

CTBTO Contribution to the

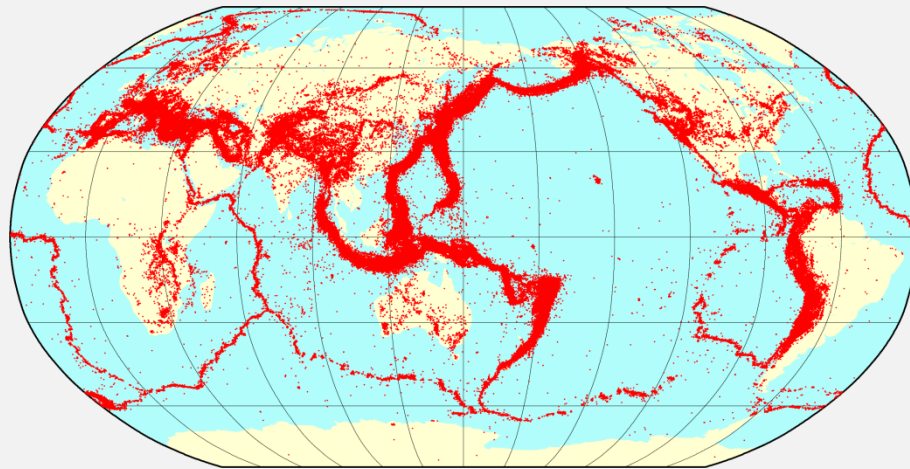
Global Earthquake Data Collection: a view from the International Seismological Centre (ISC)

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www.isc.ac.uk

ISC Mission

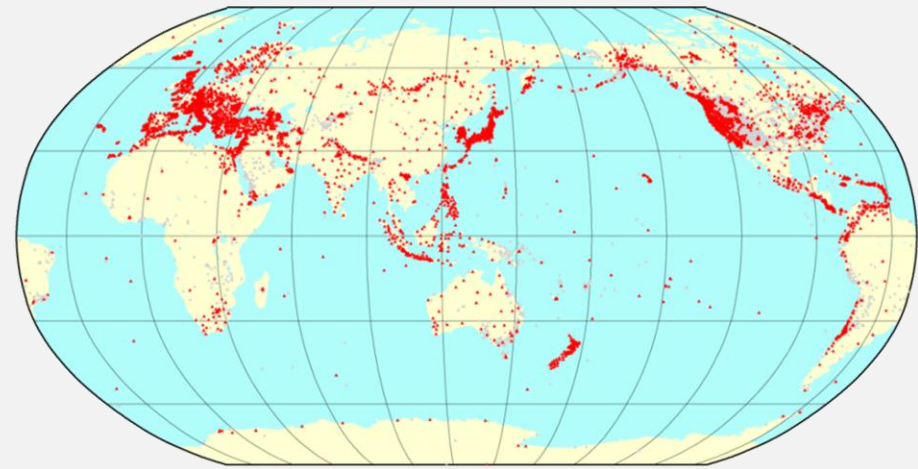
1. **ISC Bulletin** - the definitive & the longest continuous & uniform summary of the world seismicity



1960-2011

2. International Seismographic **Station Registry**

(with WDC for Seismology, Denver, USGS)



1904-2011 **16,802** stations,
(incl. ~1,600 of USArray)

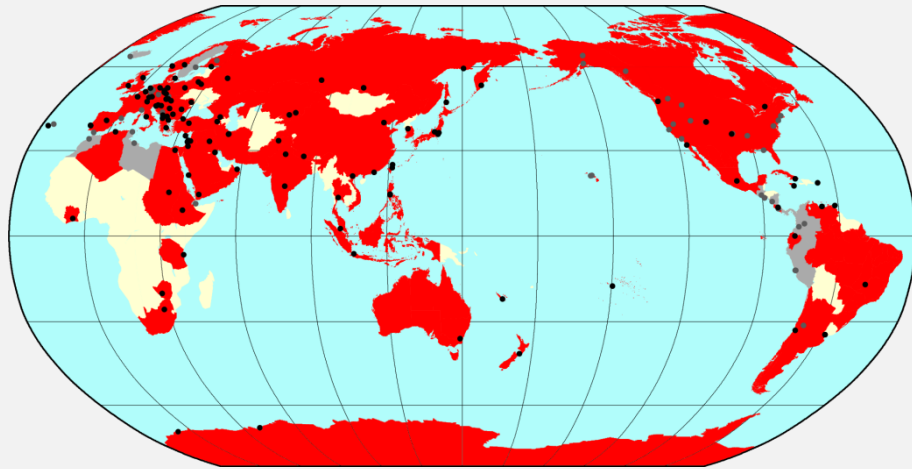
3. **Reference event collection (GT0-5)**
(with IASPEI)



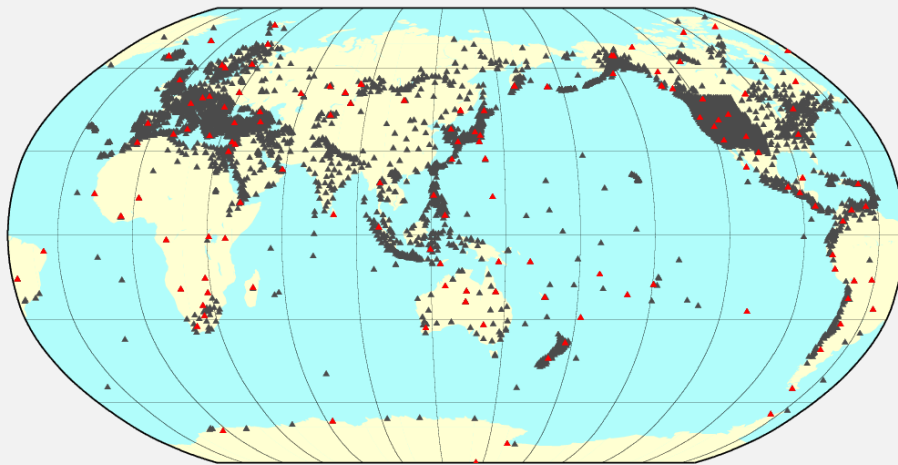
7,410 GT(0-5) seismic events
with station arrivals

1962-2008

REB value in global summary of seismicity



120 seismic networks report to the ISC directly (red) or via regional data centres (grey)



