

INTERNATIONAL SEISMOLOGICAL CENTRE (ISC)

2012

Annual Director's Report



The year 2012 was another successful year for the ISC and its data users. As many as 17 members of staff worked at the Centre during the year as the ISC was involved in several major projects. Bulletin data for earthquakes and explosions in 2010-2012, as well as earthquake data in 1900-1977 were added to the ISC database. Historical station bulletin data from the ISC warehouse were put to good use as part of the works on the ISC-GEM Catalogue. In cooperation with the INGV, we started scanning the paper-based station bulletin collection at the ISC. 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 the website mirror was operated at the IRIS DMC and ERI. The GT list and the Station Registry have been further updated. The work on the Event Bibliography started. A large number of scientific articles indicate an extensive use of the ISC data by researchers worldwide.

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EXECUTIVE SUMMARY

Despite the general economic slowdown, 2012 has been another busy and successful year for the ISC.

- ❑ With the generous support from 62 Member-Institutions and additional grants from the US NSF, GEM Foundation and CTBTO as well as the sponsorship from Reftek, the ISC finances stayed healthy, as many as 17 staff members worked during the year and essential improvements to the ISC services have been made.
- ❑ Parameters of 949 stations, including those from USArray, have been registered and modified in the International Seismograph Station Registry (IR).
- ❑ The ISC initially collects preliminary bulletin data from 28 networks and data centres worldwide. This information arrives within hours, days and weeks after event occurrence and is grouped and distributed with a few hours delay as part of the automatic preliminary ISC Bulletin.
- ❑ The main collection of revised bulletins from 132 networks stands at 12 months behind real time.
- ❑ The reviewed ISC Bulletin is produced 24-27 months behind real time.
- ❑ For data year 2010, ~61,000 reviewed and ~294,000 un-reviewed (small) events as well as ~10.4 million seismic arrivals were added to the ISC database.
- ❑ The ISC database size has increased by ~22% in just one calendar year and reached 113Gb 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 ISC led an international team in compilation of the ISC-GEM Global Instrumental Earthquake Catalogue (1900-2009). As part of the project, parametric data from historical station bulletins stored in the ISC warehouse have been entered into the database to re-compute homogeneous locations and magnitudes of the large earthquakes during the 110 year period.
- ❑ 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 database and the website mirror were operated at IRIS DMC in Seattle and the ERI in Tokyo. This improved the speed of access to the ISC data users.
- ❑ We continued maintaining the IASPEI Reference (GT) Event List and EHB Bulletin.
- ❑ We started work on the ISC Event Bibliography.
- ❑ The ISC staff participated in a large number of conferences and 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

As many as 17 members of staff worked at the ISC during 2012, thanks to the regular Member's support and a number of additional projects such as the ISC-GEM Catalogue, CTBTO Link and the Bulletin Rebuild (NSF) as well as the sponsorship from Reftek.

Among the staff we have 5 PhD, 7 M.Sc. or equivalent and 2 B.Sc. or equivalent degrees.

Many of the staff take part in professional meetings, travel to international conferences and participate in professional training programmes.

The ISC staff often organise sessions during major scientific conferences. Several ISC staff are members and often take part in running professional organizations such as IASPEI, AGU, SSA and SECED.

During the year we saw the departure of seismologists Ben Dando and Elizabeth Robertson. New employees included Ivana Jukić from Croatia to help with the Bulletin Analysis and Sepideh Rastin from Iran to assist with the download and processing of seismic waveforms under the CTBTO Link project. Rosemary Wylie moved from the Historical Data office to the Analyst Team to further strengthen the ISC Bulletin review.

In addition, three students from the *University of Potsdam*, *University of Leeds* and *University of Birmingham* helped the ISC on a voluntary basis for several weeks.

MANAGEMENT and ADMINISTRATION



Dmitry Storchak, Ph.D.
Director/Seismologist
Russia/UK



Maureen Aspinwall
Administration Officer
UK

DATA and SYSTEMS MANAGEMENT



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John Eve, B.Sc.
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BULLETIN ANALYSIS TEAM



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



Blessing Shumba, M.Sc.
Seismologist / Analyst
Zimbabwe



Rosemary Wylie,
M.Phys.Geog., Analyst
UK

(transferred from the
Historical Data Office in
January)



Elizabeth Robertson, M.Sc.
Seismologist / Analyst
New Zealand (left in August)



Ivana Jukić, M.Sc.
Seismologist / Analyst
Croatia (joined in September)

DEVELOPMENT



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



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



Ben Dando, Ph.D.
Seismologist/Developer, *UK*
(left in February)



Sepideh Rastin, M. Eng.
Developer, *Iran*
(joined in July)

HISTORICAL BULLETINS and EVENT BIBLIOGRAPHY OFFICE



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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/USGS). 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.

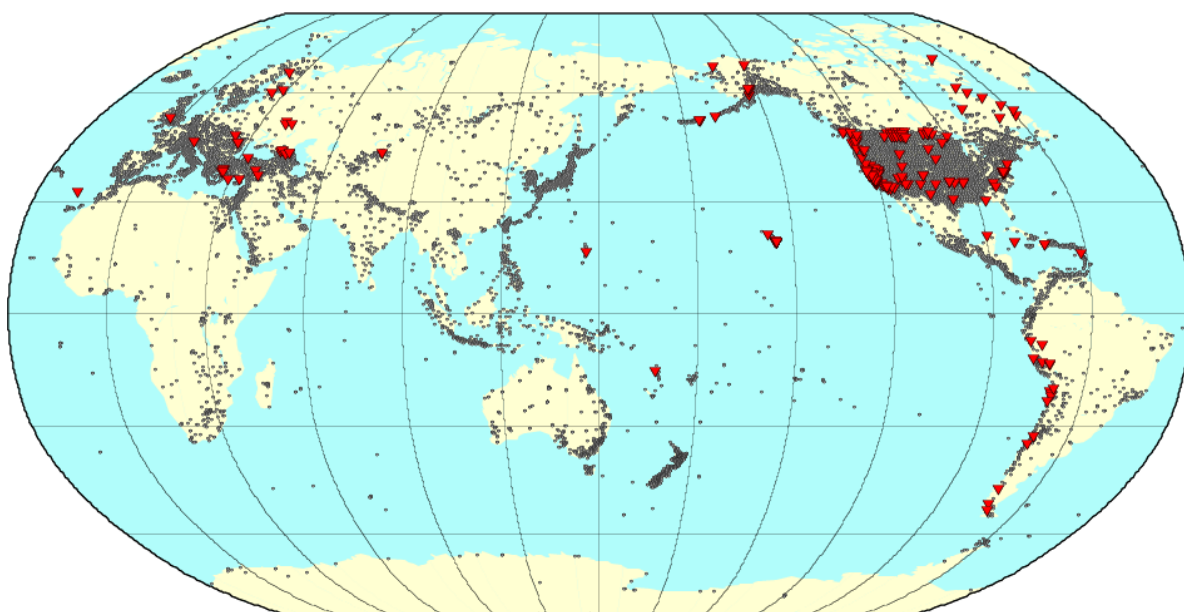


Figure 1. 18,705 stations, open or closed, were fully registered in the IR at the end of 2012 (in grey); parameters of 949 of those (in red) were either registered or modified during 2012. The USArray is a prominent feature of the Registry in North America.

Joint work with the NEIC is currently underway to update the IR with the new Agency.Deployment.Station.Location (ADSL) convention 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 2012 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. As many as 28 agencies reported preliminary data to the ISC during year 2012 (Table 1).

Two new agencies started contributing preliminary earthquake determinations: Institute of Seismology, Academy of Sciences of Kyrgyz Republic and the Helmholtz Centre Potsdam GFZ German Research Centre Geosciences.

Unfortunately, contributions of preliminary solutions from the Council of Geosciences, South Africa were still not resumed, having been previously interrupted for the period of internal review of the data availability policy.

Table 1. Twenty eight agencies (two more compared to 2011) reported preliminary hypocentre determinations and corresponding arrival time data to the ISC in 2012.

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
Egypt	National Research Institute of Astronomy and Geophysics
France	European Mediterranean Seismological Centre
Germany	Helmholtz Centre Potsdam GFZ German Research Centre Geosciences
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
Kyrgyzstan	Institute of Seismology, Academy of Sciences of Kyrgyz Republic
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
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.

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.

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 for use 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 NETWORK BULLETINS

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 2 shows 132 agencies that routinely report final reviewed bulletin data directly to the ISC. In addition, a few tens of 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.

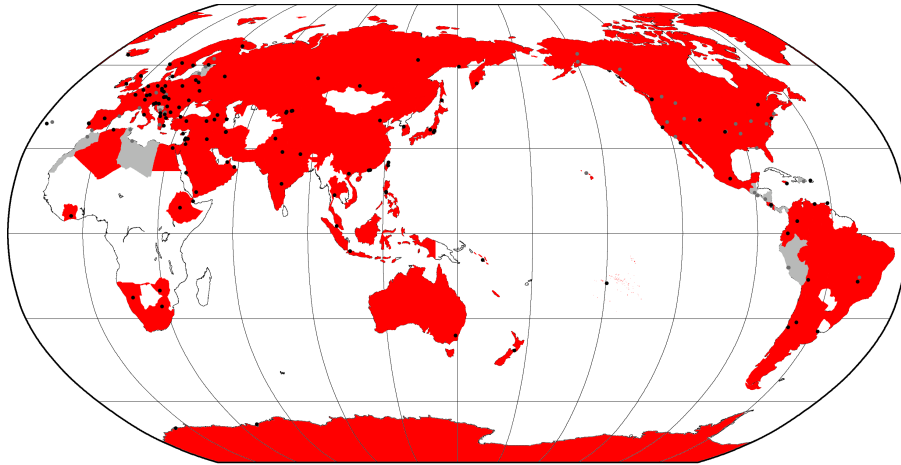


Figure 2. 132 agencies around the world (black dots) report bulletin data directly to the ISC. Dry land territories covered by these reports are in red. Grey areas and grey dots indicate those territories and agencies that are covered indirectly via reports from NEIC, EMSC and CASC. Light colour indicates areas that are not covered by local network operator reports.

During 2012 we did not receive bulletin contributions from the

- Kuwait Institute of Scientific Research (KISR),
- IRD Centre de Nouméa,
- Saudi Geological Survey.

