting an event of interest into context with the seismicity of the surrounding region;
- examination of observations reported by non-IMS stations;
- comparison of hypocentre solutions provided by various agencies;
- investigation of station histories and residual patterns of IMS or IMS surrogate stations.

During 2011, the user interface was updated to take advantage of the Google Maps in numerous map-based applications. Those interfaces that use area selection tools have been upgraded to use more flexible and easily adaptable polygons, rectangles and circles. It is now

During 2011 we maintained the dedicated server at the ISC that holds a mirror version of the ISC database. A new fibre-optic internet connection has been installed with a speed of 10 Mbps both upstream and downstream, which is 20 times faster than a regular upstream on a typical broadband line maintained by the ISC in the past.

The web-based software package, originally created under the UK FCO support, allowed users from PTS and National Data Centres for

possible that these areas cross the 180 degrees meridian. Corner points can be adjusted whilst keeping most of the original polygon.

We also developed an interface for selecting waveforms of non-IMS stations for REB events from the IRIS DMC archive. For each REB event, this interface allows:

- selection of stations by distance / azimuth to the REB epicentre,
- shows the number of stations, for which waveforms are available at IRIS DMC,
- exhibits pre-prepared images of selected waveforms, filtered and un-filtered with theoretical first arrivals indicated on top of the waveform images;
- offers a form to request part of waveform, based on an absolute or relative theoretical arrival times of required seismic phases or on group velocity of surface waves;
- triggers a request to IRIS DMC; as a result, users receive required waveforms by e-mail in the SEED format.

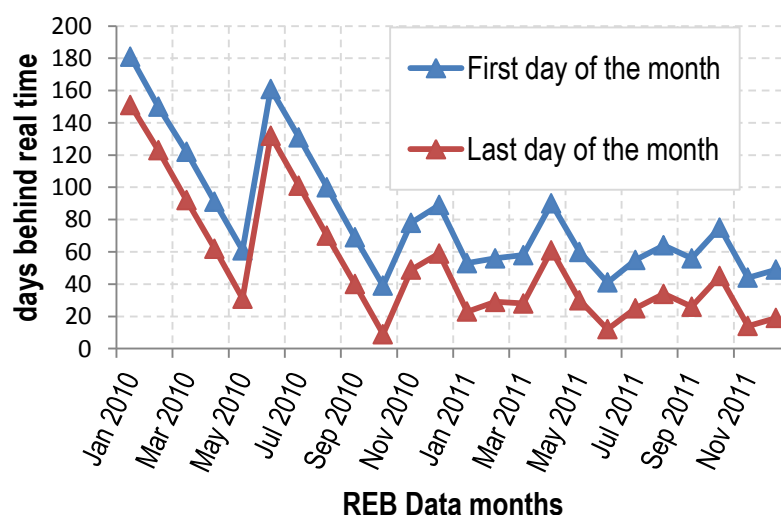


Figure 13. The availability of the IDC REB data to general ISC Bulletin users (days behind real time) has considerably improved with the routine operation of the CTBTO Link.

A general introduction and two tutorials / demonstrations have been given to the States Parties and NDCs during the WGB-37 in Vienna. Figure 12 shows user activity on the Link by both PTS/CTBTO and NDCs. Many comments and suggestions have been received from the Link users and are being gradually implemented.

Although it may appear that this project benefitted only the

CTBTO, the ISC, its Member-Institutions and the ISC Bulletin and other product users also gained from the experience:

- The ISC development staff acquired important skills and experience during this project. The advances made under this project are gradually implemented to improve the traditional open ISC web services.
- The ISC and its Bulletin users gained much speedier access to the REB Bulletin which is now available within 20-50 days after event occurrence as opposed to half a year to a year in the past (fig. 13).

- Many National Data Centres for CTBTO are run by institutions that are either Members of the ISC or reporters of data to the ISC.
- Several NDC's either became the ISC Members or increased their financial contributions, based on the added value of the ISC service.

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.

NSF: ISC DATABASE and WEBSITE MIRROR at IRIS DMC

Following suggestions, raised at the 2009 ISC Governing Council meeting, and as a result of the successful application to the NSF in 2010, the ISC has set up one of its servers at the IRIS DMC in Seattle, US in order to hold a mirror of the ISC database and the ISC website. This was done with the kind assistance from the DMC in order to achieve a general ISC data back-up, fall over facility in case of a breakdown of services at the ISC itself as well as to spread the load on the ISC Internet line and give ISC users faster access to data.

In addition, the IRIS DMC is able to use the database on a daily basis to serve the DMC archive users with event based selection of waveform data.

The mirror has been operational since September 2011. The database in Seattle is updated with 1 hour time lag. Usage has steadily increased and the ISC continues to promote the mirror on the website, in regular newsletters and email notifications.

Another mirror of the ISC database is maintained by the Earthquake Research Institution (ERI) of University of Tokyo that serves research community in Japanese universities.

NSF: ISC BULLETIN REBUILD (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 approach was introduced from data year 2009.
- Throughout the ISC history different sets of seismic phases were used for location: P & (from 2001) S with other *ak135* phases from 2009.
- 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 rebuilt 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.

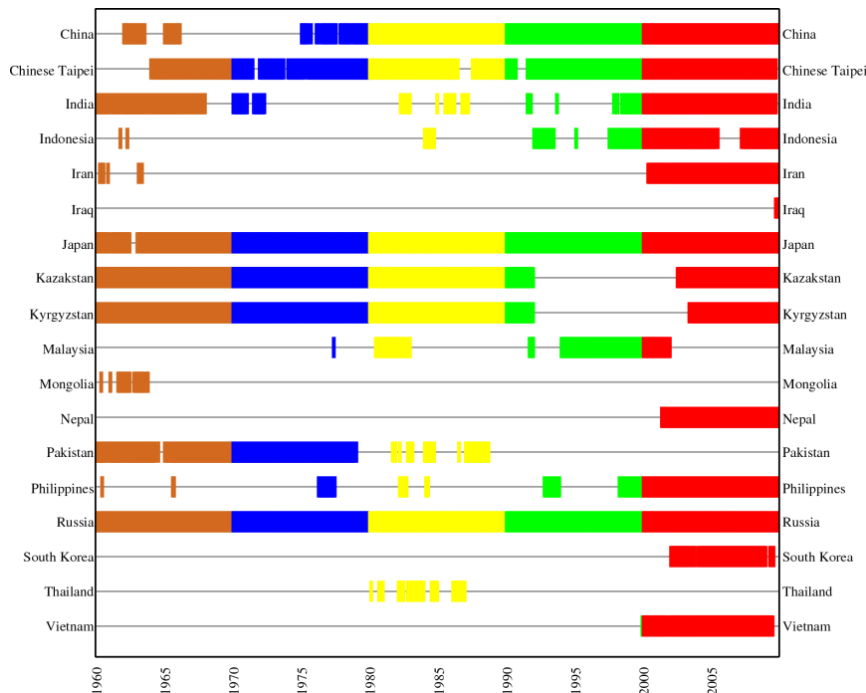


Figure 14. An example of the gaps in reporting from various countries in Asia over a 50 year long period since 1960. Large efforts were put towards recovering missing bulletin data from China, Mongolia and Iran that are known to exist, yet with little success so far.

During 2011 we conducted a thorough review and clean-up of the contents of the ISC Bulletin in area of seismic arrival phase identifications, channel information, first motion information, suspiciously large magnitude estimates.