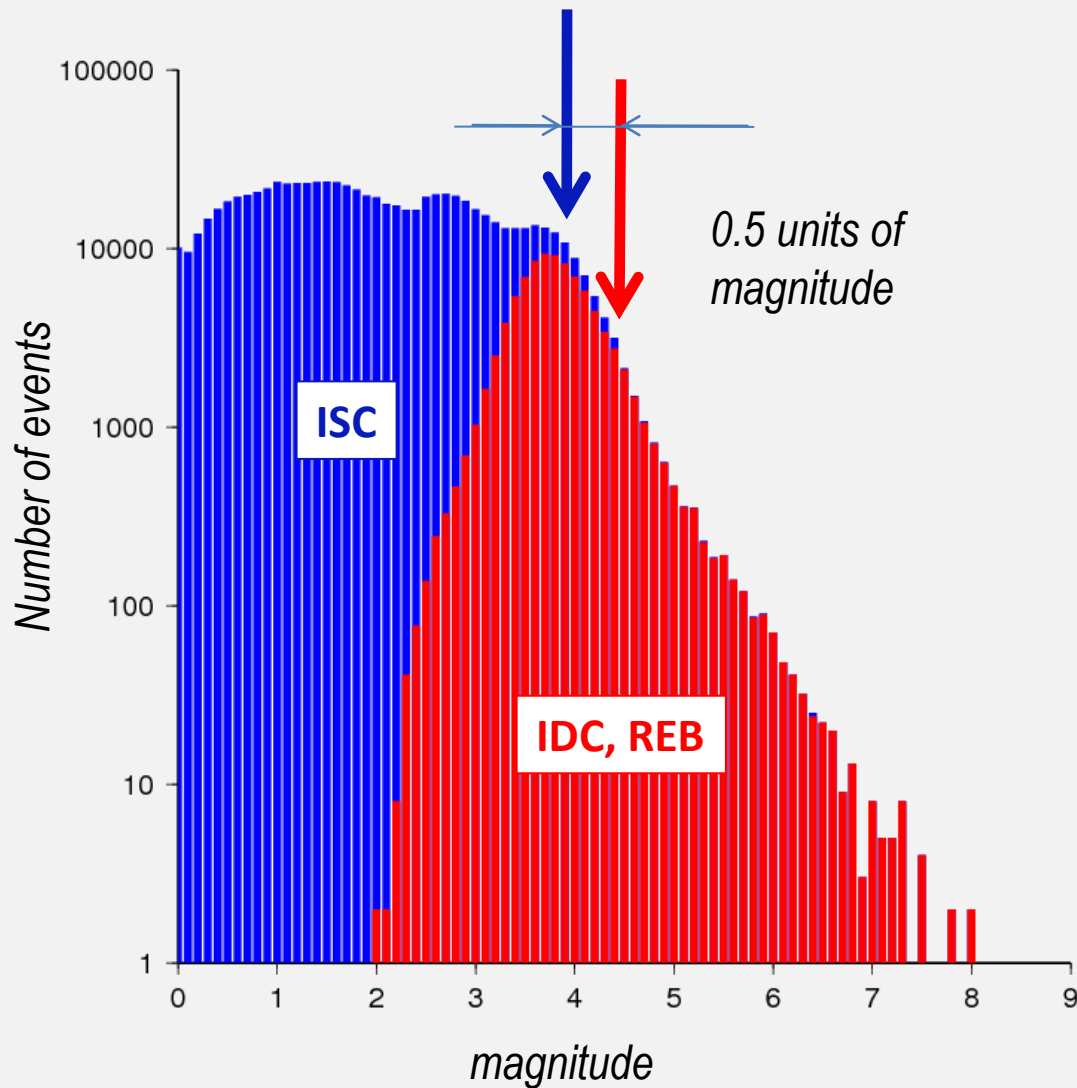
IMS seismic arrays and stations (red); non-IMS arrays and stations that take part in international data exchange (black)

- ❑ ~120 seismic networks report seismic bulletin data to the ISC;
- ❑ The Reviewed Event Bulletin (REB) of IDC/CTBTO is an integral part of this data collection;
- ❑ The **REB** is indeed a **critical component** of the global seismicity summary.

Features of the CTBTO input:

- ✓ High quality certified instruments;
- ✓ Globally distributed;
- ✓ Data are 100% reviewed;
- ✓ Consistency in procedures over long period of time;
- ✓ On average, high accuracy arrival picking & phase identification thanks to array processing;
- ✓ Reasonably well documented procedures;
- ✓ Complements an alternative set of picks from co-located with CTBTO stations.