During 2012 we began receiving bulletin data from:

- Instituto Nacional de Prevencion Sismica, *Argentina*
- Observatorio San Calixto, *Bolivia*
- Observatorio Vulcanológico y Sismológico, *Costa Rica*
- Red Sismológica Nacional, *Colombia*
- Observatoire Geophysique d'Arta, *Djibouti*
- Icelandic Meteorological Office, Department of Geophysics, *Iceland*
- Seismological Experimental Methodological Expedition, *Kazakhstan*
- Macao Meteorological and Geophysical Bureau
- Kola Regional Seismological Centre, GS RAS, *Russia*
- Yakutiya Regional Seismological Centre, GS SB RAS, *Russia*
- Ministry of Mines, Energy and Rural Electrification, *Solomon Islands*
- University of Uppsala, *Sweden*
- Earthquake Research Center, Ataturk University, *Turkey*
- Subbotin Institute of Geophysics, National Academy of Sciences, *Ukraine*
- Dubai Seismic Network, *UAE*

During 2012, 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. 3). Whilst being a major

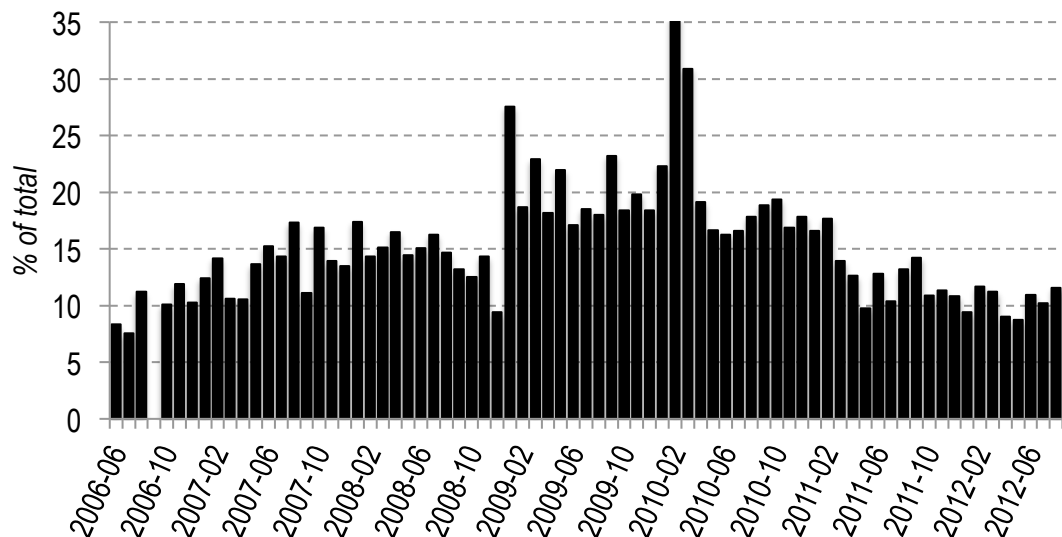


Figure 3. Fraction of arrival time picks reported by USArray network facility as compared to the total number of arrivals associated to ISC Bulletin events of magnitude over 4.5.

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 ~17% 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 four analysts (including two trainees) completed review of 11 months of the ISC Bulletin (Jan-Nov 2010) during the calendar year 2012. The work on the month of December 2010 was in progress at the end of the year.

Ms Emily Delahaye (Canada) continued her service as the Lead Analyst. She was helped by two other Analysts: Mr Blessing Shumba from Zimbabwe and Ms Elizabeth Robertson from New Zealand.

Ms Rose Wylie, a Berkshire resident with the degree in Geography, joined the Analysis team in January following the end of her duties for the ISC-GEM Catalogue project. At the beginning of her work in this capacity she was trained in waveform processing of local, regional and teleseismic earthquakes for one week in each Pacific Geoscience Centre in Canada and the National Earthquake Information Center at USGS.

In August, the Seismologist/Analyst Ms Elizabeth Robertson returned back to her home country. Ms Ivana Jukić started her work as part of the Bulletin Analysis Team in September. Prior to her appointment she had undergone additional training in waveform processing at seismological services of Slovenia, Serbia and her home country, Croatia.

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

Despite the ever increasing volume of reported parametric data and the need to train two members of staff, the Analysis Team performed quite well continuing to provide high quality Bulletin. The Team is going to be under further pressure next year, when the project of creating the new interactive bulletin analysis system will start.

DEVELOPMENTS on the NEW BULLETIN ANALYSIS SYSTEM

The issue of the constantly increasing number of station arrival information available for each event in the Bulletin is still pressing. It was recognised earlier that a new approach to the Bulletin review process was required. An introduction of an interactive on-screen Bulletin analysis system in place of the existing paper-scanner-screen based batch-type analysis (fig. 4) is planned. The new system would allow the ISC analysts to concentrate on the review of graphical information summaries with highlighted outliers instead of reviewing all data in text format.

This year, on the advice of Prof. John Woodhouse, we teamed up with the Oxford e-Research Centre (OeRC). Jointly with Min Chen, professor of visualization at OeRC, we submitted a

three-year proposal to the UK Government Knowledge Transfer Programme (KTP) to develop a Visual Bulletin Analysis System (VBAS). The KTP is set up to pass the expertise accumulated by UK universities to the business world as well as to give working experience to recent graduates. Our proposal was granted in late December with the government funding commitment (66.6%) equally shared between two UK Research Councils for Natural Environment (NERC) and Engineering and Physical Sciences (EPSRC). The ISC will have to contribute only one third of the project costs.



Figure 4. Huge stacks of computer printout listings are still used for analysis of the ISC Bulletin. This is set to change with the VBAS development funded by the Knowledge Transfer Programme of UK Government.

At the beginning of the next year the ISC and OeRC will run the process of recruiting the KTP Associate who will formally become an employee of Oxford University yet will be stationed at the ISC to work on this exciting and long awaited development under the guidance of Prof Min Chen and relevant ISC staff whilst benefitting from advice of other OeRC staff at Oxford.

In the meantime, a number of additional projects run by the ISC have produced a necessary funding surplus to pay the ISC's monetary contribution towards this project.

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 2012, over 61,000 reviewed (by the ISC analysts) events and over 294,000 unreviewed (small) events were added to the ISC Bulletin. At the same time ~5.5 million arrivals were associated to reviewed events and further ~4.9 million seismic arrivals were associated to the unreviewed (small) events. A further ~850 thousand arrivals from unknown events were also added to the ISC database.

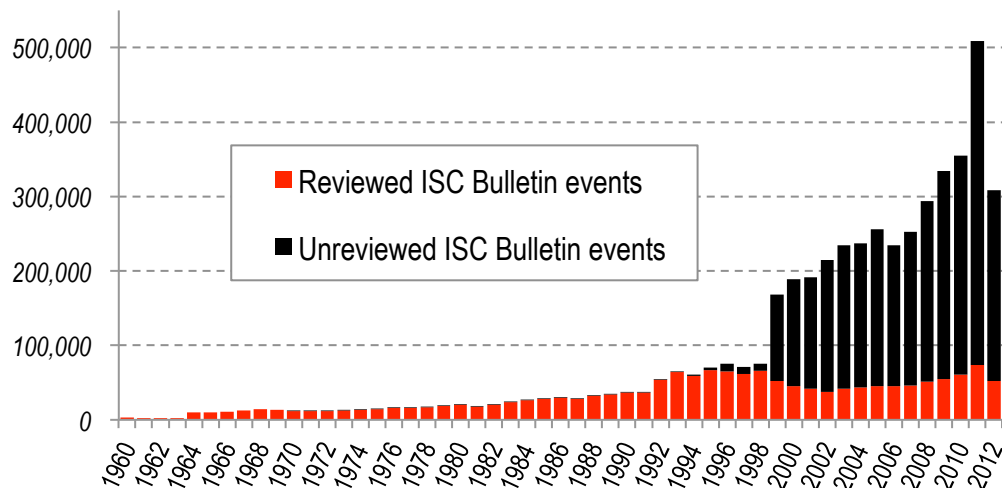


Figure 5a. Timeline of the annual number of reviewed and unreviewed (small) events in the ISC Bulletin. The total height of each column represents the annual number of all seismic events in the ISC Bulletin.

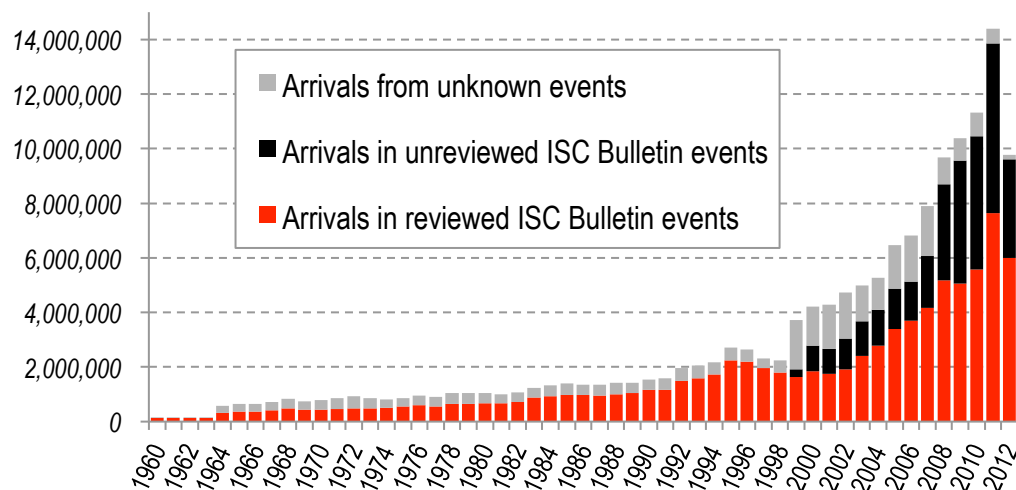


Figure 5b. Timeline of the annual number of seismic arrivals associated with both reviewed (red) and unreviewed (black) events in the ISC Bulletin, as well as those arrivals in the ISC database that are not associated to any known events (grey). The total height of each column represents the annual number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

Figure 6 demonstrates the 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.

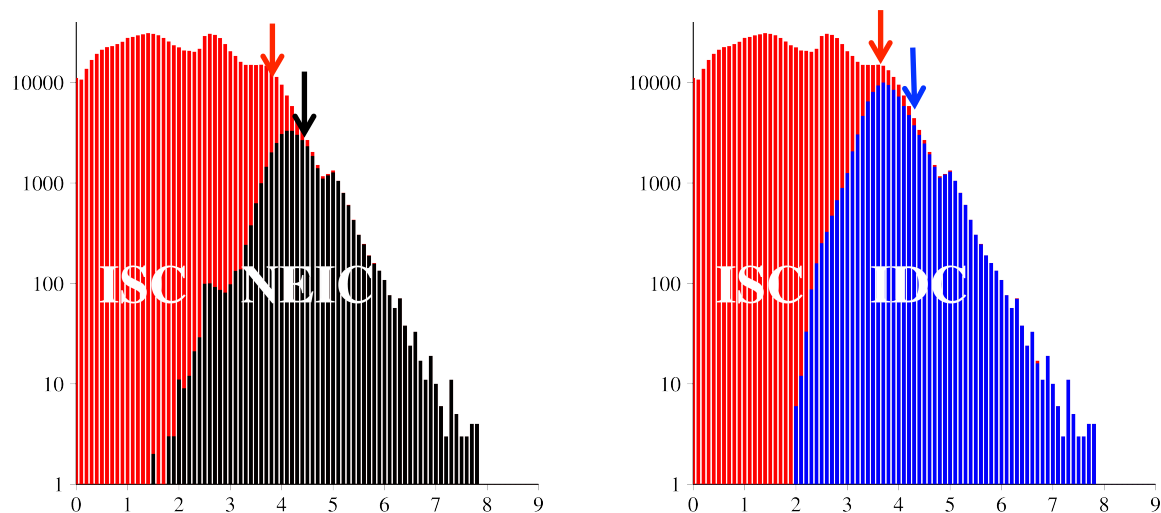


Figure 6. *Comparative global magnitude completeness of the ISC, NEIC/USGS and IDC/CTBTO (REB) bulletins (2007-2009). The ISC appears to be more complete than any of NEIC or IDC Bulletins by at least half a unit of magnitude.*

ISC DATABASE

The ISC holds its entire collection of data in the relational Postgre database on a Linux server with a RAID Array. In 2012 this database grew by 22% and reached the volume of 113Gb, 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 7,640 reference events (1962-2012) and approximately 500,000 station arrivals facilitates better visualization of the Earth structure, better modelling of velocities of seismic waves, more accurate travel time determinations and increased accuracy of event locations. ISC users are able to search this database at the ISC website and receive GT locations and corresponding ISC locations along with station arrival data available for each event. A cross-link to the ISC Bulletin is provided for users to go between ISC and GT databases.

