



# DATA SETS FOR MONITORING RESEARCH AT THE INTERNATIONAL SEISMOLOGICAL CENTRE (ISC)



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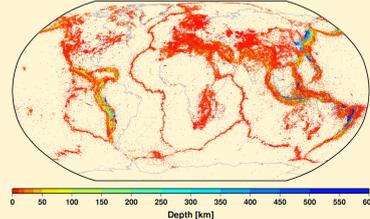
## ISC Bulletin

The International Seismological Centre (ISC) is a non-governmental, non-profit making organization supported by 55 research and operational institutions around the world. The prime mission of the ISC is to compile and distribute the ISC Bulletin that serves as the definitive summary of global seismicity. The ISC Bulletin is the longest continuous and uniform set of bulletin data. To produce this bulletin, the ISC receives and processes parametric data for natural and non-natural seismic events from over 120 seismic networks worldwide.

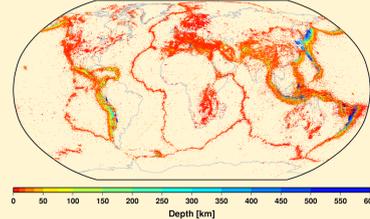
The ISC Bulletin includes hypocentre solutions, damage reports, source mechanisms, magnitudes and station arrivals. Because of its international and non-governmental status, the ISC is able to collect seismic bulletin information from 120 agencies worldwide.

As the number of seismic networks has grown over the years, the ISC is collecting progressively larger number of seismic events, phases and amplitudes each year. In order to cope with the exponentially growing data volume, since 1999 ISC seismologists review only those events with magnitude larger than  $-3.5$ . Nevertheless, all reported events are available at the ISC website, [www.isc.ac.uk](http://www.isc.ac.uk).

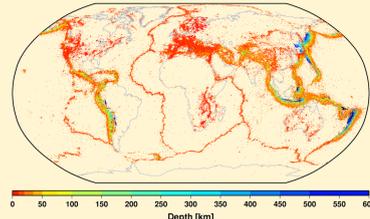
ISC Bulletin 1960-2011, ~4M events



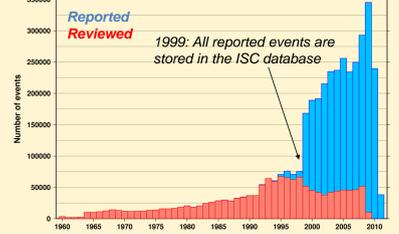
Reviewed ISC Bulletin 1960-2009, ~1.5M events



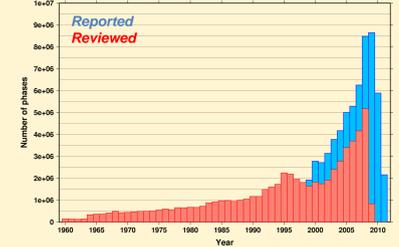
ISC Locations 1960-2009, ~1.1M events



Number of events reported to / reviewed by the ISC

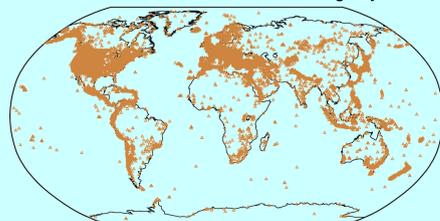


Number of associated phases reported to / reviewed by the ISC



## International Registry of Seismograph Stations

The ISC, in conjunction with the World Data Center for Seismology (NEIC), is responsible for running the International Registry of Seismograph Stations.



Some 16,000 stations, open or closed, are currently registered in the IR. Recently ~5,000 of those report seismic arrival data to the ISC each year. The registry includes the USArray and IberArray stations, as well as the IMS seismic, infrasound and hydroacoustic stations.



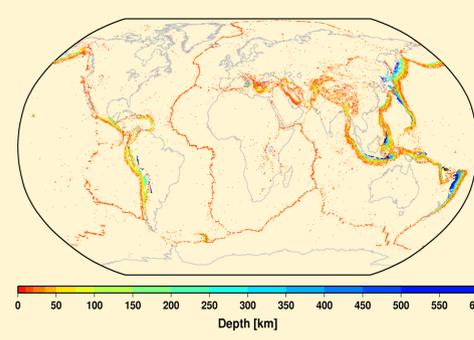
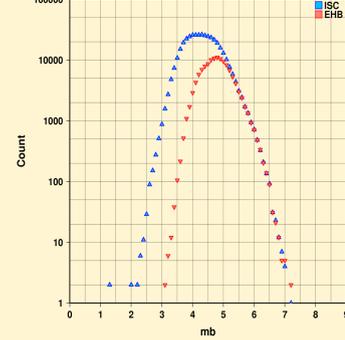
At the ISC web-site one can submit information to register a new station as well as search and obtain information about already registered stations.