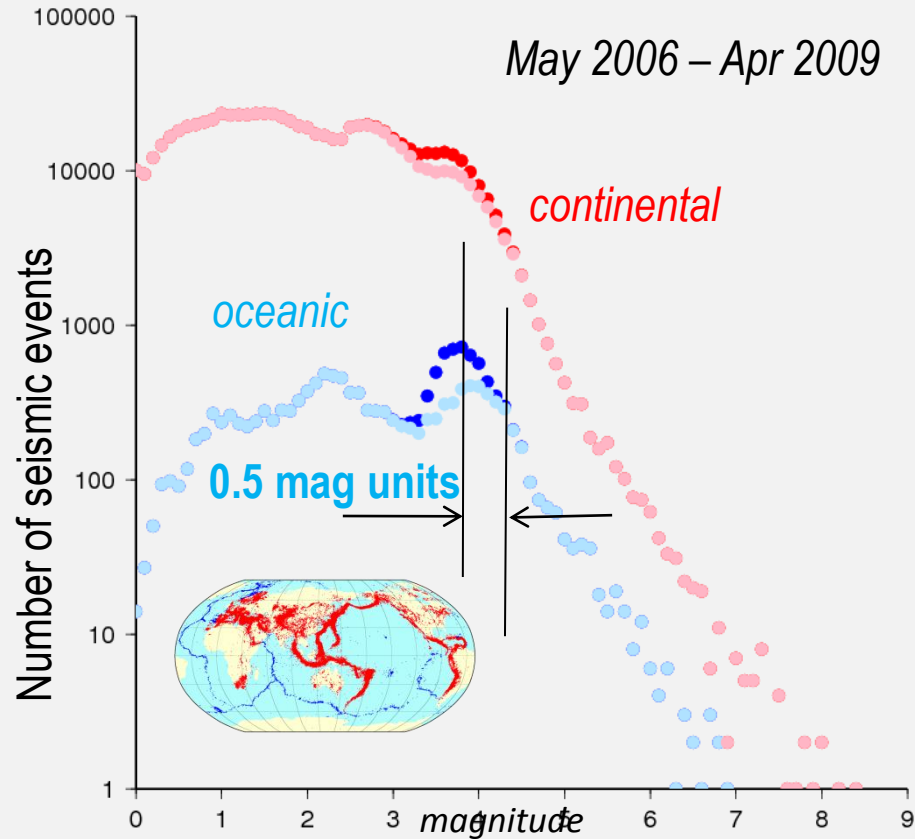
Overall Completeness



May 2006 – Apr 2009

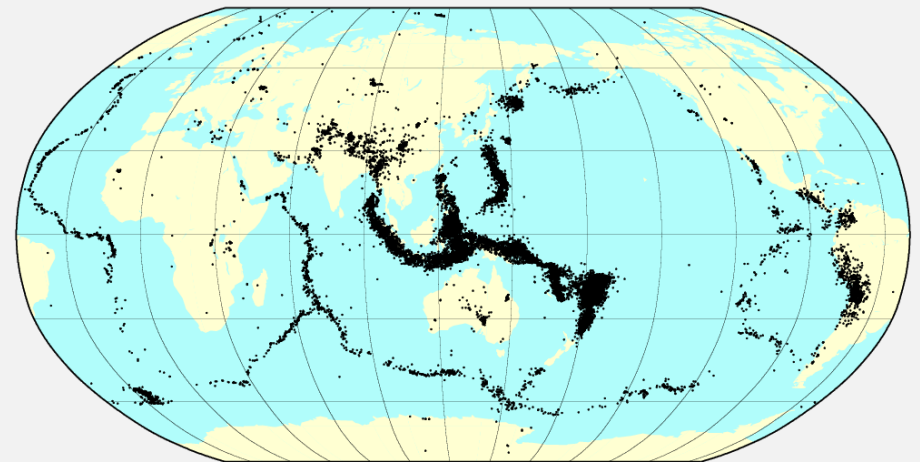
- ❑ The difference in completeness of the ISC Bulletin and the IDC REB is small.
- ❑ Using a network of only a few tens of seismic installations around the world, the CTBTO is capable of detecting all events with magnitude above 4.2 reported by world-wide networks of thousands of seismometers.
- ❑ The ISC Bulletin provides an authoritative independent reference for studies of the REB completeness and evaluation of possible missed events.

Monitoring Continental & Oceanic Seismicity



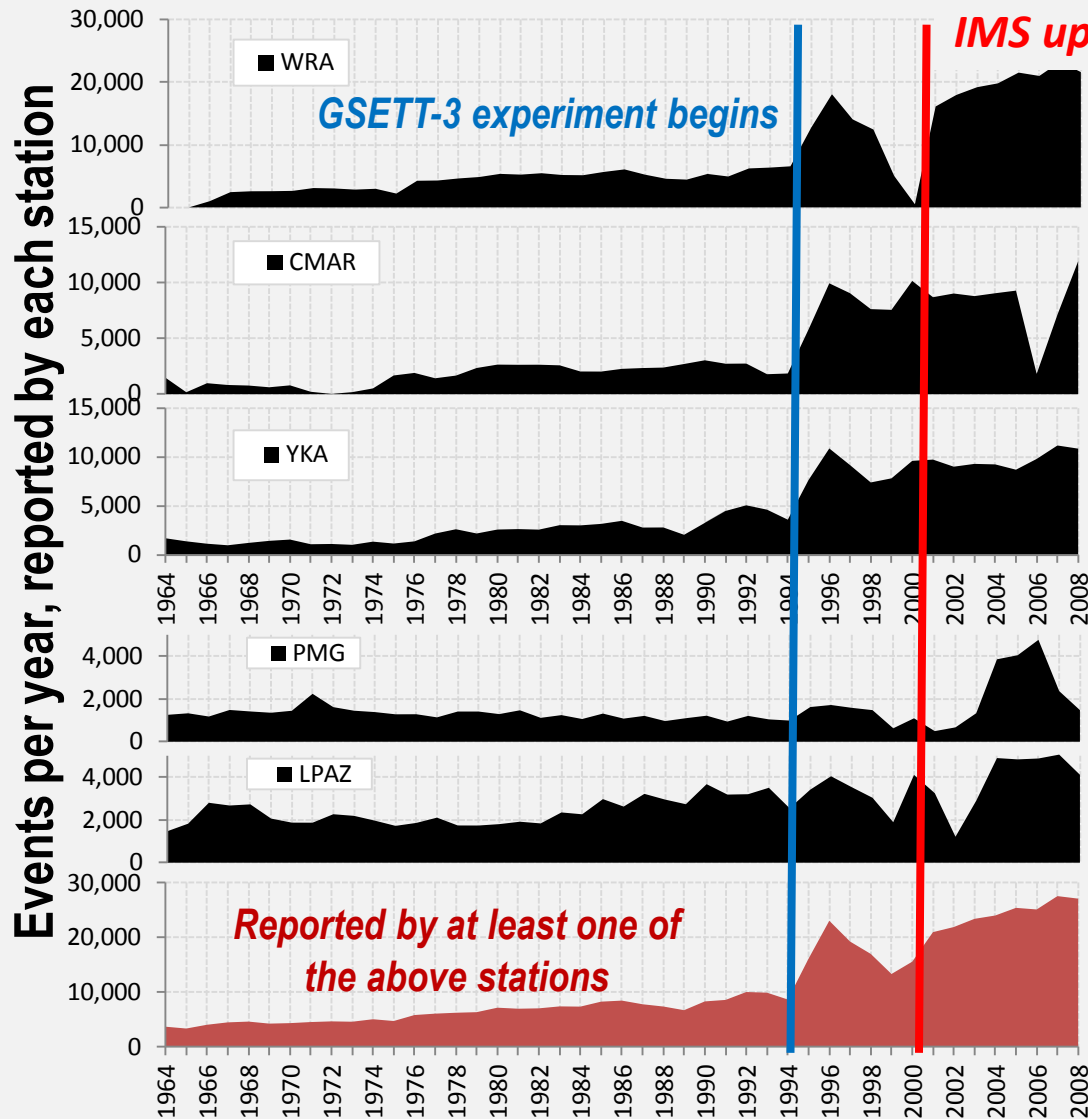
Bright red & blue colours indicate the CTBTO contribution in completeness of the ISC Bulletin in **continental** and **oceanic** areas.