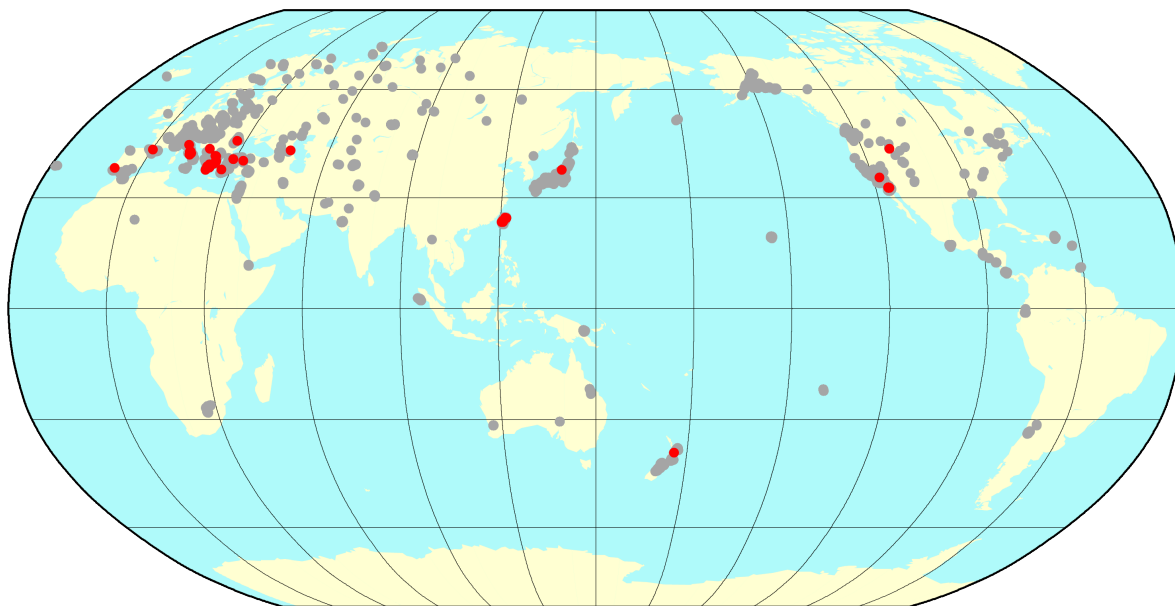


Figure 7. During 2012, 247 events (red) have been either updated or added to the IASPEI list of Reference earthquakes and explosions.

At the end of each data year analysis, we add new events to the Reference Event List. During 2012, 247 events have been added to the List or updated (fig. 7).

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 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.

With the new ISC Location algorithm 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 understood that further production of the EHB bulletin, that made such a great contribution towards the global tomographic studies, is 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 2012 (fig. 8a,b). The number of hits reached ~11.2 million, having increased more than 50% compared with 2011. Both the number of the ISC Bulletin searches and the number of searches through the station registry (IR) in 2012 have doubled since 2011.

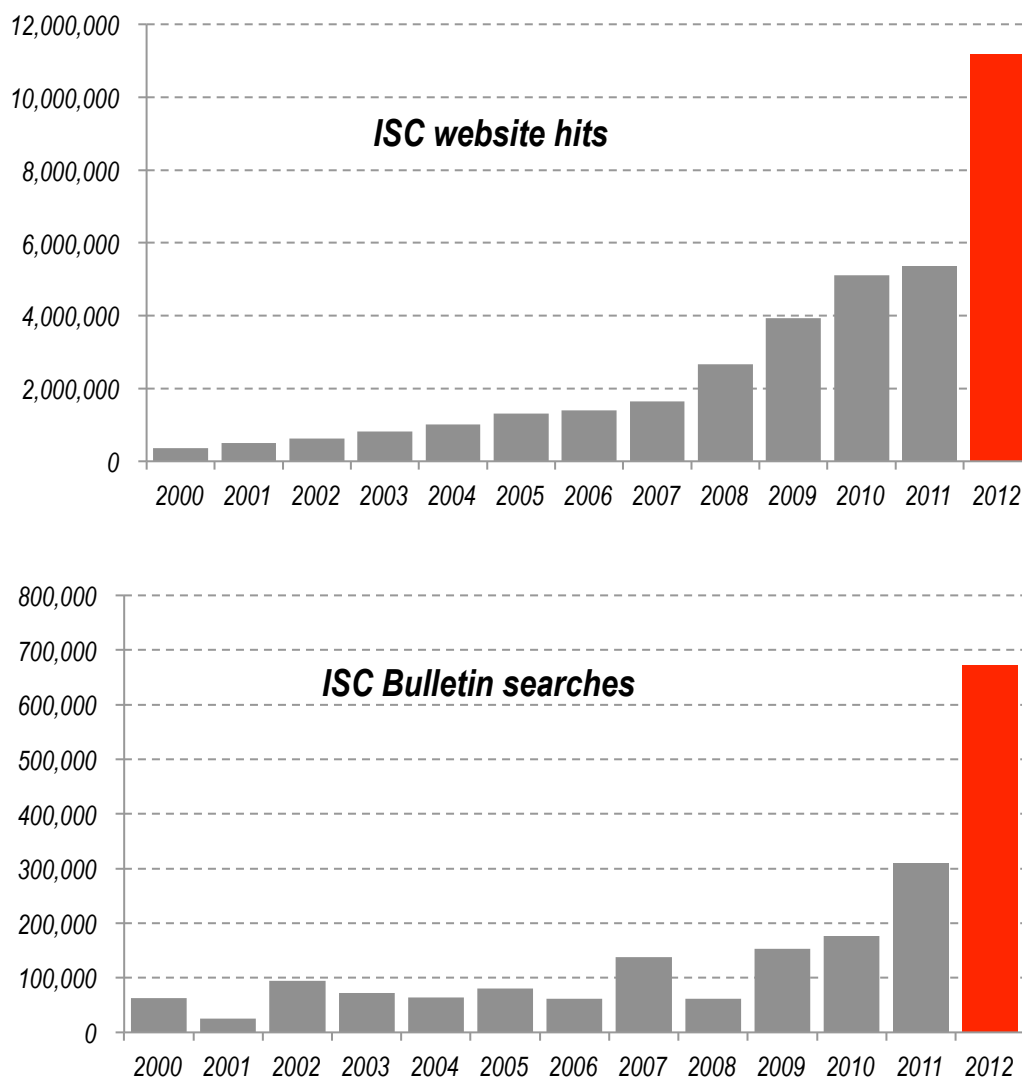


Figure 8a,b. Annual numbers of the ISC website hits (a) and the Bulletin searches (b).

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

- International Station Registry (~959,000, 100% increase on 2011),
- ISC Bulletin search (~671,000, 100% increase on 2011),
- Bulletin map (~14,000, 50% increase on 2011)
- Search of original data contributed to the ISC (~140,000, 20 times above 2011),
- Bibliography search (~52,000, 20 times on 2011)

General usage of the ISC web and ftp services, with Bulletin and Station Registry searches in particular are described on Figure 9 (a-d).

