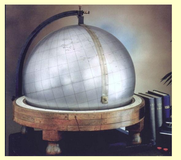
Developments at the International Seismological Centre (ISC).

***Dmitry Storchak**, István Bondár, James Harris and Emily Delahaye*
dmitry@isc.ac.uk,
www.isc.ac.uk

The International Seismological Centre (ISC) is a non-governmental, non-profit making organization supported by 55 research and operational institutions around the world.



MISSION and STATUS

Bulletin

The prime ISC mission is to compile the Bulletin that serves as the definitive summary of global seismicity. The ISC Bulletin is the longest continuous and uniform set of seismic event hypocentre solutions, moment tensors, magnitudes, felt and damage reports and station arrival information. To produce the Bulletin, the ISC receives parametric bulletin data for natural and non-natural seismic events from over 120 seismic networks worldwide.

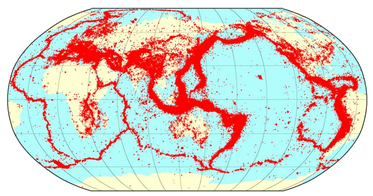


***Figure 1a.** ISC Bulletin epicentres for natural, induced and man-made seismic events 1964-2011.*

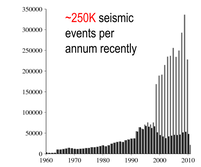


***Figure 1b.** Number of reviewed (black) and un-reviewed (grey) events (1960-2011) in the ISC Bulletin*

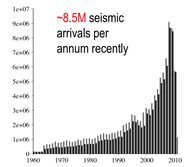


***Figure 1c.** Number of all seismic station arrivals (grey) and those associated with events in the ISC Bulletin events (black) (1960-2011)*

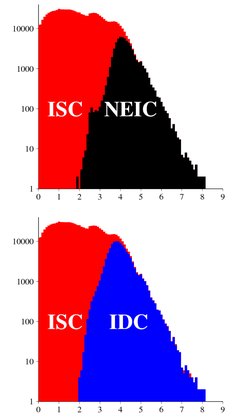


***Figure 1d.** Comparative magnitude completeness of the ISC, NEIC and IDC bulletins (2005-2008).*

Station Registry

The ISC, together with the World Data Center for Seismology, Denver (NEIC), is responsible for running the International Seismographic Station Registry (**IR**).

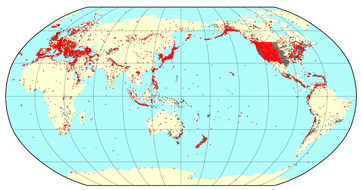


***Figure 2.** 16,606 stations, open or closed, are currently registered in the IR. 5445 (red) of these reported seismic arrival data to the ISC in 2008. US Array stations are prominent in N. America.*

GT

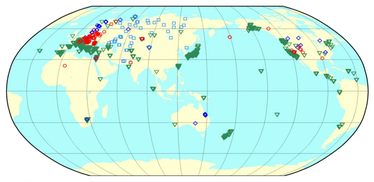


***Figure 3.** 7,334 GT0-5 events with station arrivals.*

The ISC maintains the IASPEI Reference List (GT0-5). GT (ground truth) locations at 95% confidence level are necessary to validate 3D earth models against observed travel-times.

EHB

The EHB (E..R. Engdahl, R.D. van der Hilst, R. Buland,1998) catalogue is predominantly based on 20% of larger events in the ISC Bulletin. It contains a set of the most accurate seismic event locations regularly used in seismic tomography. The EHB catalogue is hosted on the ISC website and currently contains over 140,000 events along with roughly 20 million phase arrivals.

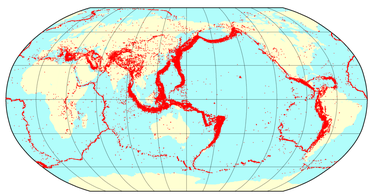


***Figure 4.** EHB catalogue epicentres for 1960-2008.*

RECENT DEVELOPMENTS

Timeliness of the ISC Bulletin

Currently, the analysis of the Final ISC Bulletin occurs roughly 24 months behind real-time. However, we are making steps to bring the ISC Bulletin schedule to 15-18 months behind real-time.