- One of the most important CTBTO contributions to monitoring of the world seismicity is the systematic reporting of seismic events in oceanic areas where seismic networks are sparse or non-existent.
- The ISC Bulletin would have been **0.5** units of magnitude less complete in the **oceanic areas** without CTBTO.



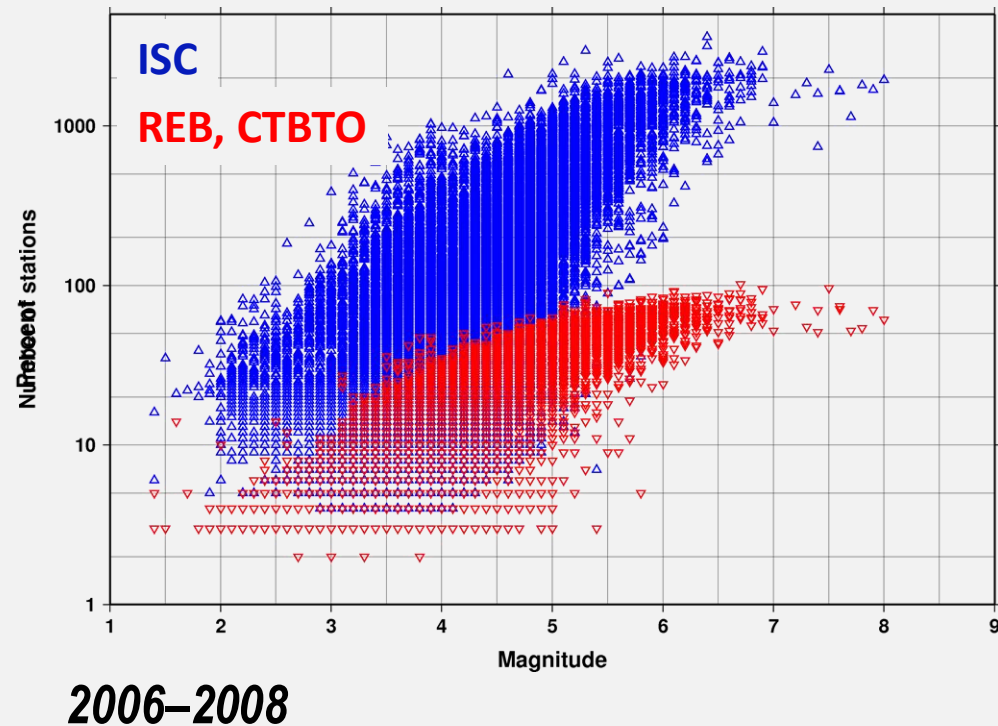
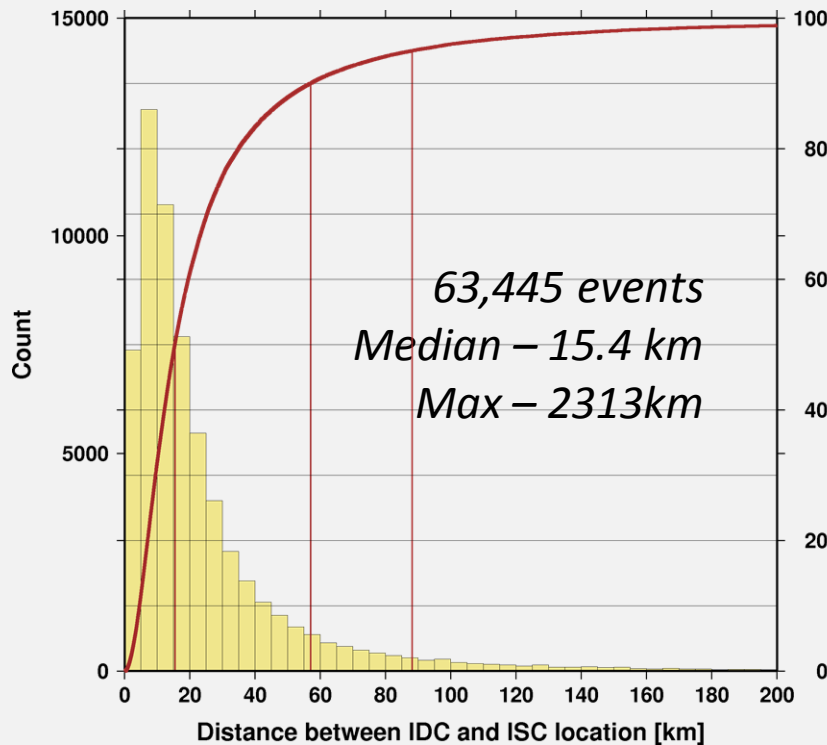
~**9,400** events a year are reported to the ISC by the CTBTO only

Improvements in Event Detection



- Many seismic stations were operated for decades before becoming part of the IMS network.
- GSETT experiments, followed by the upgrade to IMS standards typically resulted in a considerable increase of the number of reported events and seismic arrivals and **lowered detection thresholds**.