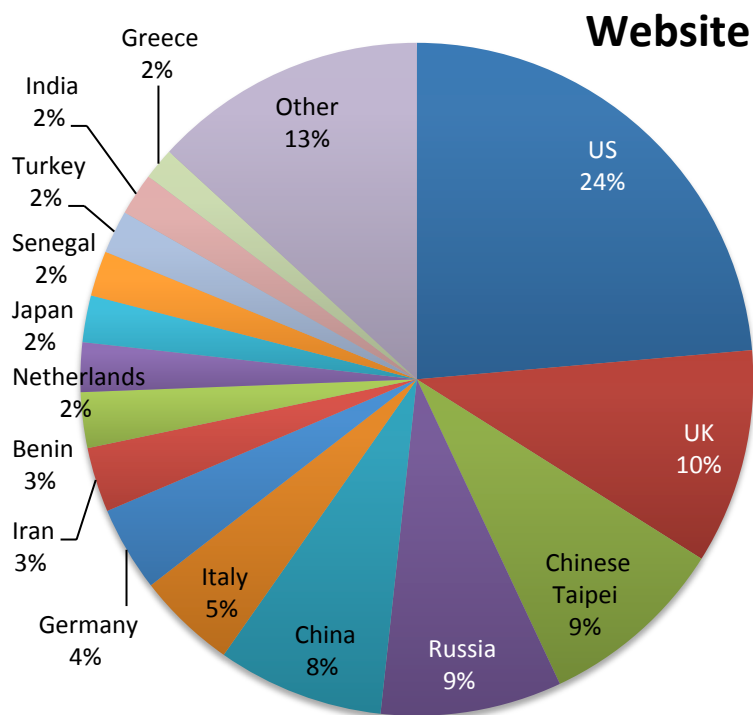


Figure 9 (a). *Per country statistics of the ISC web site use*

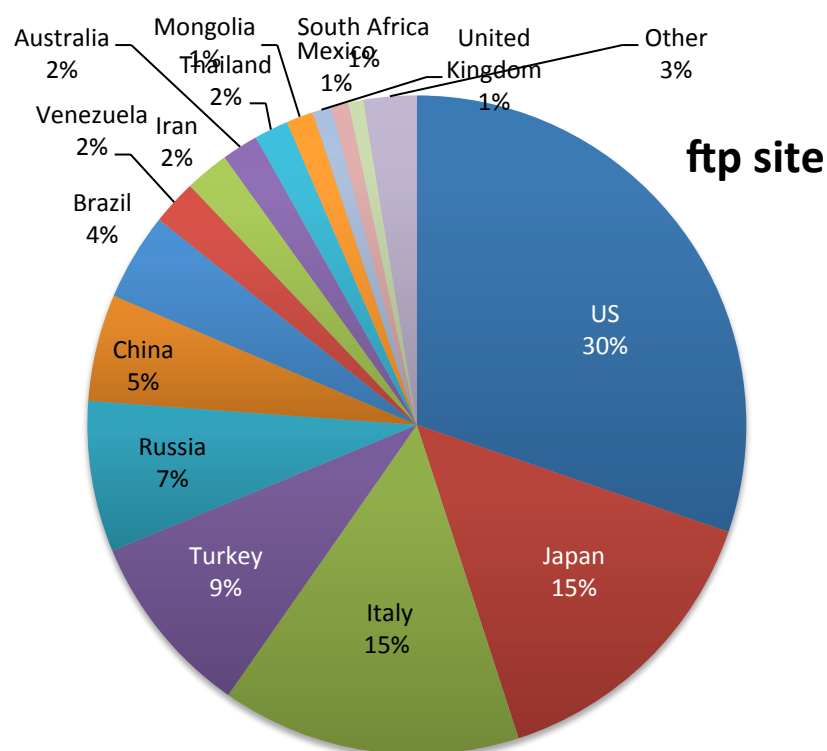


Figure 9 (b). *Per country statistics of the ISC ftp site use*

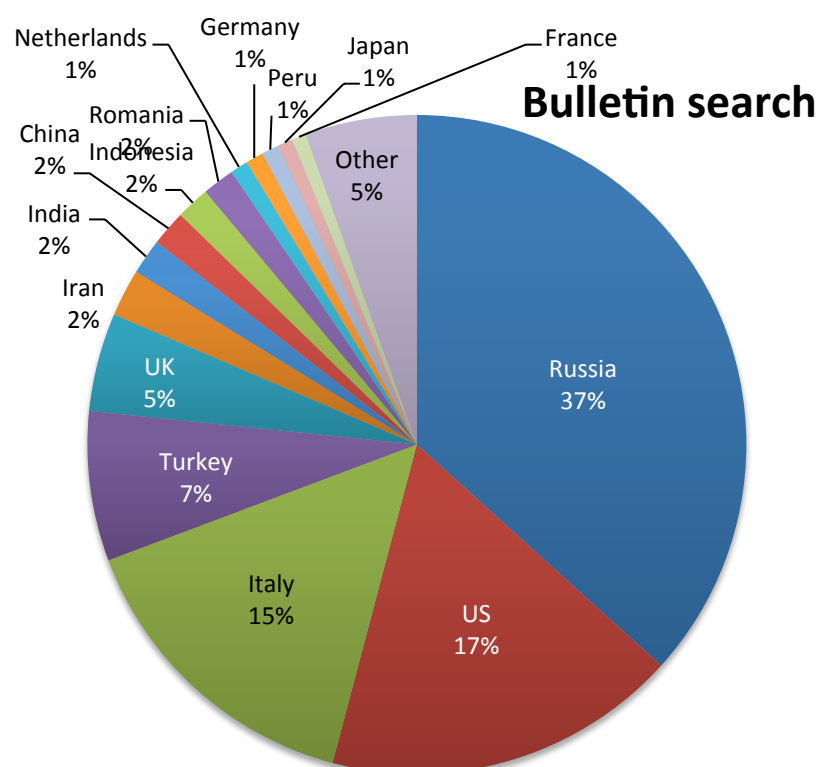


Figure 9 (c). *Per country statistics of the ISC Bulletin searches*

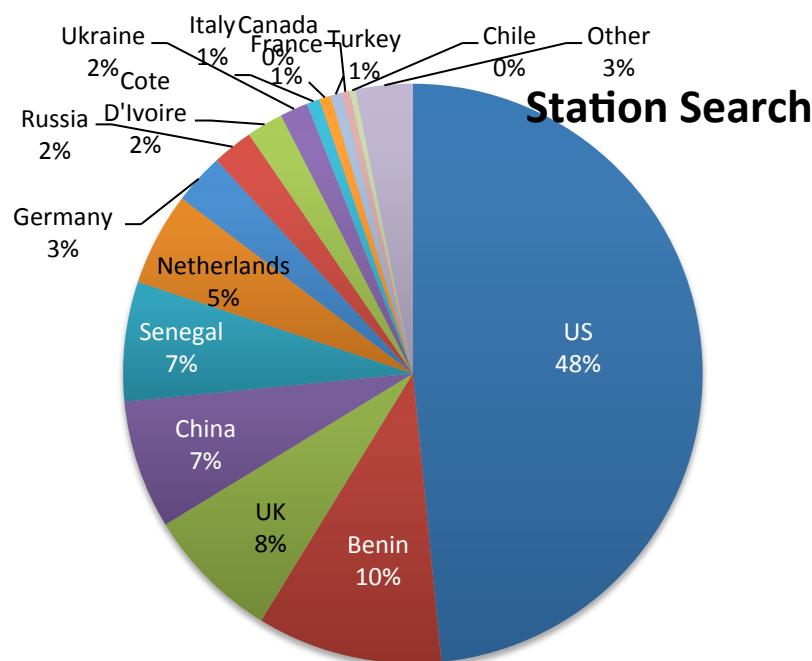


Figure 9 (d). *Per country statistics of the Station Registry searches*

DEVELOPMENT PROJECTS

ISC-GEM GLOBAL INSTRUMENTAL EARTHQUAKE CATALOGUE (1900-2009)

At the end of 2012 the ISC was finishing preparations for the public release of the ISC-GEM Global Instrumental Earthquake Catalogue (1900-2009).

The Catalogue (1900-2009) is the result of a special effort to adapt and substantially extend and improve currently existing bulletin data to serve the requirements of the specific user group who assess and model seismic hazard and risk.

Moreover, the Catalogue will also have a multidisciplinary use in a wide range of other areas such as studies of global seismicity, inner structure of the Earth, tectonics, nuclear monitoring research, rapid determination of hazard etc

This global catalogue was also designed to serve as a reference to be used for calibration purposes by those compiling regional seismicity catalogues that contain events of much smaller magnitudes. This way the catalogues prepared by other teams for different regions may contain comparable earthquake locations and magnitude parameters, especially in border regions

The work on the Catalogue was funded by the **GEM Foundation** as part of the five Global Hazard Components. The ISC also contributed its resources to create the product to be widely used by the geoscientists worldwide.

This project was led by the ISC and performed by the Team of International Experts in accordance with the requirements of the Scientific Board of GEM and following recommendations of the team of IASPEI Observers.

The Team of International Experts included several members of the ISC staff as well as Bob Engdahl (University of Colorado Boulder), Antonio Villaseñor (IES Jaume Almera, Spain), Peter Bormann (GFZ, emeritus), Willie Lee (USGS, emeritus) and Graziano Ferrari (INGV/SISMOS).

The effort is monitored by a team of observers on behalf of the IASPEI: Roger Musson (BGS), Johannes Schweitzer (NORSAR), Göran Ekström (Columbia Uni) and Nobuo Hamada (JMA).

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 and M_W .

ISC EVENT BIBLIOGRAPHY

The ISC began working on the project of preparing data for the ISC Event Bibliography. The Event Bibliography will allow users to search for references to scientific publications linked to both natural and anthropogenic events that have occurred in the geographical region of their interest by performing an interactive search based on earthquake (location, time, magnitude, etc.) and/or publication parameters (author name, journal, year of publication, etc.).

References are collected based on the titles and abstracts of scientific publications that can be found in the ISC Bibliography of Seismology, electronic indexes provided by scientific journals as well as bibliography collected during the work on the ISC-GEM Catalogue.

References to publications will not be limited to Seismology. They will cover a broad range of disciplines including, but not limited to earthquake engineering, tectonics, structural geology, geodesy, remote sensing, nuclear test monitoring, tsunamis, landslides, environmental studies, coastal science, natural disasters, hydrology, geochemistry, atmospheric sciences and geomagnetism. This feature will make the Event Bibliography an

attractive tool for multidisciplinary studies and useful for researchers and students from different fields.

We expect the Event Bibliography to become operational in the first part of the next year.

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. From April 2011, the funding of the project was taken over by the CTBTO with an intention to continue on an annual basis.

During 2012 we maintained a dedicated server at the ISC that holds a mirror version of the ISC database.

The dedicated web-based software package allows users from PTS and National Data Centres for CTBTO to query the ISC database in ways specific to the explosion monitoring community. The software package includes 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 is 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.

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 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 12 shows user activity on the Link by both PTS/CTBTO and NDCs.

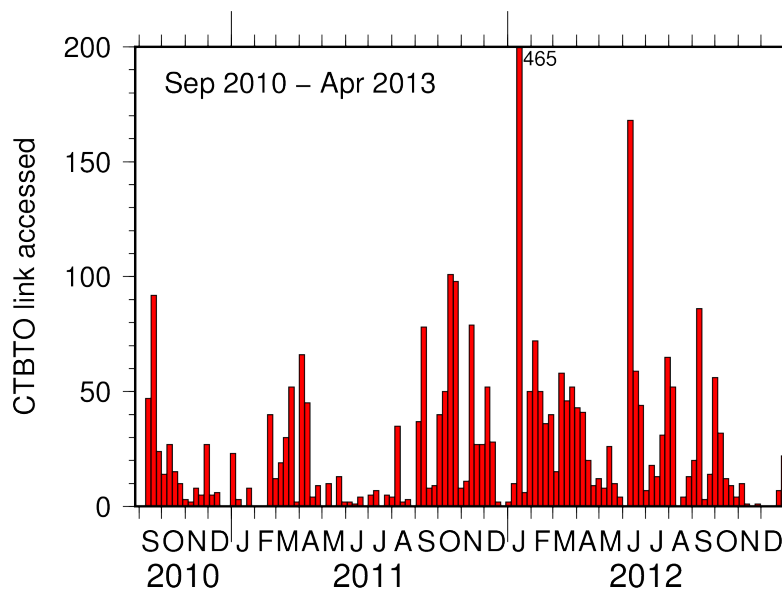


Figure 12. The Link to the ISC database mirror is provided to the NDCs through the IDC secure website. The figure shows the healthy stream of user activity.

It may first appear that this project benefits only CTBTO. This isn't true as the ISC, its Member-Institutions and the ISC Bulletin and other product users gain a great deal from the developments on this project:

- 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.
- In particular, experience of downloading, checking quality and processing waveforms on the industrial scale will help the ISC's mid-term plans of making own automatic waveform measurements to further improve the quality of the ISC Bulletin.
- 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 ISC Members or increased their financial contributions, based on the added value of the ISC service.