We obtained and prepared to load into the ISC database the following new bulletin datasets:

- *GNS, New Zealand*: bulletins going back to 1931
- *CWB, Chinese Taipei*: bulletins (arrival times for all events) going back to 1991
- *Baykal Branch, GS RAS, Russia*: bulletin going back till 1994
- *IISSE/BRI, Japan*: catalogue of active fault planes for major events in 1994-2009.
- *USArray, IRIS*: phase picks, originally missed for May-Aug 2009
- *AWE Blacknest, UK*: dataset of arrival time and amplitude measurements for 28 US nuclear explosions complete with maximum likelihood mb determinations
- *Baykal Branch, GS RAS, Russia*: updates on the event type flags of specific events
- *Obninsk, GS RAS, Russia*: updates on the event type flags of specific events

The rebuilt ISC Bulletin is planned to be made available to users in the middle of 2014.

As part of this project we are:

- Re-computing all ISC hypocentres with uncertainties;
- Re-computing all ISC event magnitudes with uncertainties;
- Soliciting, obtaining and integrating essential additional datasets that have not been available at the time of original ISC Bulletin production (fig. 14);
- Performing essential integrity and consistency checks, quality control and correction.

IUGG: IMPROVING GEOPHYSICAL SCIENCE LINK to SOCIETY (during Natural Extreme Events)

The objective of this joint ISC/IASPEI project is to update and maintain up-to-date information on the network of scientific institutions, seismologists and geophysicists in each country willing to serve as scientific points of contact to:

- Seismologists and Geophysicists in other countries;
- Governments;
- Charitable, Response and Relief organizations;
- Media.

Particular care is given to establishing and maintaining contacts in developing countries.

In addition to the IUGG funding, the project benefits from additional support in terms of staff time from the Institute of Geophysics and the China Earthquake Networks Center of China Earthquake Administration.

The registry in its current form is readily available for scientific & research institutions, governmental bodies, charitable and relief organizations and media at:

www.isc.ac.uk/projects/seismocontacts

This webpage lists all countries worldwide in three distinct categories:

- In **RED** are countries in which institutes and individual members of staff are willing to share information and serve as a local point of contact.
- In **BLUE** are countries for which we have limited information about operating geophysical organisation(s).
- In **BLACK** are countries for which we do not currently hold any information.

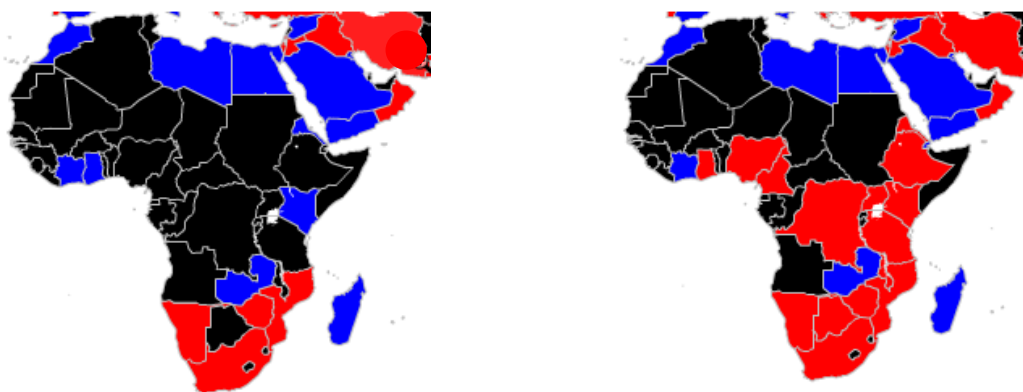


Figure 15. Comparison of the state of the service in 2010 (left) and 2011(right). Many more territories highlighted in red or blue can be taken as a good indication of progress in obtaining contact details in Sub-Saharan Africa.

For each country in “red” category users can obtain the details of the name of an Institution, name, title and position of particular member of staff, postal address, telephone and fax number as well as an e-mail address. For each country in “blue” category institutional contact details are available but no specific person's details are given.

During 2011 we concentrated our efforts in improving the contact information in Central and East Asia and Sub Saharan Africa (fig. 15) – the most important areas as far as the goals of the project are concerned.

IMPROVEMENTS to the ISC OFFICE BUILDING



Figure 16. *Shelving in the ISC warehouse*

Heavy-duty shelving rows (fig. 16) were purchased and installed in the ISC warehouse which saw the ISC historical station bulletin collection finally lifted off the floor to mitigate a possibility of flood damage. Digital scanning of the entire collection is planned in collaboration with the SISMOS project run by Graziano Ferrari at the INGV (Italy), a long-term Member of the ISC.

Further improvements were made to the staff kitchen. Central heating was extended to include the kitchen and the stairwell.

This investment into the ISC, its historical data collection and the 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 2011 were audited by Griffins, Chartered Accountants (Newbury, UK) and approved by Prof. John Woodhouse of ISC Executive Committee. These statements present the state of ISC's financial affairs as at 31 December 2011.

INCOME

In 2011, ISC had a total income of £772,111 from national contributions and a collection of grants for special projects totalling £195,739 and itemised on page 7 of the accounts. Interest on ISC bank accounts plus the income from selling ISC publications is also included. The NSF funds and also other grants where the work has yet to begin have been split between 2011 and 2012.

The exchange rate between the UK £ and USA \$ steadily changed from £1=\$1.56 at the start of the year to £1=\$1.66 in the middle of the year and £1=\$1.55 at the end of December.

During 2011, two new members joined the ISC Governing Council: the Disaster and Emergency Management Presidency in Turkey (AFAD) and the SOREQ Nuclear Research Centre in Israel (also paid in advance for 2012). At year-end, after 3 consecutive years the membership fees from Geological Research Authority of Sudan (GRAS) were unpaid and written off as bad debts in the accounts. Some £82,927 had yet to be paid by members for 2011 but at the time of writing this report some of them have been received.

EXPENDITURE

About 84% of ISC expenditure in 2011 was committed to personnel costs some £103,471 more than in 2010 yet the figure was less than budgeted. 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 came in under budget as did the computer expenses although the amount rose from 2010 by just under £11,000 due to hardware purchases made to run additional projects. The total travel costs for the staff and the Executive Committee fell slightly despite the fact that the annual Executive meeting was held in Australia.

RESERVES

The gain in income over expenditure for 2011 was £85,607 which is good news in view of the forthcoming expenditure on the programming staff to improve the Interactive Bulletin Analysis System (IBAS). The 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 2011 to £592,069. The Contingency Fund stands at £30,000 in accordance with the wishes of the ISC Governing Council. The

ISC General Reserve of £562,069 is equivalent to almost 8 months future operation of the ISC. This is well within British guidelines for charitable organizations.

CASH FLOW

The cash flow in Fig. 17 shows receipts and outlays using dates when transactions were recorded at the bank and the bank balances where US Dollars and Euros are converted to Sterling using the exchange rate as of the end of each month.