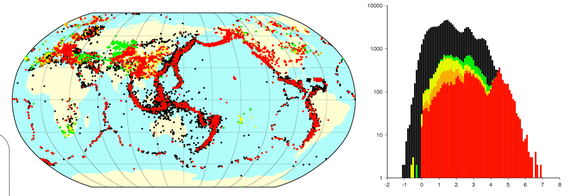
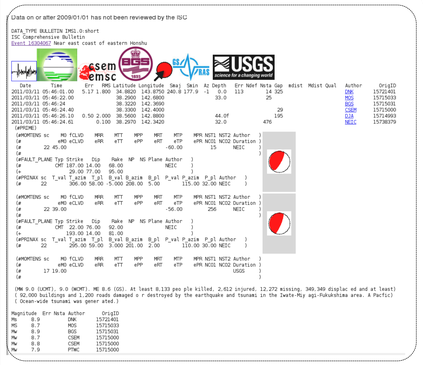


***Figure 5.** Events first reported within 3 days of occurrence, 7 days, 1 month, 4 months, and greater than 4 months for the period May-Aug 2009.*



The ISC Preliminary Bulletin is available on the ISC website and is based on preliminary hypocentre solutions and station arrival data. Many seismic events are reported to the ISC within 3 days after event occurrence. Final network bulletins arrive at the ISC approximately 12 months after event occurrence, and at this time the corresponding preliminary solutions are discarded and the ISC's own hypocentre solutions and magnitudes are computed and thoroughly reviewed at this point.

***Figure 6.** The preliminary hypocentre solution from the ISC website for the 2011 March 11, M 8.9 Sendai main shock. This event has not yet been analysed by ISC seismologists, however, there are hypocentres (6), magnitudes (22) and station arrivals (3896) from 16 different seismic agencies available already. This information was first available within hours and is subsequently updated as new data become available.*

The New ISC Earthquake Locator

A major change to the ISC earthquake location procedures has recently occurred with the introduction of the new ISC earthquake locator. The ISC earthquake location algorithm had remained unchanged for many years, but has been improved greatly by the upgrade. The new locator has been operational since the start of data year 2009.

The new location algorithm:

- ✓ uses all ak135 predicted phases
- ✓ obtains an 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
- ✓ provides robust network magnitude estimates with uncertainties
- ✓ attempts free-depth solution only in the presence of local networks or reported depth-sensitive phases
- ✓ if there is no depth resolution, the depth is fixed to a region-dependent default depth

Relocation tests on seismic events in the IASPEI Reference List (GT) demonstrated that the new locator provided improvements in locations and depth determinations and more accurate formal uncertainty estimates. The new locator reduces the scatter in event locations as seen in the better clustering of events (Figure 7).

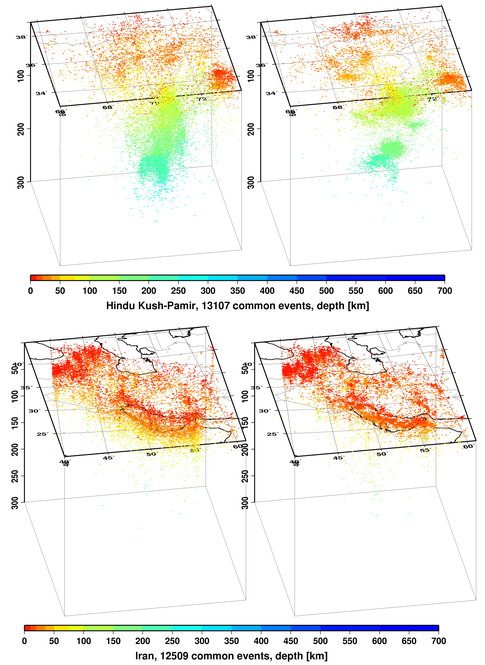
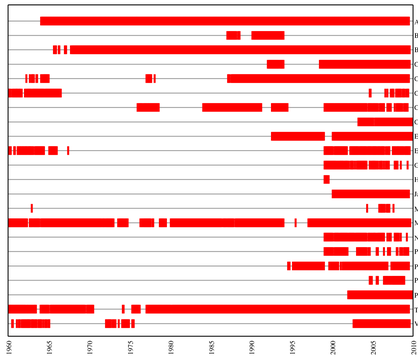