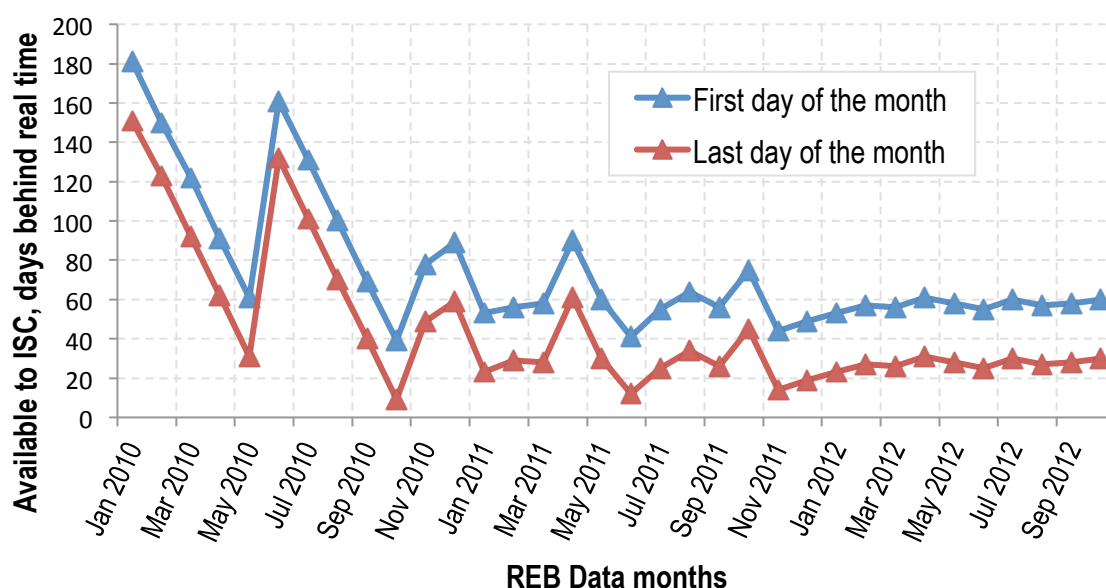


Figure 13. The availability of the IDC REB data to general ISC Bulletin users (days behind real time) has considerably improved with the routine operation of the CTBTO Link.

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

Based on the NSF funding, the ISC maintains 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 to serve the 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.

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.

During 2012 we continued with a thorough review and clean-up of the contents of the ISC Bulletin in the areas of seismic arrival phase identifications, channel information, first motion information and suspiciously large magnitude estimates.

To this date, we have obtained and prepared to load into the ISC database the following new bulletin datasets:

- *GCMT*, *GCMT/HRVD* moment centroid tensor catalogue going back to 1976
- *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
- *Geodynamisches Observatorium Moxa, Germany*: archive bulletins, back to 1981
- *Collm Observatory, Germany*: Observatory bulletins 1990-1997
- *IFREE/JAMSTEC, Japan*: OHP western Pacific dataset 1991-2004
- East Africa: 2005-2009 bulletins - selected events
- GSETT-2, 1991 bulletins
- HIMNT, Himalayan-Nepal-Tibet region temporary deployment, 2001-2002
- MCO, Macao arrival lists, 2005-2009
- HNR, Honiara arrival lists, 2002-2009
- MOZ, Mozambique arrivals, 2009
- LEDBW, Baden-Wuerttemberg regionals, 2009

- EUROP, European tomographic deployments compilation, 1988-2001
- IASBS, Iranian sequence data-sets, 1996-2008
- *University of Washington, US*: IRIS Farm observations, 1978-2007
- *University of Utah, US*: Utah regional moment tensors, 1998-2011
- *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.

PRINTED SUMMARY of the BULETIN of the ISC

The ISC has ceased publication of the printed ISC Bulletin with the last data of year 2009. It was decided to replace this publication with the printed Summary of the ISC Bulletin which will cover six months of the Bulletin data enclosed on a DVD. The old Bulletin was a listing of individual event hypocentres and magnitudes. The new publication will feature articles on the following topics:

- The ISC (Mandate, History, Evolution of the Bulletin, Member Institutions, Sponsors, Data Contributors, Staff)
- Operational Procedures (data collection, grouping, association, thresholds, event location, magnitude determination, review, history of operational changes)
- Availability of the ISC Bulletin
- Citing the ISC
- IASPEI Standards
- Summary of Seismicity (6 months)
- Notable Events
- Statistics of Collected Data
- Overview of the ISC Bulletin
- Leading Data Contributors
- Glossary
- Acknowledgements
- References

As many as seven members of the ISC staff worked on the project to prepare the first Summary and it should come out in print in the middle of the next year. As a book publisher, the ISC receives a refund of the Value Added Tax on all goods and services that it buys from other suppliers.

SEISMOLOGICAL CONTACTS

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.

The project benefitted from 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.

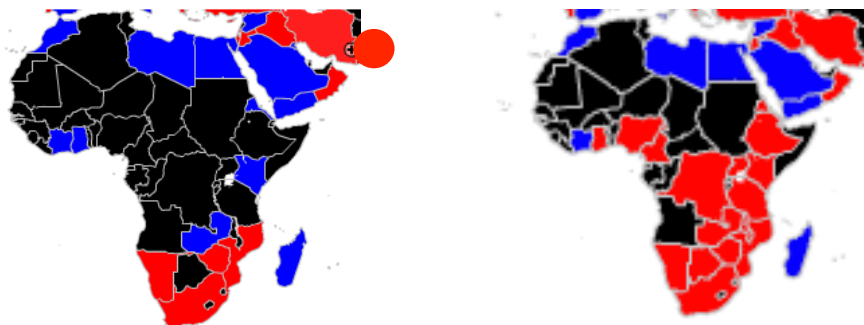


Figure 15. Comparison of the state of the service in 2011 (left) and 2012 (right). Many more territories highlighted in red or blue can be taken as a good indication of progress in obtaining contact details in Sub-Saharan Africa.

For each country in the “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 2012 we concentrated our efforts on 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.

SCANNING of the HISTORICAL STATION BULLETIN COLLECTION



Figure 16. Rows of historical station bulletins stored in the ISC warehouse

Digital scanning of the historical station bulletin collection began in collaboration with the SISMOS project run by Graziano Ferrari at the INGV in Italy. At this point a considerable fraction of station bulletins used for preparation of the ISC-GEM Catalogue has been transported to INGV in Rome and will be returned to the ISC in the Autumn 2013. Digital images bearing the ISC and INGV logos will become available to users from the ISC and SISMOS websites. This project was made possible thanks to funding from the GEM Foundation.

FINANCE

The detailed financial statements of the ISC for 2012 were audited by Griffins, Chartered Accountants (Newbury, UK) and approved by Prof. John Woodhouse of the ISC Executive Committee. These statements present the state of ISC's financial affairs as at 31 December 2012.

INCOME

In 2012, ISC had a total income of £781,748 from national contributions and grants for special projects. The latter amounting to 25% of the total, £198,555, from sources itemised on page 7 of the accounts. Interest on ISC bank accounts plus the income from selling ISC publications are also included. The NSF funds and also other grants where work has yet to continue have been split between 2012 and 2013.

The exchange rate between the UK £ and USA \$ veered between the opening rate of £1=\$1.55 at the start of the year, down to £1=\$1.54 and then finishing the year at £1=\$1.62 at the end of December.

During 2012, the Centre for Research in Astronomy, Astrophysics and Geophysics (CRAAG, Algeria), the Centre of Geophysical Monitoring (Belarus) and the University of Melbourne (Australia) joined the ISC as Members. At the year-end some £16,760 had yet to be paid by Members but at the time of writing this report some of the funds have already been received.

EXPENDITURE

Approximately 82% of the ISC expenditure in 2012 was committed to personnel costs, some £2,735 more than in 2011 yet the figure was less than budgeted due to an unplanned gap between the leaving and joining members of staff. The personnel 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 (to run the building) were just above the previous years' costs reflecting the rising utility prices. The computing costs were also up to cover additional computer hardware purchased under the CTBTO Link project. The total travel costs for the staff and the Executive Committee fell slightly to reflect the fact that the annual Executive meeting was held at the ISC in Thatcham.

RESERVES

The gain in income over expenditure for 2012 was £82,547. This amount will be spent in the coming years to fund the most vital program of modernisation of the ISC Bulletin Analysis system (VBAS) to make it fully interactive. This project, in view of the constantly rising volume of incoming parametric data, will help the ISC to avoid running out of cash by spending progressively larger amounts of funds on the analyst's salaries.

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) increased during 2012 to £674,616. The Contingency Fund stands at £30,000 in accordance with the wishes of the ISC Governing Council. The ISC General Reserve of £644,616 is equivalent to almost 10 months future operation of the ISC. This is well within British guidelines for charitable organizations.

Notably, the ISC building loan was finally paid off during 2012.

CASH FLOW

The cash flow in Fig. 9 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.

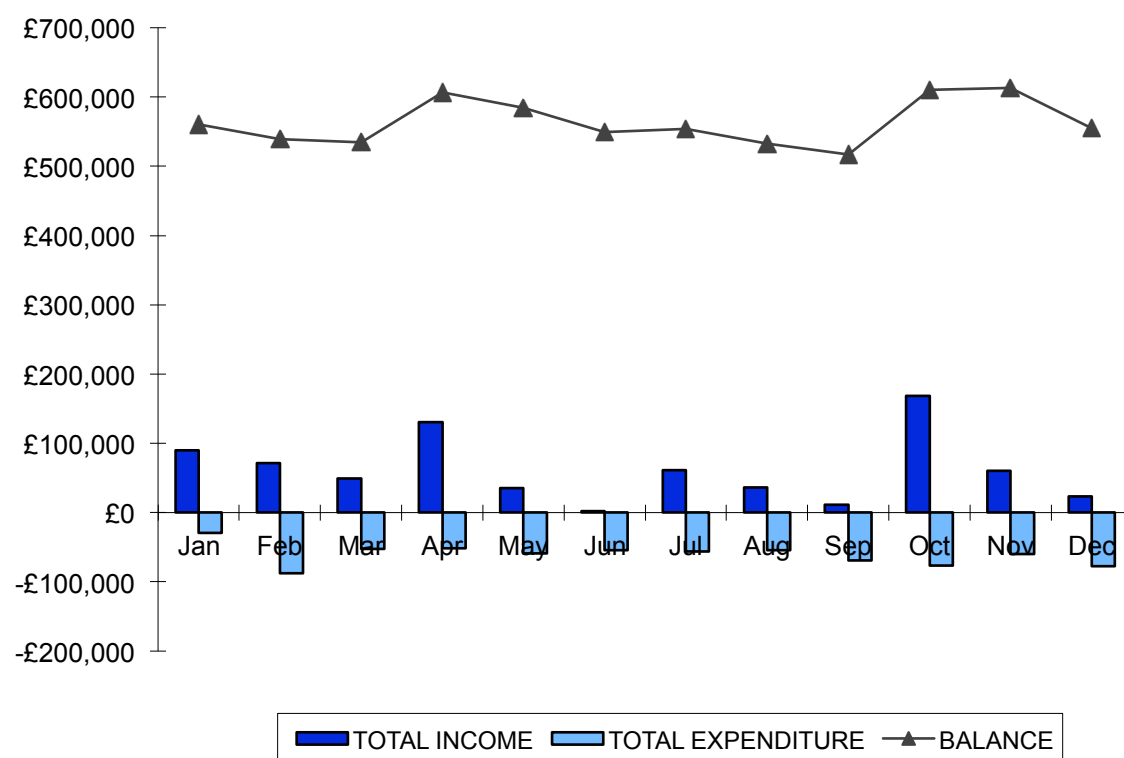


Figure 17. *Income/Expenditure cash flow and cash balance*

PUBLIC LIAISONS

CONTACTS with the MEDIA

During 2012 we had several communications on recent earthquakes with the following media channels:

- CNN
- BBC Radio 5
- BBC Radio Berkshire
- Sky
- Sky News
- Reuters New York
- France24
- Bulgarian TV
- Vietnam Press Association

PUBLIC LECTURES GIVEN by the ISC STAFF

The ISC staff uses opportunities to publicise its cause and develop public knowledge on earthquakes in the local community.