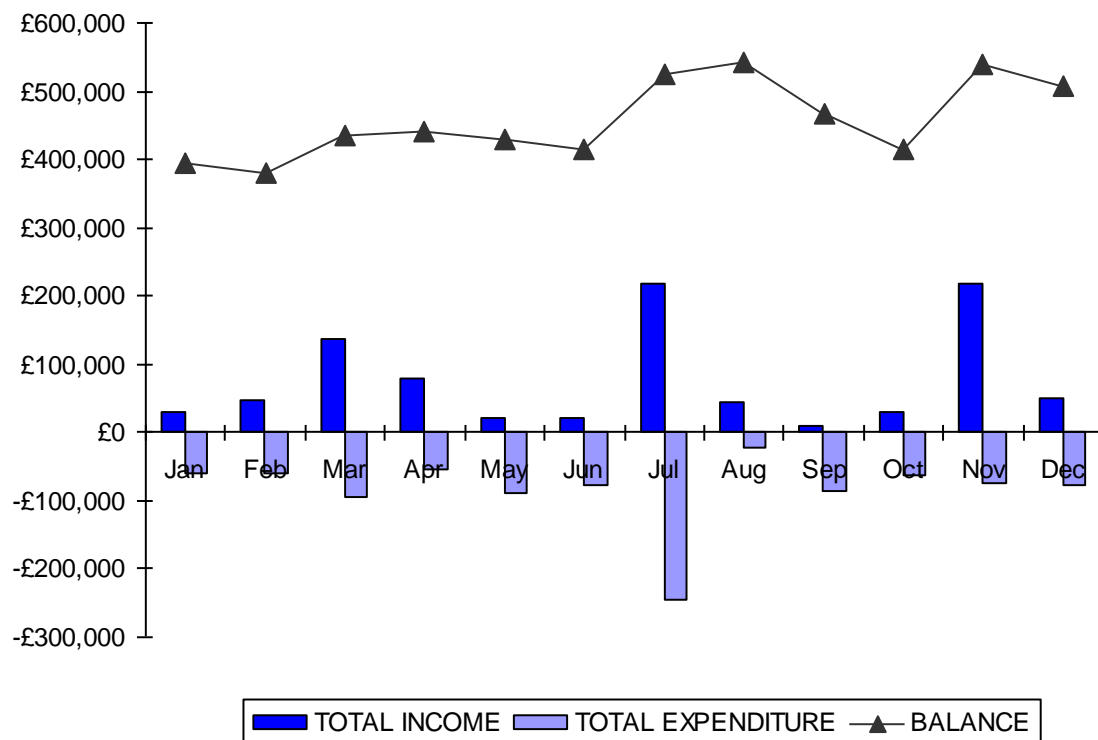


Figure 17. Income/Expenditure cash flow and cash balance

PUBLIC LIAISONS

CONTACTS with the MEDIA

During 2011 the members of the ISC staff provided information and performed live interviews for a number of media channels worldwide, usually as a follow-up of the major disastrous earthquakes and tsunamis:

- *ITN, London, UK*, a British broadcaster providing world news, sports news, UK news, business news and lifestyle news.
- *RT, Moscow, Russia*, 24/7 English-language channel covering global news.
- *eNews, Cape Town, South Africa*, provides breaking news on national and worldwide issues
- *ARD, Germany*, a joint organization of Germany's regional public-service broadcasters.
- *IRIN, Bangkok, Thailand*, provides humanitarian news and analysis service from the UN Office for the Coordination of Humanitarian Affairs.

PUBLIC LECTURES GIVEN by the ISC STAFF

The ISC staff use every opportunity to publicise its cause and develop public knowledge on earthquakes in the local community:

- In January, the ISC's GEM Seismologist, Domenico Di Giacomo, gave a lecture to the students of the Physics Society in Oxford University on the topic "Earthquake magnitude: meaning and problems".
- In July, an ISC Senior Seismologist, Wayne Richardson gave a talk on the ISC mission and earthquakes in general to a group of visitors from the Newbury & District U.N. Association Branch.

SCIENTIFIC LIAISONS

VISITORS to the ISC

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

- Spiro Spiliopoulos – CTBTO, Vienna, Austria
- Alsion Bird – Pacific Geoscience Centre (PGC), Sidney, Canada
- Liu Yuchen - China Earthquake Administration (CEA), Beijing, China
- Li Ming - China Earthquake Administration (CEA), Beijing, China
- Zhou Gang - the North West Institute of Nuclear Technology, Sian, China
- Jin Ping - the North West Institute of Nuclear Technology, Sian, China
- Zheng Xuefeng - the North West Institute of Nuclear Technology, Sian, China
- Danijel Shorlemmer - GFZ, Potsdam, Germany

- Thomas Beutin - GFZ, Potsdam, Germany
- Peter Bormann – GFZ, Potsdam, Germany
- Tomas Blake – Dublin Institute for Advanced Studies (DIAS), Ireland
- Masaki Kanao - the National Institute of Polar Research (NIPR), Japan
- Antonio Villasenor – Jaume Almera Institute of Earth Sciences, Barcelona, Spain
- Carol Tubby – Earthquake Enthusiast, Wales

CONFERENCES, MEETINGS, WORKSHOPS

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

- SSA Meeting, Memphis, U.S.
- EGU meeting, Vienna, Austria
- GEM Outreach, Beijing, China
- CTBTO Science and Technology Conference, Vienna, Austria
- IUGG Assembly, Melbourne, Australia
- CTBTO WGB37, Vienna, Austria
- NEIC-ISC-EMSC Coordination Meeting, Bruyères le Châtel, France
- Conference on Seismic Monitoring of Moscow Region, Moscow, Russia
- International Seismology School, GS RAS, Apatity, Russia
- Monitoring Research Review, Tucson, U.S.
- Seminar on East Asia Earthquake Studies, Beijing, China
- GEM Progress Review Meeting, Potsdam, Germany
- GEM Progress Review Meeting, Menlo Park, U.S.
- 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:

- Geoscience Australia, Canberra, Australia
- International Data Centre, CTBTO, Vienna, Austria
- China Earthquake Networks Center, CEA, Beijing, China
- Institute of Geophysics, Beijing, China
- National Data Centre for CTBTO, Beijing, China
- EMSC, Bruyères le Châtel, France
- LDG, Bruyères le Châtel, France
- EUCENTRE, Pavia, Italy
- Kola Seismic Regional Centre, GS RAS, Apatity, Russia
- SECED, London, United Kingdom
- Royal Society, London, United Kingdom

ISC STAFF TRAINING

Two more members of the ISC staff have obtained Doctorate degrees at the beginning of 2011 that brought the total to five in the entire ISC staff. Domenico Di Giacomo received his PhD from GFZ in Potsdam, Germany in February and Ben D.E. Dando obtained his from Leeds University in UK in January. These achievements strengthen the ISC team and contribute to the scientific quality of the ISC development.

In August, the ISC Seismologist/Developer, Ben Dando, attended the EarthScope USArray data processing and analysis short course that took place at the Northwestern University in Evanston, Illinois. Topics covered included the latest methods for data access at IRIS DMC, using databases to manage seismological data, and tutorials for various programming resources available in seismology. An introduction was also given to parallel processing, the development of GUI applications and different methodologies for visualisation.

The course was an excellent opportunity to learn about current methods and development practice, which benefitted the development of new waveform related procedures at the ISC. The ISC is grateful to EarthScope Program for partial support of this training.

WORK EXPERIENCE at the ISC

Mr Nick Gallo, a student from the local secondary school, the Kennet School in Thatcham, helped the ISC with the update of the bibliographical references to scientific articles on specific earthquakes available as part of the ISC Bulletin. Nick is interested in Earth Sciences and this work experience has helped him to reaffirm his wish to continue his education in the field of Geoscience.

ISC PRIZE for OXFORD UNIVERSITY STUDENTS

A few years ago the ISC established a small annual Prize in Mathematics and Geophysics (£200 and the annual ISC DVD-ROM) 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. 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

The ISC seismologist, Domenico Di Giacomo, and his co-authors Dino Bindi, Stephano Parolai and Adrien Oth have been awarded the Geophysical Journal International (GJI) prize for the best student paper in 2011. Designed to recognise and acknowledge the 'best papers' submitted to GJI from young scientists in the field, manuscripts are short-listed by the Journal's high profile Editorial Board and highlighted on the GJI homepage.

Di Giacomo, D., D. Bindi, S. Parolai and A. Oth (2011). Residual analysis of teleseismic P-wave energy magnitude estimates: inter- and intra-station variability. *Geophys. J. Int.*, 185(3), 1444-1454, [doi: 10.1111/j.1365-246X.2011.05019.x](https://doi.org/10.1111/j.1365-246X.2011.05019.x).