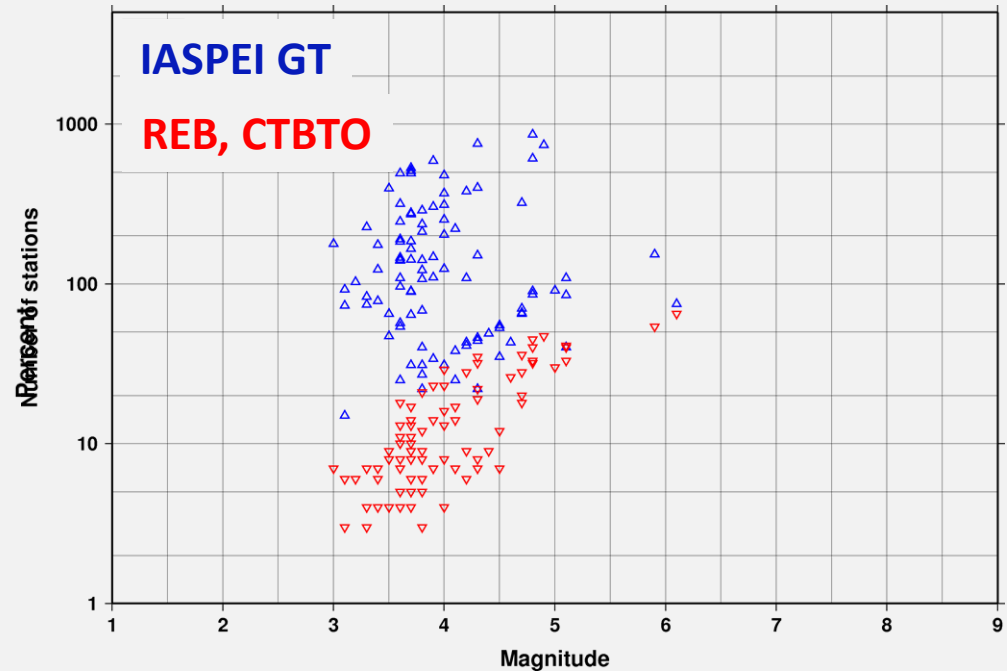
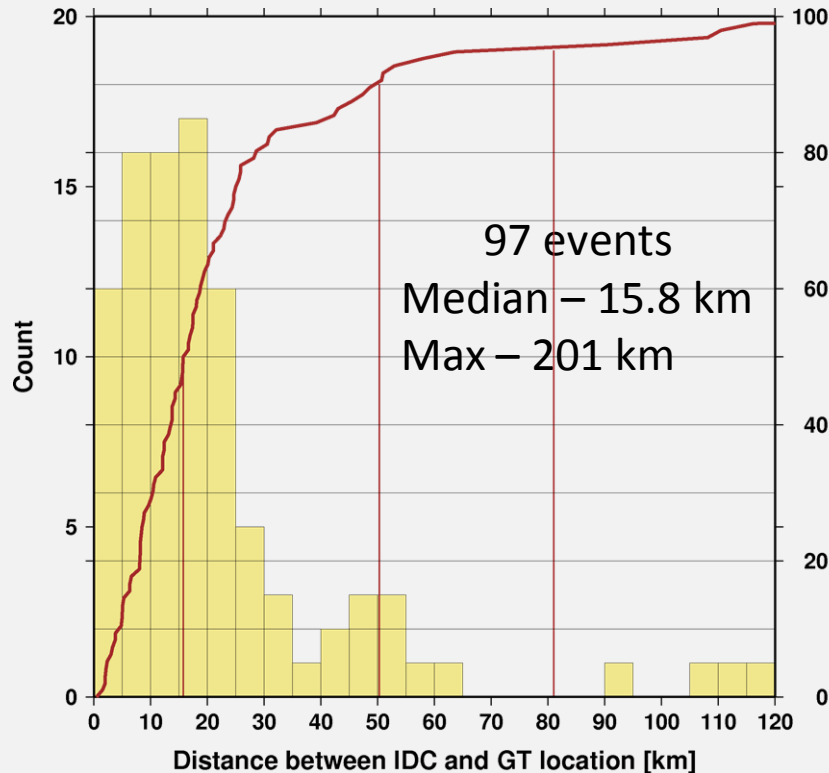
Event Location: CTBTO versus ISC



Technically, the ISC locations can not be considered as “ground truth” as these are biased by uneven configuration of network, location procedures and the standard 1D velocity model used. Yet the sheer volume of stations used by the ISC, including those very close to events, compared to CTBTO, in general should provide reasonably high degree of accuracy.

The fact that as many as 50% of IDC locations are within 16 km of corresponding ISC locations and as many as 90% are within 57 km is indicative of a good CTBTO performance.

Event location: CTBTO versus IASPEI GT

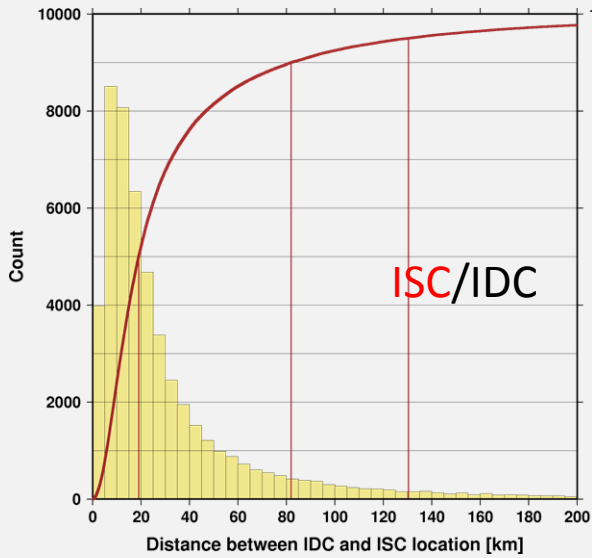


2006–2008

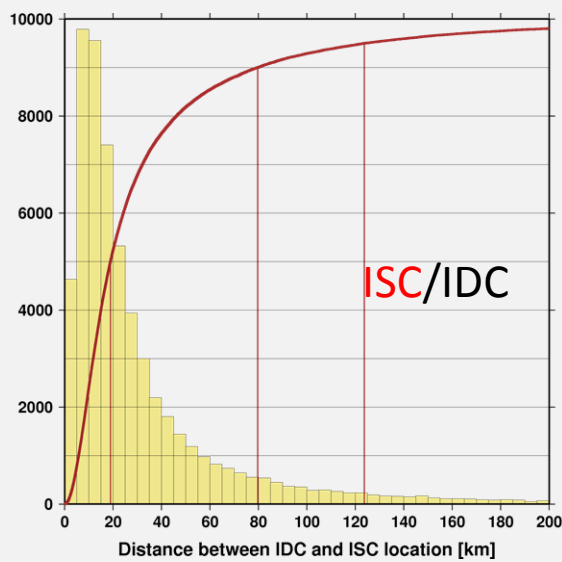
The ISC maintains the IASPEI collection of Ground Truth events. Between Jan 2006 and Dec 2008 these are just 97 moderate to large and very well constrained earthquake locations (up-to GT5).

As many as 50% of REB events are within 16 km of the GT locations and as many as 90% within 50 km of GT.