In July, the ISC's Seismologist/Analyst, Elizabeth Robertson, gave a lesson on earthquakes and their causes to the pupils of Elstree preparatory School in Woolhampton as part of Geography course.

SCIENTIFIC LIAISONS

VISITORS to the ISC

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

- Lassina Zerbo – CTBTO, Vienna, Austria
- Vorian Maryssael – CTBTO, Vienna, Austria
- Jerry Carter – CTBTO, Vienna, Austria
- Jeff Given – CTBTO, Vienna, Austria
- Bob Engdahl – Colorado University, Boulder, USA
- Antonio Villaseñor - Institute of Earth Sciences "Jaume Almera", Barcelona, Spain
- Min Chen – Oxford e-Research Centre, UK
- Qian Shun-qin – Earthquake Administration of Guandong Province, China
- Graziano Ferrari – INGV, Italy
- David Bowers – Blacknest, UK

- Niel Selby – Blacknest, UK
- Stuart Nippreff – Blacknest, UK
- John Adams – Geological Survey, Canada
- Johannes Schweitzer – NORSAR, Norway
- Guy Masters – IGPP, University of California San Diego, USA
- Oleg Starovoit – Geophysical Survey, Academy of Sciences, Russia
- Gary Gibson – ES&S / University of Melbourne, Australia
- R.S. Dattatrayam – Meteorological Department, India
- John Woodhuse – Oxford University, UK
- Alexander Borisov – Institute of Marine Geology and Geophysics, Yuzhno-Sakhalinsk, Russia
- Roger Musson – British Geological Survey, UK
- Natalia Mikhailova – KNDC, Almaty, Kazakhstan
- Maiclaire Bolton – RMS, San Francisco, UK

CONFERENCES, MEETINGS, WORKSHOPS

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

- RSTT Meeting, CTBTO, Vienna, *Austria*
- International Seismology School, Naroch, *Belarus*
- Nordic Seismology Seminar, Tallinn, *Estonia*
- GEM Platform Meeting, Pavia, *Italy*
- GEM Progress Review Meeting, Pavia, *Italy*
- Asian Seismological Commission Meeting, Ulan-Bator, *Mongolia*
- Latin American Seismology Symposium, Lima, *Peru*
- European Seismological Commission Meeting, Moscow, *Russia*
- Gulf Seismic Forum, Jeddah, *Saudi Arabia*
- East and South African Regional Seismological Working Group, Entebbe, *Uganda*
- AGU, San Francisco, *USA*
- NEIC-ISC-EMSC Coordination Meeting, Golden, *USA*
- SSA Meeting, San Diego, *USA*

ISC STAFF VISITING OTHER INSTITUTIONS

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

- International Data Centre, CTBTO, Vienna, *Austria*
- EUCENTRE, Pavia, *Italy*
- Geophysical Institute of Peru, Lima, *Peru*

- SECED, London, *United Kingdom*
- Royal Society, London, *United Kingdom*
- Risk Management Solutions, Newark, *USA*
- Lawrence Livermore National Laboratory, Livermore, *USA*

ISC STAFF TRAINING

The ISC Trainee Analyst, Rosemary Wylie, spent a week at the Pacific Geoscience Centre in British Columbia, Canada, where she learned about the processing of local seismic events under the supervision of the former ISC Analyst, Alison Bird. Rose also received training in Colorado where several members of NEIC/USGS personnel demonstrated to her the specifics of waveform processing of global and regional earthquakes as part of their 24x7 service under the supervision of Bruce Presgrave. Special thanks are due to Susan Hoover as well as other analysts: Julie Dutton, John Bellini, Dale Grant, Paul Caruso and Shengzao Chen.

Immediately before her arrival to the ISC Trainee Analyst, Ivana Jukić, went through a training programme in reviewing waveforms and learning about operational procedures at seismological services of three Balkan countries. At the Seismological Survey of the Republic of Croatia in Zagreb she was helped by Snježan Prevolnik, Tomislav Fiket. Special thanks are to Vlado Kuk, Marijan and Davorka Herak. At Environmental Agency of the Republic of Slovenia she was assisted by Tamara Jesenko, Jurij Pahor, Milka Ložar Stopar, Mladen Živčić and Ina Cecić. At Seismological Survey of Serbia she was helped by Nataša Kotur, Svetlana Kovačević, Goran Krunic, Dejan Valčić. Special thanks are to Slavica Radovanović and Branko Dragičević.

WORK EXPERIENCE at the ISC

Waveform Picking

The seismic phase arrival times and amplitudes have been always submitted to the ISC by the network operators. In spring 2012 the ISC made a small start with something that it never was engaged in the past – the actual waveform picking. **Silvana Jacob**, a student from the University of Potsdam in Germany spent six weeks under the supervision of Domenico Di Giacomo, identifying P and S arrivals of moderate to large earthquakes in the vicinity of two past seismic deployments with waveform data available from the IRIS DMC.

The INDEPTH project was an interdisciplinary program of geophysical and geological studies designed to develop a better understanding of the deep structure and mechanics of the Himalaya-Tibet region. It represents a major collaboration between the Chinese Academy of Geological Sciences of the Ministry of Geology and Mineral Resources and a number of institutions from the US, Germany, and Canada. Funding for INDEPTH has come from the Ministry of Geology and Mineral Resources of China, the U.S. NSF, the Chinese National Natural Science Foundation, the Deutsches Forschungsgemeinschaft, and the GeoforschungsZentrum Potsdam.

The BANJO and SEDA arrays were deployed as a passive source, broadband, seismic experiment in the central Andean Cordillera of Bolivia and northern Chile. This was an international multi-institutional project with participants from the University of Arizona, Carnegie Institution of Washington, and Lawrence Livermore National Laboratory in the U.S.A, San Calixto Observatory and the University of Bolivia in La Paz, the University of Chile in Santiago, and ORSTROM, a French research organization.

Based on Silvana's effort, the waveform picks from these two experiments were used alongside already available picks from the ISC Bulletin to relocate known earthquakes using an improved network geometry. The results of this work will be integrated into the ISC Bulletin as part of the Bulletin Rebuild project.

Reviewing Tsunami Databases

Morgan Plain, 1st year student at the University of Leeds, helped the ISC to review the relationship between the events in the ISC-GEM Catalogue with seismic events that caused a tsunami according to the databases run by both National Geophysical Data Centre, NOAA in the US and by the Institute of Computational Mathematics and Mathematical Geophysics in Novosibirsk, Russia. The goal was to make a preliminary comparison of the earthquake parameter data in order to plan further collaboration with the above data centres.

The ISC History and Event Bibliography

Kate Godsmark, the 1st year student at the University of Birmingham, was tasked with preparing a webpage describing the life and achievements of the Great British Seismologist John Milne, who is rightly considered to be one of the founders of the organization now called the ISC. Kate studied several books as well as printed and photographic materials available at the ISC. Kate also helped with re-attributing the scientific articles to correct events in the database of the GEM-ISC Catalogue.

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. In 2012, the prize was given to Mr Guy Paxman, 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.

SCIENTIFIC PAPERS PUBLISHED by the ISC STAFF

Several scientific articles describing the work on the ISC-GEM Catalogue have been prepared for submission during 2013.

SCIENTIFIC PAPERS PUBLISHED in 2012 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 2012. 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 the ISC data. We used the exact phrases “International Seismological Centre”, and “International Seismological Center” and “EHB”+ “seismic” for papers appearing in 2012. No doubt many more references can found by using different search phrases.

[Submarine landslide triggered by volcanic eruption recorded by in situ hydrophone](#) WW Chadwick, RP Dziak, JH Haxel, RW Embley... - ..., 2012 - [geology.gsapubs.org](#) ... PRE-ERUPTION EARTHQUAKE SWARM. An unusually large sequence of earthquakes was detected near NW Rota-1 volcano by the global seismic network (**International Seismological Centre**, 2011) starting on 17 April 2009 (Fig. 3A). ...

[Rapid response to the earthquake emergency of May 2012 in the Po Plain, northern Italy](#) M Moretti - [Annals of Geophysics](#), 2012 - [annalsofgeophysics.eu](#) ... and Re.Mo.Tel stations (22 stations, named as T0800-T0828) are available on EIDA at the time of writing (July 2012). All of both the real-time and standalone INGV stations are, or are going to be, registered at the **International Seismological Centre** (ISC); <http://www.isc.ac.uk/>. ...

[mb: Ms event screening revisited](#) ND Selby, PD Marshall, D Bowers - [Bulletin of the Seismological ...](#), 2012 - [bssaonline.org](#) ... The m b magnitudes used are listed here in order of preference: (i) First are the joint-maximum-likelihood (Lilwall, 1986) magnitudes for specific test sites, based on **International Seismological Centre** (ISC) bulletins, in which the effects of censoring due to station reporting ...

[Analyzing the seismogram of earthquakes on Sumatra-Java Subduction plane at CHTO observation station](#) BJ Santosa - [Jurnal Sains MIPA Universitas Lampung](#), 2012 - [baitul-ummah.unila.ac.id](#) ... trigger the occurrence of earthquakes. In the recent years, the tomography of the global seismic wave processes the data of travel time routinely, eg **International Seismological Centre** (ISC). This routine especially has become ...

[Model update March 2011: Upper mantle heterogeneity beneath North America from traveltimes tomography with global and USArray transportable array data](#) S Burdick, RD van der Hilst, FL Vernon - [Seismological ...](#), 2012 - 171.66.125.217 ... The data included in the inversion consist of ~10 million P-wave residuals from the **International Seismological Centre** and the National Earthquake Information Center processed using the algorithms developed by Engdahl et al. ...

[The European-Mediterranean Earthquake Catalogue \(EMEC\) for the last millennium](#) G Grünthal, R Wahlström - [Journal of seismology](#), 2012 - Springer ... National Institute for Earth Physics, Bucharest, Romania (www-old.infp.ro/catal.php); INGV (2007) Data file of Italian earthquakes. Inst Naz Geofis Vulc, Milan, Italy; ISC

bulletins **International Seismological Centre** (previously International Seismological Summary) bulletins. ...