Other papers published by the ISC staff include:

Bondár, I. and D.A. Storchak (2011). Improved location procedures at the International Seismological Centre, *Geophys. J. Int.*, 186, 1220-1244, [doi:10.1111/j.1365-246X.2011.05107.x](https://doi.org/10.1111/j.1365-246X.2011.05107.x)

Dando B.D.E., G.W. Stuart, G.A. Houseman, E. Hegedus, E. Bruckl, S. Radovanovic, (2011). Teleseismic tomography of the mantle in the Carpathian-Pannonian region of central Europe, *Geophys. J. Int.*, 186 (1), 11-31, [doi: 10.1111/j.1365-246X.2011.04998.x](https://doi.org/10.1111/j.1365-246X.2011.04998.x)

Di Giacomo, D., and P. Bormann (2011). Earthquake energy, in *Encyclopaedia of Solid Earth Geophysics*, ed. H. Gupta, pp.233-236, doi: 10.1007/978-90-481-8702-7, Springer Science+Business Media B.V. 2011.

Engdahl, E.R. and I. **Bondár (2011).** Seismological networks, in *Encyclopedia of Solid Earth Geophysics*, 1324-1334, Ed. H.K. Gupta, Springer, [ISBN: 978-90-481-8701-0](https://doi.org/10.1007/978-90-481-8701-0)

Storchak D.A., J. Schweitzer and P. Bormann (2011). Seismic phase names: IASPEI Standard, in *Encyclopedia of Solid Earth Geophysics*, 1162-1173, Ed. H.K. Gupta, Springer, [ISBN: 978-90-481-8701-0](https://doi.org/10.1007/978-90-481-8701-0)

PAPERS PUBLISHED in 2011 that USED 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 2011. 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 2011. No doubt many more references can found by using different search phrases.

[Geo-environmental hazards assessment of the north western Gulf of Suez, Egypt](#) MO Arnous, HA Aboulela... - Journal of Coastal Conservation, 2011 – 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 ...

[The New Zealand National Seismograph Network](#) T Petersen, K Gledhill, M Chadwick... - Seismological ..., 2011-rl.geoscienceworld.org.. The earthquake information is also

provided to the National Earthquake Information Center (NEIC), part of the United States Geological Survey responsible for locating major earthquakes worldwide, and the **International Seismological Centre (ISC)**, a non-governmental ...

[Seismicity and active tectonic processes in the ultra-slow spreading Lena Trough, Arctic Ocean](#) C Läderach, V Schlindwein... - ... Journal International, 2011 - Wiley Online Library... et al. (2007) with a geological interpretation of teleseismic earthquakes archived in the catalogue of the **International Seismological Centre (ISC)**, **International Seismological Centre** 2001) which we relocated thoroughly. ISC

[A seismotectonic study of the Southeastern Alaska Region](#)

DI Doser... - Tectonophysics, 2011 - Elsevier... phase data listed in either the bulletins of the **International Seismological Summary**(1919–1963) or the **International Seismological Centre** (1964–1972 ... Alaska Earthquake Information Center (AEIC) (1/10/1973-12/29/2005) and the Canadian National Data Centre for Earthquake ...

[A strong-motion database from the Peru–Chile subduction zone](#)

MC Arango, FO Strasser, JJ Bommer... - ... of seismology, 2011 - Springer... sequence and from the 1966, 1970, 1971 and 1974 Peruvian events available at the COSMOS Virtual Data Centre ...published in the Centennial catalogue (Engdahl and Villaseñor 2002) and locations and depths determined by the **International Seismological Centre** (ISC ...

[Overview of the Italian strong motion database ITACA 1.0](#)

Pacor, R Paolucci, L Luzi, F Sabetta... - Bulletin of Earthquake ..., 2011 – Springer ... EMMA **International seismological centre** bulletin ISC Up to now <http://www.isc.ac.uk> ISC National earthquake information centre. Earthquake catalogue NEIC Up to now <http://earthquake.usgs.gov/v/regional/neic> NEIC Global centroid-moment-tensor (CMT) LDEO ...

[Earthquake deformation in the northwestern Sierras Pampeanas of Argentina based on seismic waveform modelling](#)

P Alvarado... - Journal of Geodynamics, 2011 – Elsevier ... We believe that the smaller differences observed for the events that occurred before 1989 are due to the fact that their focal depths are based on depth phase determinations calculated by the **International Seismological Centre**-ISC which, were then used by the regional ...

[Teleseismic tomography of the mantle in the Carpathian–Pannonian region of central Europe](#)

BDE Dando, GW Stuart, GA Houseman... - ... International, 2011 - Wiley Online Library ... The Bulletin of the **International Seismological Centre** was searched for earthquakes with $M_w > 5.5$ in the distance range from 30° to 100° from the centre of the CBP network for the 16 months after 2006 May. After bandpassing ...

[Probabilistic Seismic Hazard Assessment at the Eastern Caribbean Islands](#)

F Bozzoni, M Corigliano, CG Lai... - ... of the Seismological ..., 2011 - bssaonline.org ... Seismic Research Centre—The University ... Data have been retrieved from the most accredited databases: the **International Seismological Centre** (ISC), National Earthquake Information Center (NEIC), Advanced National Seismic System (ANSS), and National Geophysical Data ...

[The Mw 7.5 2009 Coco earthquake, north Andaman region](#)

P Mahesh, A Bansal, B Kundu, JK Catherine... - Journal of the ..., 2011 – Springer ... is known about it, other than its location, aftershocks and focal mechanism from the National Earthquake Information Centre (NEIC) of ... checked this depth estimate by analysing the depth phase waveform data from worldwide stations (**International Seismological Centre**, 2009). ...

[Recent evaluation of the assessment seismic hazards for Nuweiba, Gulf of Aqaba](#)

AZ Hamouda - Arabian Journal of Geosciences, 2011 – Springer ... Earthquake data has been

collected from the **International Seismological Centre** catalogue (ISC 2006), National Earthquake Information Service (NEIS), from the National Oceanic and Atmospheric Administration (NOAA) catalogue (NOAA 2006), and National Egyptian

[Imaging Poisson's Ratio of the Uppermost Mantle beneath China](#)

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[The Vale de Santarém Neogene trough in the seismotectonics framework of the Lower Tagus Valley \(Portugal\)](#)

D D'Amato, B Pace, J Cabral... - Trabajos de geología, 2011 - ... mental seismicity in the Lower Tagus Valley Region and adjacent areas for the period 1915 to 2004, from the **International Seismological Centre**, on-line Bulletin, <http://www.isc.ac.uk/bull>, **International Seismological Center**, Thatcham, United Kingdom, 2001. ...

[Probabilistic seismic hazard assessment for Thailand](#)

Ornthammarath, P Warnitchai... - Bulletin of Earthquake ..., 2011 – Springer ... CG Lai European Centre for Training and Research in Earthquake Engineering (EUCENTRE), Pavia, Italy 123 Page 2. 368 ... Remarks: TMD Thai Meteorological Department PDE National Earthquake Information Center, USGS) **ISC International Seismological Centre** ...

[The moment magnitude \$M_w\$ and the energy magnitude \$M_e\$: common roots and differences](#)

P Bormann... - Journal of Seismology, 2011 – Springer ... P. Bormann · D. Di Giacomo Division 2: Physics of the Earth, GFZ German Research Centre for Geosciences, Telegrafenberg, 14473 Potsdam, Germany Present Address: D. Di Giacomo (B) **International Seismological Centre**, Pipers Lane, RG19 4NS Thatcham, UK

[Global compilation of interferometric synthetic aperture radar earthquake source models: 1. Comparisons with seismic catalogs](#)

J Weston, AMG Ferreira... - J. geophys. Res., 2011 - ... archive. We compare source parameters from over 70 InSAR studies of 57 global earthquakes with those in the Global CMT (GCMT), **International Seismological Centre** (ISC) and Engdahl, Hilst, Buland (EHB) seismic catalogs. We ...