## EHB – Groomed ISC Bulletin

The EHB (E.R. Engdahl, R.D. van der Hilst, R. Buland, 1998) catalogue contains a set of most accurate seismic event locations regularly used in academic research. The EHB algorithm has been used to significantly improve routine hypocenter determinations made by the ISS, ISC and PDE. The EHB algorithm uses

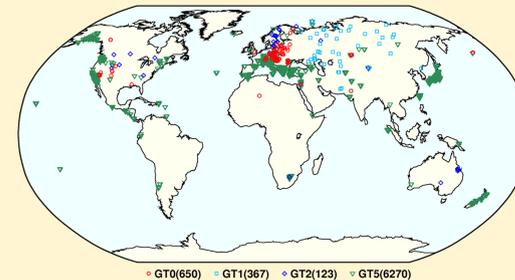
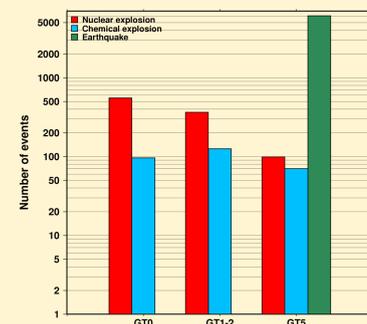
- The ak135 1D global travel-time model with ellipticity and elevation corrections
  - Iterative relocation with dynamic phase identification
  - First arriving P, S and PKP phases and teleseismic depth phases pP, pwP and sP
  - Empirical teleseismic patch corrections (for 5x5 degree patches)
  - Weighting 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  $< 180^\circ$
- The EHB bulletin is regularly updated by Bob Engdahl
- The EHB is hosted on the ISC website and currently contains some 138,000 events between 1960 and 2004 accompanied with ~20,000,000 arrival data

EHB bulletin 1960-2007 (138394 events)



## IASPEI Reference Event List of GT0-5 events

- GT (ground truth): locations known at high, 95% confidence level
- GT0-5 locations are necessary to
  - Validate 3D Earth models against observed travel-times
  - Test new location algorithms
  - Develop empirical path corrections
  - Assess the accuracy of published bulletins
- The effort was coordinated by the CoSOI/IASPEI Working Group on Reference Events for Improved Locations co-chaired by Bob Engdahl and Paul Richards
- The data set is hosted on the ISC website and currently contains 7,410 GT0-5 events between 1962 and 2008 accompanied with ~500,000 arrival data



## New ISC Location Algorithm

The ISC location algorithm remained virtually unchanged in the past 40 years. The introduction of the ak135 travel-time predictions in event locations in 2006 presented an opportunity to incorporate state-of-the-art methodologies in the ISC location procedures to further improve the accuracy of event locations in the ISC bulletin. The new locator has been operational since the start of data year 2009.

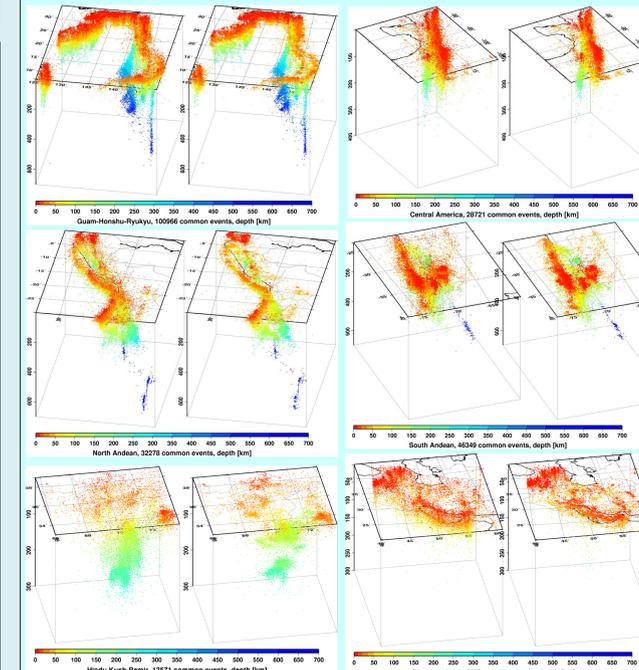
The new location algorithm:

- 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 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

The new location algorithm was validated by relocating more than 7,000 events in the IASPEI Reference Event List, as well as by relocating the entire ISC bulletin. The new ISC location algorithm, by using later phases, testing for depth resolution and accounting for correlated travel-time prediction errors:

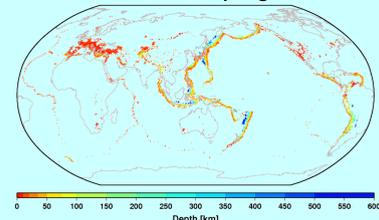
- provides small, but consistent location improvements
- considerable improvements in depth determination
- reduces location bias due to correlated travel-time errors
- obtains reliable uncertainty estimates with 85% actual error ellipse coverage.

Comparison between the reviewed ISC Bulletin (left) and unreviewed locations with the new ISC location algorithm (right)



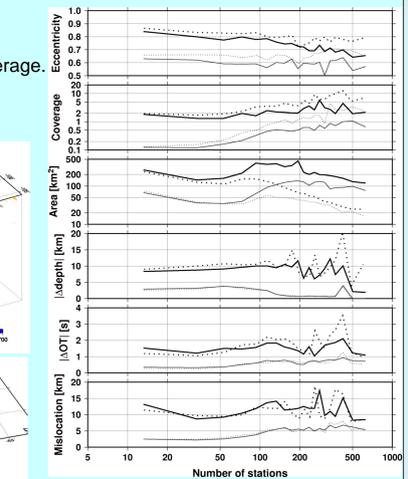
The new ISC locator provides better clustering of events, thus giving an improved view of the seismicity of the Earth.

ISC default depth grid



The ISC default depth  $0.5^\circ \times 0.5^\circ$  grid, derived from the EHB bulletin and relocated free-depth solutions, provides a reasonable default depth for seismically active regions.

Validation test: GT0-5 relocations



Median (thin grey) and 90% percentile (thick black) mislocation, origin time and depth difference, error ellipse area, location coverage and error ellipse eccentricity as a function of number of stations with the old (dotted lines) and new (solid lines) ISC locator. When correlated errors are accounted for, the size of error ellipse levels off, providing better coverage, and the hypocenter bias is reduced once the information contained in the network is exhausted. Because the (eigen)network is more balanced, the error ellipses become more circular.