[Performance of localization algorithms for teleseismic mid-ocean ridge earthquakes: the 1999 Gakkel Ridge earthquake swarm and its geological interpretation](#) EIM Korger, V Schlindwein - [Geophysical Journal International](#), 2012 - Wiley Online Library... Riedel & Schlindwein (2010) relocated the swarm using published phases by the comprehensive bulletin of the **International Seismological Centre** (ISC), but could not confirm the proposed migration of epicentres found by Tolstoy et al. (2001). ...

[Remote triggered seismicity caused by the 2011, M9.0 Tohoku-Oki, Japan earthquake](#) H Gonzalez-Huizar, AA Velasco, Z Peng... - [Geophysical Research ...](#), 2012 - [agu.org](#) ... [5] Data from the Bulletin of the **International Seismological Centre** (ISC) and waveforms from multiple seismic networks (Table S2 in the auxiliary material) were used to detect earthquakes and tremors potentially triggered during the passing waves from this large earthquake. ...

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[An updated and extended earthquake catalogue for Greece and adjacent areas since 1900](#) K Makropoulos, G Kaviris... - ..., 2012 - [nat-hazards-earth-syst-sci.net](#) ... travel times, *Bull. Seism. Soc. Am.*, 58, 1273–1291, 1968. **International Seismological**

Centre (ISC): On-line Bulletin, available at: <http://www.isc.ac.uk>, Internatl. Seis. Cent., Thatcham, United Kingdom, 2010. Kahle, H. and Mueller ...

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[Earthquake occurrence processes in the Indo-Burmese wedge and Sagaing fault region](#) B Kundu, VK Gahalaut - [Tectonophysics](#), 2012 - Elsevier ... 2.2. Current seismicity. We used the updated

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catalogue of relocated earthquakes (EHB catalogue of Engdahl et al., 1998 from **International Seismological Centre**, 2009) since 1964. In the past 50 years no great earthquake has occurred in the region. ...

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[Segmentation of seismicity along the Himalayan arc due to structural heterogeneities in the underthrusting Indian plate and overriding Himalayan wedge](#) VK Gahlaui, BR Arora - *Episodes*, 2012 - [episodes.co.in](#) ... Figure 1. (a) Earthquakes ($M > 4.5$) for the period of 1964 to 2010 (**International Seismological Centre**, ISC, catalogue) superimposed over a smooth topographic map the Himalaya and Tibetan region together with major faults (Gansser, 1964), rifts in the Tibetan plateau (Armijo ...

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[Postseismic motion after the 2001 MW 7.8 Kokoxili earthquake in Tibet observed by InSAR time series](#) Y Wen, Z Li, C Xu, I Ryder... - *Journal of Geophysical ...*, 2012 - *Wiley Online Library* ... White circles represent aftershocks with $M \geq 4.0$ (14 November 2001 to 31 December 2008) from **International Seismological Centre** (on-line bulletin, Thatcham, UK, 2001, [http://www.isc.ac.uk](#)) T448D, T176D, T405D, T133D and T362D refer to 5 adjacent Envisat SAR ...

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[Distribution of \(mb-Ms\) of moderate earthquakes along the Mexican seismic zone](#) VM Zobin - *Geofísica Internacional*, 2012 - 132.247.146.34 Page 2. 44 VM Zobin 0 to 80 km, which occurred from 1962 to 1993. Magnitudes mb and Ms were taken from the Bulletin of the **International Seismological Centre** (1964-1993) and Monthly

Listings, NEIC (1962,1963). Data are plotted for events with magnitude mb less than 6.5. ...

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[The Hazard Component of the GEM Modeller's Toolkit: A Framework for the Preparation and Analysis of Probabilistic Seismic Hazard \(PSHA\) Input Tools](#) GA Weatherill, M Pagani, D Monelli - ... of the 15th World Conference on ... , 2012 - [iitk.ac.in](#) ... i. IMS 1.0 (text format) ii. Comma separated value (.csv) file i. **International Seismological Centre** Online Bulletin ([www.isc.ac.uk](#)) ii. Modeller's Toolkit Documentation Homogenised Earthquake Catalogue i. .csv i. Modeller's Toolkit Documentation ...

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... 1) location, focal mechanism, M_w , and depth from the Global CMT catalog; 2) focal mechanism, M_w , and depth from V. Andrews (personal communication, 2010), location from CMT; 3) location, m_b , and depth from the Bulletin of the **International Seismological Centre** (ISC); 4 ...

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[Sławomir Jerzy \(George\) Gibowicz \(1933–2011\)](#) S Lasocki, A Kijko - [Acta Geophysica](#), 2012 – Springer ... Through most of his professional life he was attached to the Institute. In the years 1966–1968, he worked at the **International Seismological Centre** in Edinburgh, where, shortly after the beginning of work, he was assigned the position of the Centre's deputy director. ...

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... The **International Seismological Centre** (ISC) based at Thatcham, United Kingdom, prepares a global seismicity catalog that is a comprehensive summary of hypocenters and phase readings for all sufficiently large earthquakes. ...

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ISC **International seismological centre** KPSZ Kohat-Potwar-Salt range seismic zone ... Their earthquake catalog includes 1057 instrumentally-recorded earthquakes ($M_w \geq 4$) obtained chiefly from the **International Seismological Centre** (ISC) and ...

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Earthquake Information Center (NEIC) provide an authoritative up-to-date Documentation of station/agency ...

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[Seismic risk study of a low-seismicity region dominated by large-magnitude and distant earthquakes](#) L Huang - [Journal of Asian Earth Sciences](#), 2012 – Elsevier ... future seismicity. Data from two earthquake databases are included: the United States Geological Survey (USGS) from 1973 through 2010 and the **International Seismological Centre** (ISC) from 1900 through 1972. A homogeneous ...

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[IA Parvez](#) - *Geomatics, Natural Hazards and Risk*, 2012 - Taylor & Francis ... The seismicity map shown in figure 1 has been prepared after compiling the earthquake catalogue from various national and international agencies and published catalogue from the literature that includes **International Seismological Centre** (ISC), National Oceanic and ...

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[Earthquake magnitude relationships in the region of the Carpathian-Pannonian Basin](#) T Zsíros - *Acta Geodaetica et Geophysica Hungarica*, 2012 – Springer ... The magnitude data have been provided by the different seismological centers. If ISC (**International Seismological Centre**, UK) magnitude is available, this value is preferred; in other cases the arithmetic mean of each magnitude type is chosen. ...

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<http://www.isc.ac.uk/search/Bulletin>), database and moment magnitudes from Global Centroid Moment Tensor (GCMT) database (<http://www.globalcmt> ...

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[Relocation of the 2006 Mw 6.1 Silakhour, Iran, Earthquake Sequence: Details of Fault Segmentation on the Main Recent Fault](#) A Ghods, M Rezapour, E Bergman... - *Bulletin of the ...*, 2012 - bssaonline.org ... For stations outside of Iran, we relied almost entirely on picks reported in standard bulletins, such as the **International Seismological Centre** (ISC), US Geological Survey Preliminary Determination of Epicenters (PDE), and European Mediterranean Seismological Center (EMSC ...

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[Seismic Wave Interactions Between the Atmosphere-Ocean-Cryosphere System and the Geosphere in Polar Regions](#) M Kanoo - *intechopen.com* ... Fig. 13. Background seismicity and Magnitude-dependent 'b'-values for Greenland and the neighboring areas, on the basis of the statistic ETAS model using the hypocentral data collected at the **International Seismological Centre** (ISC). ...

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[Conceptualizing and Confronting Disasters: A Panorama of Social Science Research and International Policies](#) S Revet - *The Politics and Policies of Relief, Aid and* ..., 2012 - [books.google.com](#) ... This focus led to contributions by UNESCO to the founding of the **International Seismological Centre** (ISC) in Edinburgh in the late 1960s, and in the early 1970s the United Nations Development Program (UNDP) and the Food and Agriculture Organization (FAO) contributed ...

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[P-wave velocity structure beneath the northern Antarctic Peninsula: evidence of a steeply subducting slab and a deep-rooted low-velocity anomaly beneath the ...](#) Y Park, KH Kim, J Lee, HJ Yoo... - *Geophysical Journal* ..., 2012 - Wiley Online Library ... Red rectangle indicates the area of the map

[Assessment of seismic performance of adobe structures in Pakistan and Portugal](#) MM Rafi, SH Lodi, H Varum, N Alam, M Ahmed... - 15th WCEE, World ..., 2012 - [ria.ua.pt](#) ... These data have been taken from different sources such as **International Seismological Centre** (ISC), National Earthquake Information Center (USGS), Pakistan Meteorology Department (PMD), British Geological Survey (BGS), etc. ...

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[Use of Seismotectonic Information for the Seismic Hazard Analysis for Surat City, Gujarat, India: Deterministic and Probabilistic Approach](#) TP Thaker, GW Rathod, KS Rao, KK Gupta - *Pure and Applied Geophysics*, 2012 - Springer ... The earthquake data were collected from different sources, ie, Geological Survey of India (GSI), Indian Meteorological Department (IMD), **International Seismological Centre** (ISC), National Geophysical Research Institute (NGRI), 38 TP

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[Mantle structure beneath Africa and Arabia from adaptively parameterized P-wave tomography: Implications for the origin of Cenozoic Afro-Arabian tectonism](#)

SE Hansen, AA Nyblade, MH Benoit - *Earth and Planetary Science Letters*, 2012 – Elsevier ... global ak135 Earth model (Kennett et al., 1995). The largest source of global travel-time residuals used is the reprocessed **International Seismological Centre** database from Engdahl et al. (1998; hereinafter referred to as the EHB ...

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[Topic The new IASPEI standards for determining magnitudes from digital data and their relation to classical magnitudes](#) JW Dewey - *ebooks.gfz-potsdam.de* ... The "ML, Ms, 20, Ms, BB, mb, mB, BB, Mw, mb_Lg" nomenclature used in this section of IS_3.3 is defined to facilitate data transmission in the IASPEI Seismic Format (ISF) (**International Seismological Centre**, <http://www.isc.ac.uk/standards/isf>, last accessed March Page 12. ...

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[\[PDF\] and Associated Topics in Relation to Nuclear Power Plant Siting Conceptualizing and Confronting](#) S Revet - *The Politics and Policies of Relief, Aid and ...*, 2012 - *books.google.com* ... This focus led to contributions by UNESCO to the founding of the International Seismological Centre (ISC) in Edinburgh in the late 1960s, and in the early 1970s the United Nations Development Program (UNDP) and the Food and Agriculture Organization (FAO) contributed ...

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[Toward quantifying uncertainty in travel time tomography using the null-space shuttle](#)

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- *hindawi.com* ... cause ice-related seismic phenomena. 389297.fig.0018. Figure 18: Globally compiled seismicity around Wilkes Land, East Antarctica for 1964–2002 by the **International Seismological Centre** (ISC). The aftershock area of the ...