[Two seismic gaps on the Sagaing Fault, Myanmar, derived from relocation of historical earthquakes since 1918](#)

N Hurukawa... - Geophysical Research Letters, 2011 - agu.org ...Figure 2. Epicentral distribution of 18 earthquakes analyzed in this study. (a) Epicenter locations according to ISS (**International Seismological Summary**) and ISC (**International Seismological Centre**) data. ... dMb (**International Seismological Centre**). eMW (Dziwonski et al. ...

[Journal of Tsunami Society International](#)

B Theilen-Willige... - Science of Tsunami Hazards, 2011 - tsunamisociety.org ... in a GIS data base as • from geologic maps derived Quaternary sediment distributions and faults, •from LANDSAT ETM

imageries derived lineaments, • from International Earthquake Centres downloaded earthquake data (**International Seismological Centre**, ISC, USGS, GFZ ...

[Studies on Seismotectonics and Geodynamical Processes between Antarctica and India](#) SVR Rao, LP Kishore, T Chaitanya, A Akilan... - 2011 - dspace.ncaor.org ... The seismic data was processed and analysed at NGRI using SEISAN software, up to September 2002 and reported to **International Seismological Centre**, United Kingdom. ... to **International Seismological Centre**, UK is being continued in this expedition. ...

[SEISMOLOGICAL OBSERVATIONS AND GEODYNAMIC ZONING PREDICTIONS](#) OE Starovoi... - eolss.net . Thus National Earthquake Information Center of the USA currently locates more than 15000 earthquakes yearly. Especially valuable is the service provided by the **International Seismological Centre** (ISC) at Great Britain. Each ...

[Seismicity and Seismotectonic in the Strait of Hormuz](#) M Rastgoo, SM Azhari... - conference.khuif.ac.ir In this article for study of seismicity and seismotectonic in the Strait of Hormuz region is used modern instrumental earthquake data from **International Seismological Centre** (ISC) catalog, Harvard Centroid Moment Tensor (CMT) catalog and historical earthquakes catalog ...

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[Studies on Seismotectonics and Geodynamical Processes between India and Antarctica](#) GS Srinivas, S Rao, GB Navinchander, A Akilan...2011 - dspace.ncaor.org .. Region. Participating in the global earthquake epicentral determination while contributing data to **International Seismological Centre** (ISC), UK, Antarctic Seismic Web Resource (AnSWer) is being continued in this expedition. The ...

[Sources of error and the statistical formulation of ms| mb seismic event screening analysis for the comprehensive ...](#) DN Anderson, HJ Patton, SR Taylor, JL Bonner... - na22.nnsa.doe.gov ... of fail to reject the null hypothesis of Explosion Characteristics (denoted H0 or H0: Explosion Characteristics) is made with a network of 27 global **International Seismological Centre** (ISC) seismic ... Seismic Event Screening for the International Data Centre Seismic energy

[Investigation of the crustal structure in the middle east from body-wave analysis](#) R Gritto, MS Sibol, P Caron, HA Ghalib, BS Ali... - na22.nnsa.doe.gov ... These data will be supplemented by waveforms from the Eastern Turkey Seismic Experiment (ETSE) as well as by bulletin data from Kandilli Observatory and Earthquake Research Institute (KOERI) and **International Seismological Centre** (ISC) stations throughout the Middle ...

[Relation between rock failure microwave signals detected by AMSR-E and a distribution of ruptures generated by seismic activity](#) T Maeda... (IGARSS), 2011 IEEE International, 2011 - ieeexplore.ieee.org ... Page 2. represents released seismic energy calculated by a earthquake catalog of **International Seismological Centre** (ISC). Figure 2 (b) is the enlarged view of Fig. 2 (a) around the day of the earthquake. We can see a good correlation between blue and red lines in Fig. ...

[P n tomographic velocity and anisotropy beneath the Tibetan Plateau and the adjacent regions](#) Y Lü, S Ni, B Liu... - Earth Planets Space, 2011 - svr4.terrapub.co.jp .. Tibetan Plateau and the adjacent regions. The investigation analyzed 105,385 Pn phase readings from the **International Seismological Centre** (ISC) and the China Earthquake Data Center. The average Pn velocity ...

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[A rare great earthquake on an oceanic fossil fracture zone](#) DP Robinson - Geophysical Journal International, 2011 - Wiley Online Library ... spreading centre. The Tasman Sea earthquake under investigation here falls into this category. ... 2 RELOCATION OF EARTHQUAKES Earthquake phase data reported by the **International Seismological Centre** (ISC) was used to relocate all seismicity in the epicentral ...

[William Joseph Cochran](#) R TECToNiCS - McNair Journal, 2011 - mcnaire.missouri.edu ... Seismic data obtained from the **International Seismological Centre** (ISC) from 1980-2010. Inset: Characteristic earthquake model by Schwartz and Coppersmith (1984) indicates that Characteristic earthquake occurs away from Gutenberg-Richter line. ... This episode is suggested to correspond with the oceanic spreading center of the Red Sea (Hempton, 1987). ... Using an earthquake catalog from the **International Seismological Center** (ISC) for the past 30 years, we constructed a histogram relating the magnitude of each event ...

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data from the **International Seismological Centre (ISC)** bulletin in addition to data from local seismological ...

Riedel shear structures in the co-seismic surface rupture zone produced by the 2001 Mw 7.8 Kunlun earthquake, northern Tibetan Plateau A Lin... - Journal of Structural Geology, 2011 – Elsevier ... 6.0) earthquakes have occurred on the Kunlun Fault over the last century, with three $M \geq 7.5$ events producing distinct surface rupture deformation structures, indicating that the fault is currently active as a seismogenic fault (eg, [International Seismological Centre, 2001], [Lin et ...

Global evaluation of large earthquake energy from 1997 through mid-2010 JA Convers... - Journal of Geophysical Research, 2011 - ... the moment release occurs. The hypocentral solutions come from the **EHB** catalog when available [International Seismological Centre, 2009], otherwise defaulting to depths reported by the NEIC Bulletin. [33] For events along ...

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Understanding Extension within a Convergent Orogen: Lithospheric Structure of the Pannonian Basin GA Houseman, GW Stuart - gef.nerc.ac.uk ... Hypocentral information is from the Bulletin of the **International Seismological Centre**. a) allseismicity - 745 events; b) events used for the P-wave tomography - 225 events; c) events used for the S-wave tomography - 124 events. The stations are located in the centre of each plot ...

The São Vicente earthquake of 2008 April and seismicity in the continental shelf off SE Brazil: further evidence for flexural stresses M Assumpção, JC Dourado... - ... International, 2011 - Wiley Online Library ... The epicentral determinations of the US Geological Survey (USGS) and the **International Seismological Centre (ISC)** have uncertainties of approximately ± 5 km. ... Sources: **ISC (International Seismological Centre, UK)**; **NEIC (National Earthquake Information Center, US Geol. ...**

New Regional Moment Tensors in South Africa MBC Brandt... - Seismological Research Letters, 2011 - ... related tremors (Saunders et al. 2008). However, we approached the **International Seismological Centre (ISC)** to relocate earthquakes A and C with both local and global phases to verify this assumption. The **ISC** fixed the depth ...

Reliable Lg Arrival-Time Picks and Potential for Enhanced Epicenter Location T Matveeva... - Bulletin of the Seismological Society of ..., 2011 - bssaonline.org ... A test of the **International Seismological Centre (ISC)** solution in terms of histogram displays of ...elaborate station time corrections as a mean for calibrating global Lg time ... Uppsala, Sweden),

NORSAR (Kjeller, Norway), and the **Kola Regional Seismological Centre (Apatity, Russia ...**

The 2008 Yutian Normal Faulting Earthquake (Mw7. 1), NW Tibet: Non-planar Fault Modeling and Implications for the Karakax Fault M Furuya... - Tectonophysics, 2011 – Elsevier ... In Fig. 1, we plot the aftershocks reported from the **International Seismological Centre** during the 8-day period from March 20 to March 27 including the main shock (**International Seismological Centre, 2001**). Overall, they are distributed from NNE to SSW. ...