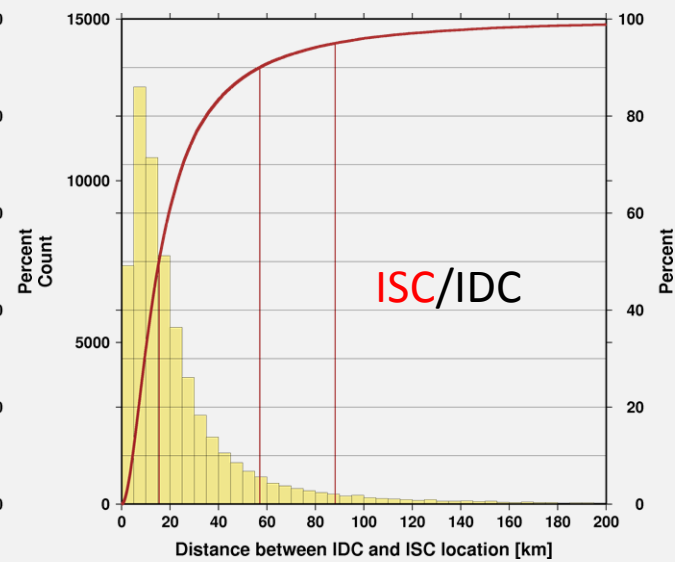
Event Location: Timeline



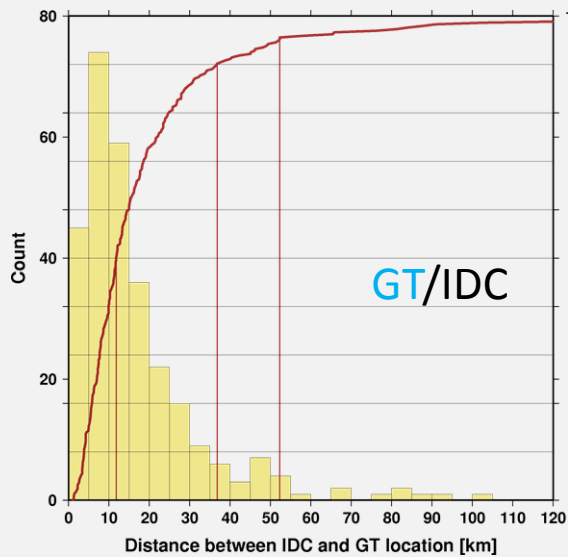
2000-2002



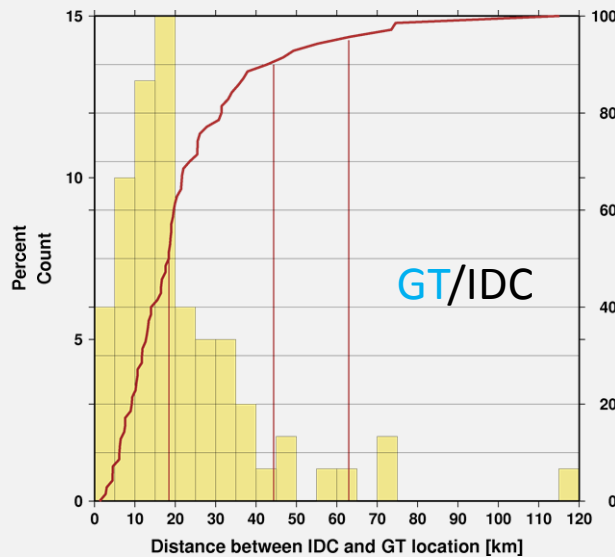
2003-2005



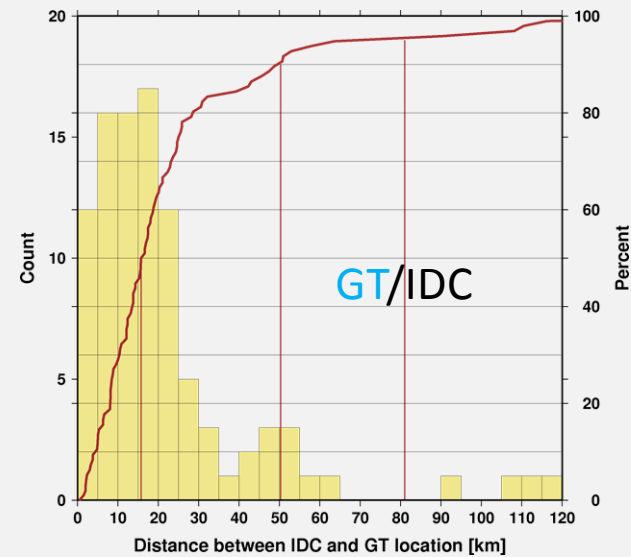
2006-2008



10 June 2011

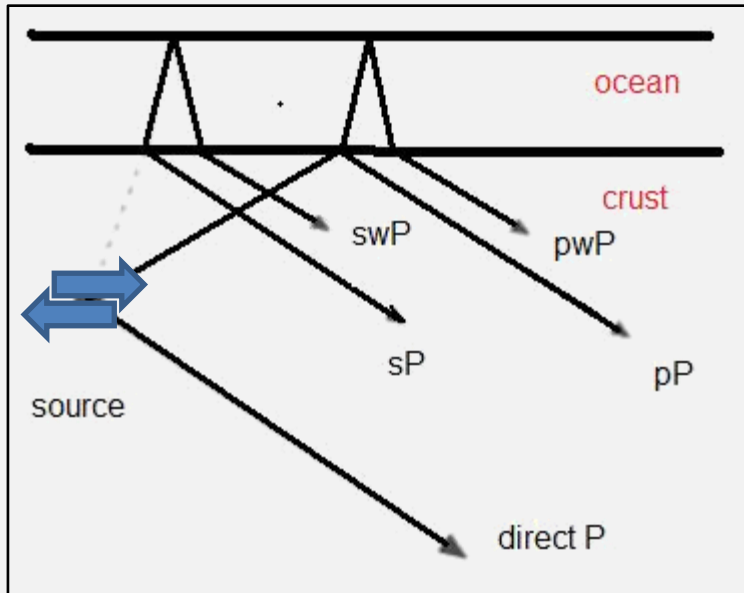


Science & Technology, Hofburg, Vienna

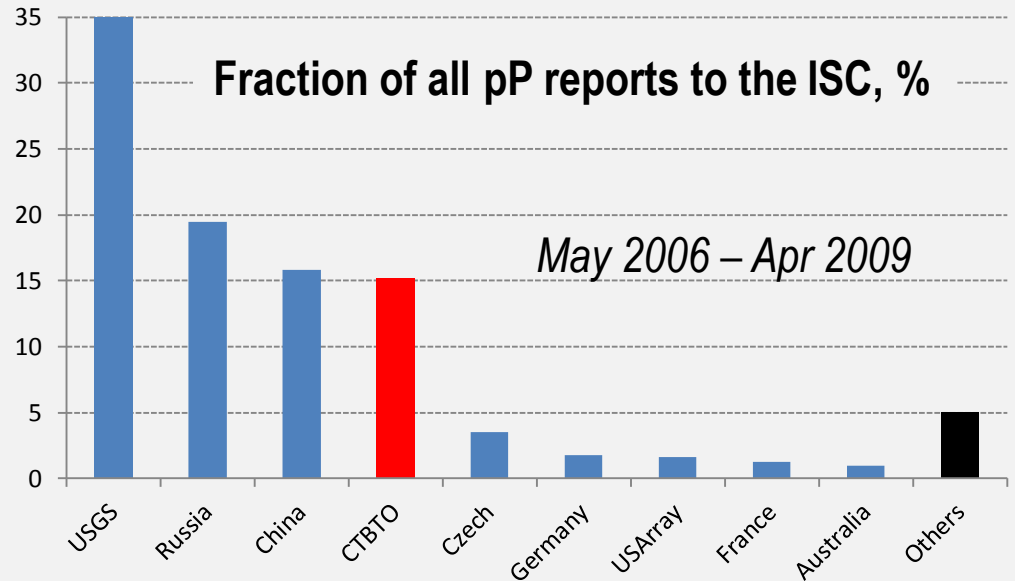


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Constraining Event Depth

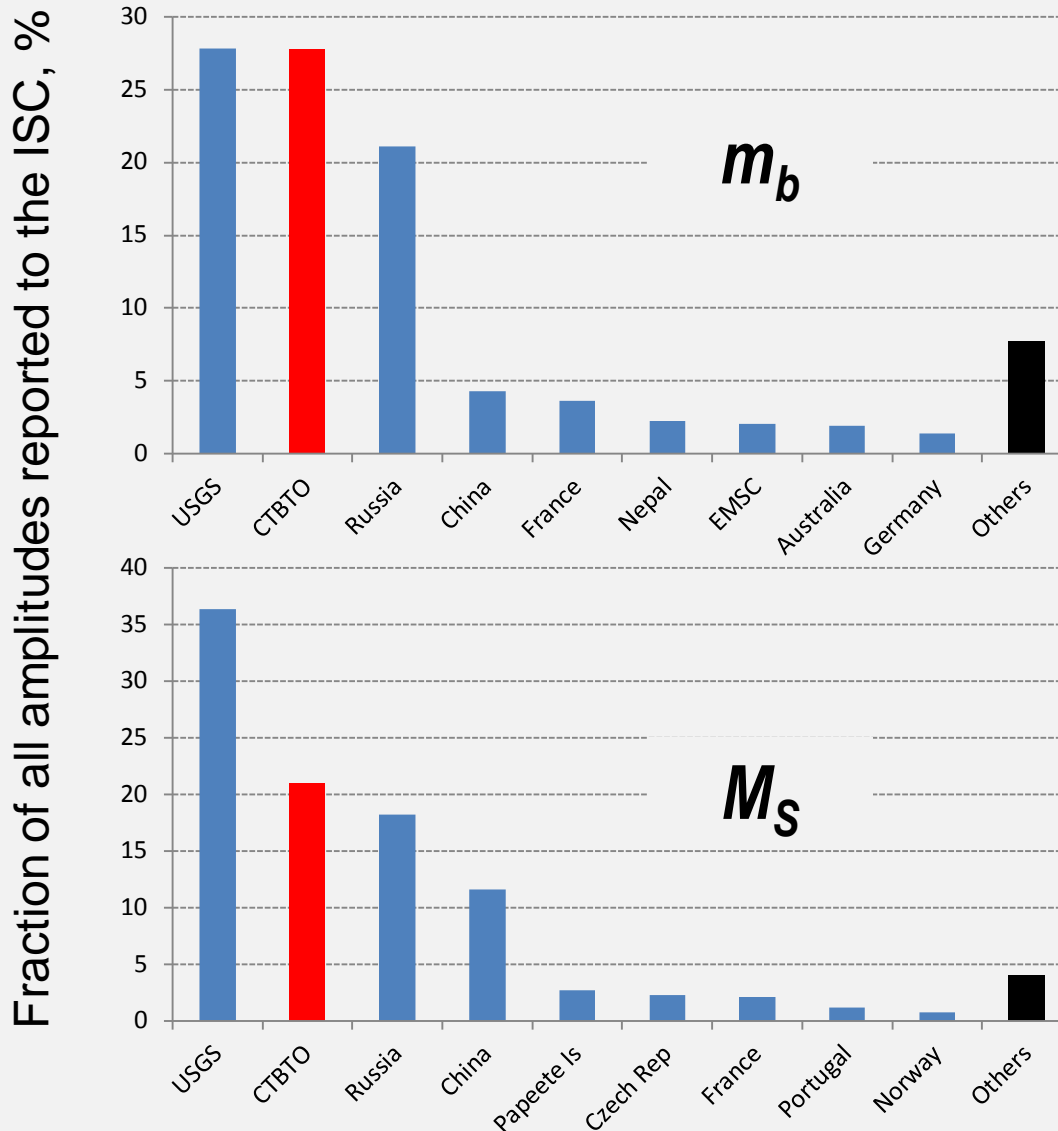


In the absence of very close seismic stations it helps to constrain the depth of seismic events using differential times of arrival of direct P wave and waves reflected from free crust or ocean surfaces (pP, sP, pwP, swP).



- ❑ CTBTO contributes 15% of all pP reports to the ISC;
- ❑ It is especially valuable that CTBTO reports are reviewed and where necessary re-picked by the IDC analysts;
- ❑ Due to well known difficulty and, at times, parochial practices of picking predicted pP arrivals by some agencies, it is important for the ISC that pP picks from other networks are complimented by those of CTBTO.