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O Averbuch, C Piromallo - *Tectonophysics*, 2012 – Elsevier ... The PM0.5 velocity model, obtained by inversion of the **International Seismological Centre** (1964–1995) P wave delay times, has been largely used to image mantle heterogeneities from recent geodynamical processes across the Alpine-Mediterranean belt ([Facenna et al ...

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[Seismicity near the slip maximum of the 1960 Mw 9.5 Valdivia earthquake \(Chile\): Plate interface lock and reactivation of the subducted Valdivia Fracture Zone](#) Y Dzierma, M Thorwart, W Rabbel, C Siegmund... - [Journal of Geophysical](#) ..., 2012 - [agu.org](#) ... respective SEISAN module [Havskov and Ottemöller, 1999]. The Chilean seismic agency SSN reports local magnitudes to the **International Seismological Center** (ISC) since November 2001. The diagram (Figure 5) shows that ...

[A New Catalogue of Eastern Mediterranean Earthquakes, 2150 BC–2011](#)

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[Structure of the upper mantle in the Circum-Arctic region from regional seismic tomography](#) AV Jakovlev, NA Bushenkova, IY Koulakov... - [Russian Geology and](#) ..., 2012 - Elsevier ... Abstract. We present a new three-dimensional model of P-velocity anomalies in the upper mantle beneath the Circum-Arctic region based on tomographic inversion of global data from the catalogues of the **International Seismological Center** (ISC, 2007). ...

[Crustal structure of the Aegean area obtained by traveltime tomography](#) Y Ma, A Brüstle, L Küperkoch... - EGU General Assembly ..., 2012 - [adsabs.harvard.edu](#)

... Using travel times from the EHB catalog data between 1980 and 1997 from **International Seismological Center** (Engdahl et al. 1998), Euro-Mediterranean Bulletin data between 1998 and 2008 from the Euro-Mediterranean Seismological Center (Godey et al. ...

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[Submarine landslide triggered by volcanic eruption recorded by in situ hydrophone](#) WW Chadwick, RP Dziak, JH Haxel, RW Embley... - ..., 2012 - [geology.gsapubs.org](#) ... A: Bathymetric map showing NW Rota-1 volcano and earthquake epicenters during 2009 (red dots), average swarm location and error (yellow dot and ellipse), and a non-double-couple focal mechanism from **International Seismological Center** (ISC) online bulletin (2011). ...

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(<http://neic.usgs.gov/neis/epic/epic-global.htm>) and HRVD ...

[[Seismicity near the slip maximum of the 1960 Mw 9.5 Valdivia earthquake \(Chile\): Plate interface lock and reactivation of the subducted Valdivia Fracture Zone](#) Y Dzierma, M Thorwart, W Rabbel, C Siegmund... - *Journal of Geophysical ...*, 2012 - agu.org ... respective SEISAN module [Havskov and Ottemöller, 1999]. The Chilean seismic agency SSN reports local magnitudes to the **International Seismological Center** (ISC) since November 2001. The diagram (Figure 5) shows that ...

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EA Bergman, MH Ritzwoller, M Barmin, SC Myers... - 2012 - DTIC Document ... Focal depths are color-coded. • The catalog contains 28,267 earthquakes in the study region, dating from 1923–2008. • The catalog is substantially complete through 2006, in that it incorporates **International Seismological Center** (ISC) data through that time. ...

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[Updating Seismic Hazard Approach: Application to New Metropolitan Area](#)

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[Uncertainty of Apollo deep moonquake locations and implications for future network designs](#)

[S Hempel, M Knapmeyer, ART Jonkers, J Oberst - Icarus](#), 2012 – Elsevier ... The resulting seismic stresses are eventually released as deep quakes. ... The location problem can be solved by several means, eg the frequently used Geiger method (Geiger, 1910), the **EHB** location algorithm applied for the compilation of the PDE catalog by USGS (Engdahl et ...

[Extreme Events and Natural Hazards: The Complexity Perspective](#) [AS Sharma, A Bunde, VP Dimri, DN Baker - 2012 - agu.org](#) ... APDI), 113–114, 115f adaptation/mitigation strategy, 346–347, 351, 353–355 Advanced National **Seismic** System (ANSS) **seismic** catalog, 46, 49 ... 347 empirical orthogonal function (EOF) analysis, 198 energy resources, 354 Engdahl, van der Hilst, and Buland (**EHB**) method, 56 ...

[Aftershock seismicity of the 27 February 2010 < i> Mw</i> 8.8 Maule earthquake rupture zone](#) [D Lange, F Tilmann, SE Barrientos... - Earth and Planetary ...](#), 2012 - Elsevier ... filled a seismic gap (Campos et al., 2002, Comte et al., 1986 and McCann et al., 1979) that has experienced little seismic activity since ... before the M w 8.8 Maule earthquake of 27 February 2010 (yellow star: main shock epicentre in SSN catalogue) from the **EHB** catalogue (1960 ...

[Velocity and Attenuation Structure of the Tibetan Lithosphere Under the Hi-CLIMB Array From the Modeling of Pn Attributes](#) [AC Bakir, RL Nowack - Pure and Applied Geophysics](#), 2012 – Springer ... earthquakes used in this study are reported from either the PDE or Engdahl (**EHB**) catalogs (USGS, 2010 and ENGDAHL et al., 1998; see GRIFFIN et al. (2011) for the specific location information). Six regional events are utilized for modeling of the seismic Pn attributes, one ...

[Constraining sediment subduction: A converted phase study of the Aleutians and Marianas](#) [AC Horleston, GR Helffrich - Earth and Planetary Science Letters](#), 2012 - Elsevier

... A permanent broadband seismic station (GUMO) has been running on the island of Guam since June 1975. ... We used events between January 1986 and December 1998 listed in the Engdahl, van der Hilst and Buland (**EHB**) catalogue (Engdahl et al., 1998) to obtain more ...

[Segmentation of the Izu-Bonin and Mariana plates based on the analysis of the Benioff seismicity distribution and regional tomography results](#) [K Jaxybulatov, I Koulikov... - Solid Earth ...](#), 2012 - solid-earth-discuss.net ... In this study we present a new seismic model of the mantle seismic structure down to 1300 km depth beneath the IBM arc. ... Most of scientists use a revised **EHB** catalogue which was created from careful refining of the ISC data by Engdahl et al. (1998). ...

[New insights on the offshore extension of the Great Sumatran fault, NW Sumatra, from marine geophysical studies](#) [D Ghosal, SC Singh, APS Chauhan... - Geochemistry, ...](#), 2012 - Wiley Online Library ... Earthquake CMT solutions are from Harvard catalog; locations are from the **EHB** catalog. Blue: Normal events, Red: Strike-slip events and Orange: Thrust events. Brown contours indicate area with strong seismic activities discussed in the paper. ...

[Upper-mantle structure beneath the Southern Scandes Mountains and the Northern Tornquist Zone revealed by P-wave traveltimes](#) [AB Medhus, N Balling, BH Jacobsen... - Geophysical Journal ...](#), 2012 - Wiley Online Library ... Hypocentre information originates from mainly the **EHB**-list (Engdahl et al. ... 3) reveal significant traveltimes differences typical between –0.5 and +0.5 s and up to between –1 and +1 s, indicating significant seismic velocity variations at depth across our study area. ...

[Fault plane orientations of deep earthquakes in the Izu-Bonin-Marianas subduction zone](#) [R Myhill, LM Warren - Journal of Geophysical Research: Solid Earth](#) (1978– ...), 2012 - agu.org ... External forces, slab geometry, rates of subduction, thermal structure and inherited seafloor structure could all potentially affect seismic activity and the ... Thin black contours represent a fit to the **EHB** seismicity [Engdahl et al., 1998], approximating the shape of the subducting slab. ...

[The Influence Of Technogenic Impacts On The Hydrogeological Conditions In The City Of Baku](#)

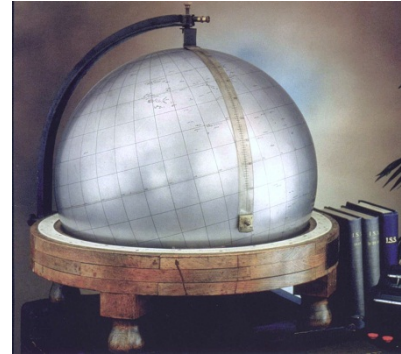
[R İsrailov - seismology.az ...](#) (2006). Red circles are high-quality earthquake epicenters from the **EHB** catalog (Engdahl et al., 1998, and subsequent updates); the size indicated the ... AP is the Absheron Peninsula, CCSZ is the Central Caspian Seismic Zone and BZFTB is the Bitlis-Zagros Fold and Thrust Belt ...

[Constraints on fault and lithosphere rheology from the coseismic slip and postseismic afterslip of the 2006 Mw7. 0 Mozambique earthquake](#) [A Copley, J Hollingsworth, E Bergman - Journal of Geophysical Research: ...](#), 2012 - agu.org ... order to constrain the dip of the fault planes we have performed inversions to find the dip that best fits the **seismic** and geodetic ... The earthquakes were first relocated in single event fashion using the **EHB** methodology [Engdahl et al., 1998] with special attention to the analysis of ...

[Earthquakes in the Eastern Mediterranean](#) [B Shaw - Active tectonics of the Hellenic subduction zone](#), 2012 – Springer ... Table 3.3 Offset between **EHB** locations and those obtained from dense local networks of stations. ... In my modelling procedure I used P ...

SUMMARY OF ACHIEVEMENTS

- Through the support from Member-Institutions and grants from the US NSF, GEM Foundation and CTBTO, the ISC finances stayed healthy, as many as 17 staff members worked during the year and essential improvements to the ISC products and services have been made.
- Parameters of 949 stations have been registered and modified in the International Station Registry.
- Preliminary bulletin data are collected from 28 networks and data centres worldwide.
- Revised bulletins are collected from 132 networks.
- The reviewed ISC Bulletin is produced 24-27 months behind real time.
- For data year 2010, ~61,000 reviewed and ~294,000 un-reviewed (small) events as well as ~10.4 million seismic arrivals were added to the ISC database.
- The ISC database size has increased by ~22% in just one calendar year and reached 113Gb 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 ISC development projects included:
 - The ISC-GEM Global Instrumental Earthquake Catalogue (1900-2009);
 - The CTBTO Link to the ISC database;
 - Printed Summary of the ISC Bulletin;
 - The ISC Event Bibliography;
 - The ISC Bulletin Rebuild (1960-2009);
 - The International Seismological Contacts
- The ISC database and the website mirror were operated at IRIS DMC in Seattle and the ERI in Tokyo. This improved the speed of access to the ISC data users.
- We continued maintaining the IASPEI Reference (GT) Event List and EHB Bulletin.
- The ISC staff participated in a large number of conferences and 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.



Signed, July 5, 2013

Dr. Dmitry A. Storchak
The Director