Time-predictable model applicability for earthquake occurrence in northeast India and vicinity A Panthi, D Shanker... - ... Earth Syst. Sci, 2011 - nat-hazards-earth-syst-sci.net ... reported by earthquake catalogues National Geophysical Data Centre, National Earthquake Information Centre, United States ... Colorado, National Earthquake Information Center (NEIC), USGS (United States Geological survey), and **ISC (International Seismological Centre)**.

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Residual analysis of teleseismic P-wave energy magnitude estimates: inter- and intrastation variability DD Giacomo, D Bindi, S Parolai... - ... Journal International, 2011 – Wiley Online Library ... Domenico Di Giacomo,1,2* Dino Bindi,1,3 Stefano Parolai1 and Adrien Oth4 1Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences, Telegrafenberg, D-14473 Potsdam,Germany. ... Now at: The **International Seismological Centre**, Pipers Lane, Thatcham ...

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Earthquake occurrence processes in the Indo-Burmese wedge and Sagaing fault region B Kundu... - Tectonophysics, 2011 – Elsevier ... The valley is located at the centre of the Indo-Burmese arc. ... 2.2. Current seismicity We used the updated catalogue of relocated earthquakes (**EHB** catalogue of Engdahl et al., 1998 from **International Seismological Centre, 2009**) since 1964. ...

[Evaluation of spatial variation of peak horizontal acceleration and spectral acceleration for south India: a probabilistic approach](#) TG Sitharam... - Natural hazards, 2011 – Springer ... small grids of size $0.1^\circ \times 0.1^\circ$, and the hazard parameters were calculated at the centre of each ... Earthquake data were collected from different sources like Indian Meteorological Department (IMD), **International Seismological Centre** (ISC), Kalpakkam Atomic Reactor (Kalpakkam ...

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[The North Anatolian Fault Zone: an Evaluation of Earthquake Hazard Parameters](#) Y Bayrak, H Çınar... - intechopen.com ... 1.2 Data, source zonation and completeness analysis The database and the seismicity data in this work were compiled from different sources and catalogues such as TURKNET, **International Seismological Centre** (ISC), Incorporated Research Institutions for Seismology (IRIS ...

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[Shield-Like Lithosphere of the Lower Indus Basin Evaluated from Observations of Surface-Wave Dispersion](#) S Prajapati, M Chauhan, AK Gupta... - ... of the Seismological ..., 2011... MATLAB. Earthquakes are located using the SEISAN software. Regional phase data were obtained from the website of the **International Seismological Centre** <http://www.isc.ac.uk/search/index.html>, last accessed May 2010).

[Integrated remote sensing and GIS techniques for landslide hazard zonation: a case study Wadi Watier area, South Sinai,](#)

[Egypt](#) MO Amous - Journal of Coastal Conservation, 2011 – Springer ... as revealed from the National Earthquake Information Centre, the **International Seismological Centre** and the Egyptian National Seismic Network. Epicenters distribution of recorded recently earthquakes with magnitudes digital map was generated using GIS environment

[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, 2011 – Springer ... Indian National Centre for Ocean Information Services (INCOIS), Ministry of Earth Science, Government of India ... The latter are the **International Seismological Centre** in the United Kingdom (ISC, since 1964; <http://www.isc.ac.uk/search/bulletin> ...

[Geophysical and geological imprints of southern Neotethyan subduction between Cyprus and the Isparta Angle, SW Turkey](#) ÜY Kalyoncuoğlu, Ö Elitok, MN Dolmaz... - Journal of ..., 2011 – 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 $M_b \geq 3.5$ and $M_s \geq 3$, from the **International Seismological Centre** (ISC) catalogue. ...

[Anisotropic Pn tomography of Turkey and adjacent regions](#) AK Mutlu... - Geophysical Journal International, 2011 - Wiley Online Library ... Fewer earthquakes were included from Caucasus and Iran. The initial catalogue for Pn tomography was compiled from the bulletins of KOERI, **International Seismological Centre** (ISC) and European-Mediterranean Seismological Centre. ...

[On finding and using repeating seismic events in and near China](#) DP Schaff... - Journal of Geophysical Research, 2011 ... of mislocations for three catalogs, namely, the ABCE, the **International Seismological Centre** (ISC), and ... that it was published by a prototype International Data Centre (IDC) from ... The Annual Bulletin of Chinese Earthquakes (ABCE); the **International Seismological Center** (ISC ...

[An Evaluation of Earthquake Hazard Potential for Different Regions in Western Anatolia Using the Historical and Instrumental Earthquake Data](#) Y Bayrak... - Pure and Applied Geophysics, 2011 – Springer .. The database used in this work was compiled from different sources and catalogs such as TURKNET, the **International Seismological Centre** (ISC), Incorporated Research Institutions for Seismology (IRIS) and The Scientific and Technological Research Council of Turkey ...

[Seismicity and Geologic Structures Indubitable in Wadi Hagul, North Eastern Desert, Egypt](#) TA Seleem... - International Journal, 2011 - scirp.org ... Page 5. TA SELEEM ET AL. Copyright © 2011 SciRes. IJG 59 Figure 5. SRTM image of Wadi Hagul and its environs enhanced by aspect technique. revealed from the National Earthquake Information Centre (NEIS), and the **International Seismological Centre** (ISC). ...

[Strong ground-motion prediction and uncertainties estimation for Delhi, India](#) GC Joshi... - Natural hazards, 2011 – Springer ... 24° – 31.5° N and Longitude 74° – 81.5° E) with Delhi

as its centre. The tectonic features in the region are plotted in Fig. 2 along with the seismicity data. The data have been compiled from India Metrology Department (IMD, Indian agency), **International Seismological Centre** (ISC ...

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[Spectral analysis of K-NET and KiK-net data in Japan, Part II: On attenuation characteristics, source spectra, and site response of borehole and surface stations](#) A Oth, D Bindi, S Parolai... - ... of the Seismological ..., 2011 - Seismol Soc America ... Now at **International Seismological Centre**, Pipers Lane, Thatcham, RG19 4NS, United Kingdom. Next Section. Abstract. In this study we apply a nonparametric spectral inversion scheme to a data set of accelerograms recorded ...

[Multifractal analysis of the spatial distribution of earthquake epicenters in the Zagros and Alborz-Kopeh Dagh regions of Iran](#) A Zamani... - IJST, 2011 - shirazu.ac.ir ... The belt is characterized by a high proportion of large magnitude shallow earthquakes.

[54], [36.] The global earthquake catalogues used in this research were compiled from the bulletins of the **International Seismological Centre** [55] and the US. ...

[GIS and remote sensing as tools for conducting geo-hazards risk assessment along Gulf of Aqaba coastal zone, Egypt](#) MO Arnous... - Journal of Coastal Conservation, 2011 – Springer ... Tabular and ancillary data including seismicity distribution over the study area during the period 1904–2005 have been obtained from the National Earthquake Information Centre (NEIS), the **International Seismological Centre** (ISC), and the Egyptian National Seismic Network ...

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[The first peak ground motion attenuation relationships for North of Vietnam](#) LM Nguyen, TL Lin, YM Wu, BS Huang... - Journal of Asian Earth ..., 2011 – Elsevier ... and complicated geological structure at 41 many zones such as the Lai Chau-Dien Bien (LC-DB) fault zone, Red River fault zone, etc (Figure 1). During 42 the last century, 2 earthquakes (Figure 1) of Ms 6.7, 1935 and Ms 6.8, 1983 (**International Seismological Centre** 43 (ISC ...