***Figure 7**. 3D view of seismicity in Hindu Kush-Pamir (top and Iran (bottom) as located by the old (left) and the new (right) ISC Location algorithm.*

MAJOR PROJECTS

Re-build of the entire ISC Bulletin (1960-2009)



The ISC is currently engaged in the project of re-building the entire ISC Bulletin. All ISC Bulletin hypocentres will be re-computed with the new ISC event locator, using the ak135 velocity model and uniform set of seismic phases. Magnitudes will be re-computed with uncertainties.

In addition, we will introduce and integrate those essential bulletins that were not available at the time of original ISC Bulletin production, including permanent networks, temporary deployments and OBS installations.

***Figure 8.** Gaps in event hypocentre reporting from countries in Central and South America.*

Global Instrumental Catalogue (1900-2009)

The ISC is leading an international team working on the compilation of the Reference Global Instrumental Earthquake catalogue to be used by GEM (Global Earthquake Model) for characterization of the spatial distribution of seismicity, the magnitude frequency relation and the maximum magnitude.

Bob Engdahl, Antonio Villaseñor, Willie Lee, Peter Bormann, Graziano Ferrari are collaborating with the ISC on this project.

Deliverables:

- ✓ 110 years of earthquake hypocentres based on uniform modern location techniques and velocity models;
- ✓ M_S magnitudes (with uncertainty) based on data, mostly unavailable in digital format in the past;
- ✓ M_W values (with uncertainty) based on seismic moment where possible and proxy values in other cases using appropriate empirical relationships;
- ✓ Database with references to original sources, including scanned historical pages.

Target Global Completeness:

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

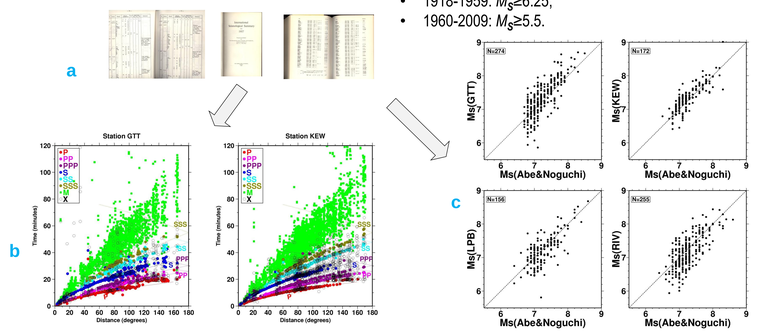


***Figure 9**. As historical records (a) are entered into the database, travel-time plots (b) of various seismic phases are reviewed for usability of the new arrival times in re-location procedure and station M_S magnitudes are computed (c) for events with known reliable event magnitude sources such as Abe and Noguchi. These data were never compiled on a global scale before. We hope to improve the parameterisation of many large earthquakes, especially those in the first half of last century.*

CTBTO Link to the ISC database

The United Kingdom Foreign and Commonwealth Office along with partners from four Nordic countries funded the project to make the ISC database of seismic events securely linked with computer facilities of PTS and NDCs. This has been achieved and CTBTO is taking over the funding from April 2011, which will pay for further development. The Link allows the monitoring community a historical perspective into the wealth of seismic data recorded by the research community worldwide.

References:

Abe, K., Magnitudes of large shallow earthquakes from 1904 to 1980, Phys. Earth Planet. Inter., 27, 72-92, 1981.

Abe, K. and S. Noguchi, Revision of magnitudes of large shallow earthquakes, 1897-1912, Phys. Earth Planet. Inter., 33, 1-11, 1983.

Bondár, I. and D. Storchak, Improved Location Procedures at the International Seismological Centre, submitted to Geophys. J. Int., 2011.