[Insights into the 1968–1997 Dasht-e-Bayaz and Zirkuh earthquake sequences, eastern Iran, from calibrated relocations, InSAR and high-resolution satellite imagery](#) RT

Walker, EA Bergman, W Szeliga... - ... Journal International, 2011 - Wiley Online Library ... irsc.ut.ac.ir/); (2) The Iran Strong Motion Network (ISMN), operated by the Building and Housing Research Centre (BHRC). ... determined with the methods described in Section 3. For most events of magnitude less than about 5.0, the **International Seismological Centre** (ISC) body ... Unlike the well-known global **EHB** catalogue ... 2008. The magnitude at which the catalogue is complete varies greatly through time, as a function of the increasing density of seismic stations around the world and even more so in Iran itself. ...

[Upper-mantle structures beneath USArray derived from waveform complexity](#) D Sun... - Geophysical Journal International, 2011 - Wiley Online Library ... BK model (Burdick et al. 2008) has the most data since it includes the **International Seismological Centre** (ISC) travel time picks. SCH model (Schmandt et al. 2009; Schmandt & Humphreys 2010a,b) includes the data used by Gao et al. ...

[Assessment of seismic hazards for Hurghada, Red Sea, Egypt](#) AZ Hamouda - Natural hazards, 2011 – Springer ... Earthquake data have been collected from the published **International Seismological Centre** catalog (ISC 2005 ... **Intern Seism Centre**, Newbury Kebeasy RM (1990) Seismicity in geology of ... A, Graham G (1998) Parametric-historic procedure for probabilistic seismic hazard analysis ...

[3D Mechanical Modeling of the GPS Velocity Field Along the Main Recent Fault and Kazerun Fault \(Zagros, Iran\)](#) HR Nankali, F Sobouti, B Voosoghi... - Journal of Seismology ..., 2011 - iiees.ac.ir ... Early studies of the Zagros using the earthquakes deeper than 50km is reported by the **International Seismological Centre** (ISC) and US Geological Survey (USGS) catalogues to postulate subduction of the continental Arabian shield beneath the Zagros [9,

[Eastern Section Meeting Report](#) JE Ebel - **Seismological Research Letters**, 2011 - 171.66.125.217 ... All aftershock locations and phase picks are forwarded to the **International Seismological Centre**. Magnitude recurrence curves show that the aftershock catalog is complete to magnitude 2.6. The majority of the aftershocks are located just north of the peninsula. ...

[A Probabilistic Assessment of Earthquake Hazard Parameters in NW Himalaya and the Adjoining Regions](#) RBS Yadav, Y Bayrak, JN Tripathi, S Chopra... - Pure and Applied ..., 2011 – Springer ... 1 Indian National Centre for Ocean Information Services (INCOIS), Ocean Valley, PB No....The latter are the **International Seismological Centre** in the United Kingdom (ISC,since1964;http://www.isc.ac.uk/ search/bulletin), the NEIC (since 1963; http://neic.

[Aseismic zone and earthquake segmentation associated with a deep subducted seamount in Sumatra](#) SC Singh, N Hananto, M Mukti, DP Robinson... - Nature ..., 2011 - nature.com ... 29), and P-wave arrival times reported by the **International Seismological Centre** (ISC) to relocate all seismicity between 1 January 1964 and 31 January 2008 in the area relative to the 12 September 2007, M w 8.4 earthquake. ...

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[Complex structure of the lithospheric slab beneath the Banda arc, eastern Indonesia depicted by a seismic tomographic model](#) S Widiyantoro, JD Pesicek... - Research in ..., 2011 - orthopedicreviews.pagepress.org ... Figure 5. Distribution of EHB earthquakes (1964–2007) plotted as maps at the depth intervals used for the vertical parameterization in the tomographic imaging. Notice the intense seismic activities in the depth interval of 0–70 km below the Seram trough and 70–220 km below ...

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[Seismic rays and traveltimes tomography of strongly heterogeneous mantle structure: application to the Central Mediterranean](#) P Serretti... - *Geophysical Journal International*, 2011 - Wiley Online Library ... Page 5. Traveltimes tomography of mantle structure 5 Figure 4. Wavefront and seismic rays through the two grids. ... Event (green dots) and station (red stars) locations reported by the **EHB** bulletin for the period 1984–2004.

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[Upper Mantle Seismic Structure Beneath Southern Africa: Constraints on the Buoyancy Supporting the African Superswell](#) MBC Brandt, SP Grand, AA Nyblade... - *Pure and Applied ...*, 2011 – Springer ... Centre, HRV Harvard Centroid Moment Tensor, MOS Moscow, Russian Academy of Sciences, BJI Beijing, China Earthquake Administration, **EHB** Engdahl, van

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conducted in depth bins ... scale structure in the Middle East using the complementary ray geometry provided by regional (subhorizontal) and tele-seismic (subvertical) raypaths ...

[Source model and the macroseismic effect of the 1991 Racha earthquake](#) RE Tatevossian... - **Seismic Instruments**, 2011 – Springer ... Epicentral distances from Table 4 [Papalashvili et al., 1997] were converted to hypocentral ones for a hypocenter depth of 5 km, which corresponds to the depth of the main shock according to the **EHB** bulletin [Engdahl et al., 1998], obtained from ... SEISMIC INSTRUMENTS Vol. ...

[Velocity structure of the Tibetan Lithosphere: Constraints from P-wave travel times of regional earthquakes](#) JD Griffin, RL Nowack, WP Chen... - **Bulletin of the ...**, 2011 - bssaonline.org ... seismic data from regional earthquakes in Tibet recorded by the densely spaced, linear component of the Hi-CLIMB array in Tibet (Fig. 1) to investigate crustal and upper-mantle structure. Based on locations of epicenters reported in the Engdahl–van der Hilst–Buland (**EHB**) ...

[Effects of sedimentary layer on earthquake source modeling from geodetic inversion](#) W Chen, S Ni, S Wei, Z Wang... - **Earthquake Science**, 2011 – Springer ... epicenter determination (Spence, 1980), double-difference earthquake location (Waldhanser and Ellsworth, 2000) as well as the **EHB** method (Engdahl et al ... sources with spatial geodetic data (such as GPS, In- SAR and SPOT), as well as studies of post-seismic

[A strong-motion database from the Central American subduction zone](#) MC Arango, FO Strasser, JJ Bommer... - **Journal of ...**, 2011 - Springer... 1 The seismicity of the Central American region, based on the Engdahl–Hilst–Buland (**EHB**) catalogue for the period 1960–2006 ... Other regions with important seismic activity include the Motagua–Polochic fault system, the North Panama Deformed Belt and the Panama ...

[Slab detachment of subducted Indo-Australian plate beneath Sunda arc, Indonesia](#) B Kundu... - **Journal of Earth System Science**, 2011 – Springer ... Figure 2. Cross sections of **EHB** (Engdahl et al 1998) seismicity in three regions (panels a, b and c) across the trench. Black and grey triangles represent position of the trench and volcanoes, respectively. (b) Distinct seismic gap at depth 300–500 km may be noted beneath Java ...

[Stress changes and aftershock distribution of the 1994 and 2006 Java subduction zone earthquake sequences](#) M El Hariri... - **Journal of Geophysical Research**, 2011 - ... tectonic activity and previous earthquakes affect the seismic patterns and also suggest a strong correlation between DCFS increase and seismic activity ... Insets show all of the seismicity included in the **EHB** catalog (June–November for the 1994 sequence and July–November for ...

[Seismological Aspect of 26 December 2003 Bam Earthquake](#) M Mostafazadeh, AM Farahbod, M Mokhtari... - **Journal of Seismology ...**, 2011 - iies.ac.ir ... The triangles are the seismological stations. The black star is the main shock and the yellowstars are the **EHB** teleseismically relocated main aftershocks (Engdahl, personal communication). The Bam fault is plotted in black and the seismic cracks in yellow. ...

[Rupture at the flank of the subducted Gagua ridge: The 18 December 2001 earthquake \(Mw 6.8\) offshore eastern Taiwan](#) KI Konstantinou, SJ Lee, Y Font... - **Physics of the Earth and ...**, 2011 – Elsevier ... Meteorological Agency (JMA), which both operate seismic networks near the focal area (cf. Figure1). Due to its large magnitude the event was also listed in the PDE catalog and in the updated global relocation database of Engdahl et al. (1998) (hereafter referred to as **EHB**). ...

[Regional centroid moment tensor solutions in Cyprus from 1977 to the present and seismotectonic implications](#) P Imprescia, S Pondrelli, G Vannucci... - **Journal of Seismology**, 2011 – Springer ... to 1997 (ie, the beginning of the RCMT catalog), the remaining selected earth- quakes are 158 (116 from PDE, 6 from **EHB**, 36 from ... This approach turned out 40 events (Online Resource Table 1), reduced to 29 considering that 11 earthquakes have a seismic moment tensor ...

[New constraints on upper-mantle S-velocity structure and crustal thickness of the Iranian plateau using partitioned waveform inversion](#) NS Manaman, H Shomali... - **Geophysical Journal ...**, 2011 - Wiley Online Library ... The depth ranges of the events used in the waveform fittings are between 2.9 and 580.7 km retrieved from **EHB** catalogue (Engdahl et ... The resulting velocity models will be biased towards the seismic structure along the main path directions and caused smearing artefacts along ...

[New views on earthquake faulting in the Zagros fold-and-thrust belt of Iran](#) E Nissen, M Tatar, JA Jackson...**Geophysical Journal ...**, 2011 - Wiley Online Library ... Hormuz salt outcrops (white circles) and the areas of local seismic surveys (dashed rectangles) at (A) Kermanshah, (B) Masjed Soleyman, (C) Borujen, (D) Ghir, (E) Fin, (F) Qeshm, (G) Khurgu and (H) Minab. (c) Black dots are epicentres from the updated **EHB** catalogue of 1960 ...

[Constraints on the long-period moment-dip tradeoff for the Tohoku earthquake](#) VC Tsai, GP Hayes... - **Geophysical Research Letters**, 2011 - gps.caltech.edu ... 4. Reducing the Moment-Dip Ambiguity [14] Given the importance of good constraints on seismic moment and source dip, it is of interest whether there may exist methods to reduce ... Yellow CMTs represent gCMT solutions plotted at their **EHB** [Engdahl et al., 1998] hypocenters. ...

[A strong-motion database from the Peru–Chile subduction zone](#) MC Arango, FO Strasser, JJ Bommer... - **Journal of ...**, 2011 - Springer... This latter event ruptured along a previously identified seismic ... Tectonic setting and distribution of seismicity along the Peru–Chile subduction zone. Seismicity corresponds to that reported in the **EHB** Bulletin (Engdahl et al. ...

[Earthquake distribution patterns in Africa: their relationship to variations in lithospheric and geological structure, and their rheological implications](#)TJ Craig, JA Jackson, K Priestley... - **Geophysical Journal ...**, 2011 - Wiley Online Library ... on the **EHB** and NEIC catalogues, for the same area, projected onto the line through the centre of the swath area. Blue box highlights the region of activity related to the oceanic

spreading centre in the Red Sea. Yellow area highlights the area of increased seismic activity along ...

[Arc segmentation and seismicity in the Solomon Islands arc, SW Pacific](#) MC Chen, C Frohlich, FW Taylor, G Burr... - Tectonophysics, 2011 - Elsevier... et al., 1995] and [von Huene et al., 2000]); (2) amounts of strain accumulation and release ([Ando,1975], [Nishenko and Jacob, 1990] and [Sykes et al., 1981]) and (3) patterns and rates of seismic activity, focal ... These were the so-called **EHB** catalog described by Engdahl...

[The 2001 Mw 7.6 Bhuj earthquake, low fault friction, and the crustal support of plate driving forces in India](#) A Copley, JP Avouac, J Hollingsworth... - J. Geophys. Res, 2011 - gps.caltech.edu ... We weight the seismic and geodetic data such that they have equal importance in the inversions, in the sense that the contribution of the ... When combined with the hypocentral location in the Engdahl, van der Hilst, and Buland (**EHB**) catalog, this plane lies along a planar zone ...

[Earthquake depth distributions in central Asia, and their relations with lithosphere thickness, shortening and extension](#) RA Sloan, JA Jackson... - Geophysical Journal ...,

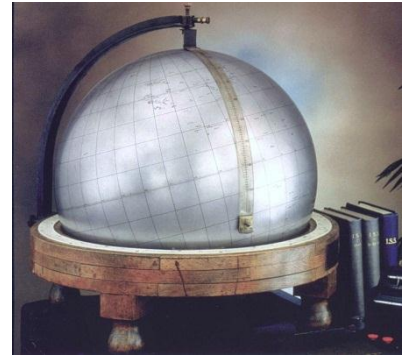
2011 - Wiley Online Library... in related subjects, including: (1) a re-examination of geotherms and thermal structure in both oceans and continents; (2) connections between seismic velocity and ... In both maps earthquakes with depths of less than 100 km from the **EHB** catalogue are shown as red circles. ...

[Crustal structure of the Darjeeling–Sikkim Himalaya and southern Tibet](#) E Acton, K Priestley, S Mitra... - Geophysical Journal ..., 2011 - Wiley Online Library ... The position of the MHT inferred from the coherent negative (blue) arrival is denoted by a green dashed line. Open circles mark the position of events located within 100 km of the profile by the **EHB** catalogue (Engdahl et al. ... Active seismic studies (Behera et al. ...

[40Ar/39Ar dating of Quaternary lavas in northwest Iran: constraints on the landscape evolution and incision rates of the Turkish–Iranian plateau](#) MB Allen, DF Mark, M Kheirkhah... - Geophysical ..., 2011 - Wiley Online Library ... Large dots are epicentres of earthquakes of $M > 6$ from 1900 to 2000 (Jackson 2001), small dots are epicentres from the **EHB** catalogue 1964–1999, $M > \sim 5$... Crustal thickness estimates based on seismic receiver function analysis are 42 ± 2 km across Central Iran (Paul et al. ...

SUMMARY OF ACHIEVEMENTS

- Through the sustained great support from Member-Institutions and additional grants, the ISC's finances stayed healthy, staff numbers increased and essential improvements to data and services have been made.
- Parameters of 278 stations, including those from USArray, have been registered and modified in IR.
- Reviewed preliminary data from 26 agencies are collected within days and weeks after event occurrence, grouped and distributed as part of the automatic preliminary ISC Bulletin.
- For data year 2009, ~54 thousand reviewed and ~280 thousand un-reviewed (small) earthquakes and explosions along with ~10 million seismic arrivals were added to the 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.
- The new ISC seismic event location program was put into operation which improved ISC locations and magnitude determinations and reduced the load on the ISC analysts.
- CTBTO Link to the ISC database was maintained and enhanced for the benefit of the monitoring community as well as the ISC Members and data users.
- 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 historical station bulletins from the ISC collection are being entered into the database in an attempt to re-compute homogeneous locations and magnitudes for the large events of the 110 year long period.
- The ISC database and the website mirror have been set up at IRIS DMC in Seattle in addition to existing database mirror at ERI in Tokyo.
- 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, May 18, 2012

A handwritten signature in black ink, which appears to read 'Dmitry A. Storchak'.

Dr. Dmitry A. Storchak
The Director