Contribution to Magnitude Estimation



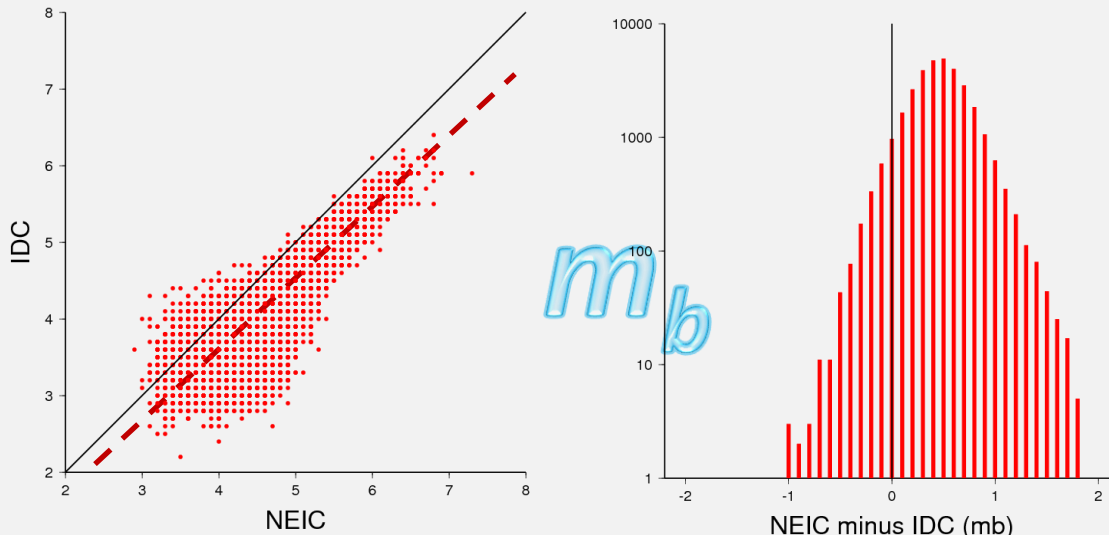
Body (m_b) and surface (M_s) wave magnitudes are important parameters of seismic events used in many fields, especially seismic hazard assessment and nuclear test monitoring.

Contribution of the CTBTO is enormous but has its positive and negative sides.

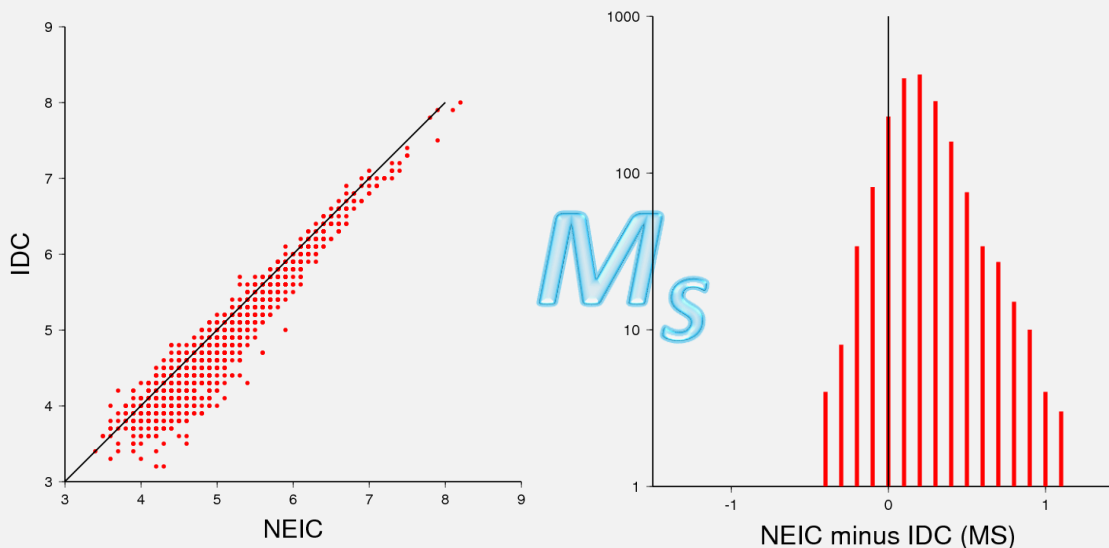
Many events, especially in oceanic areas, would have no magnitude estimate at all had the wave amplitudes not been measured and reported by the CTBTO.

May 2006 – Apr 2009

m_b & M_S : Deviating Standards



There is, on average, almost 0.5 unit difference between CTBTO and traditional m_b . This difference is dependent on m_b .



Unlike the ISC, the National Earthquake Information Center (NEIC) of USGS does not include CTBTO amplitude reports in computation of its magnitudes. Instead, the NEIC followed the procedures described in the standard Manual of Seismological Observatory Practice (Willmore, 1979).

There is a considerable **deviation** between the CTBTO and NEIC estimates, most noticeably in m_b .

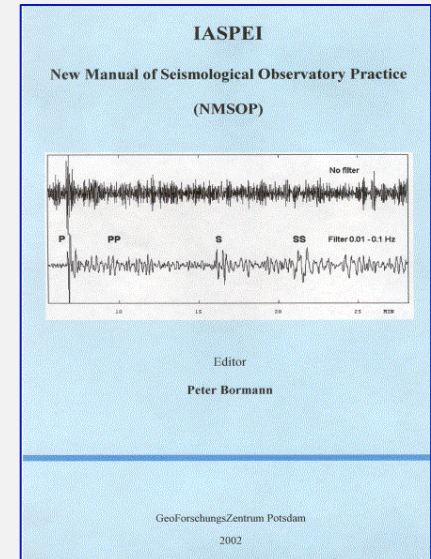
How can the CTBTO help further?

CTBTO standards to measure amplitudes (filtering & time window) of seismic waves to estimate the m_b and M_s have been set to fulfil the prime CTBTO mission – to verify and monitor compliance with the Treaty.

We propose that **without changing the existing procedures** CTBTO could **also adopt** the magnitude **standards** laid out by the International Association of Seismology and Physics of the Earth Interior (**IASPEI**) to produce an additional set of amplitudes and magnitudes.

This **alternative data set would not harm the CTBTO prime operations** yet allow the CTBTO data to be even more useful in civil applications, primarily in seismic hazard assessment and earthquake and tsunami alert and response systems.

There will be only one-off minimal cost to CTBTO, yet the benefits would be enormous. The work would be confined to introduction of the standard IASPEI procedures into the operational software. No routine analyst involvement would be required.



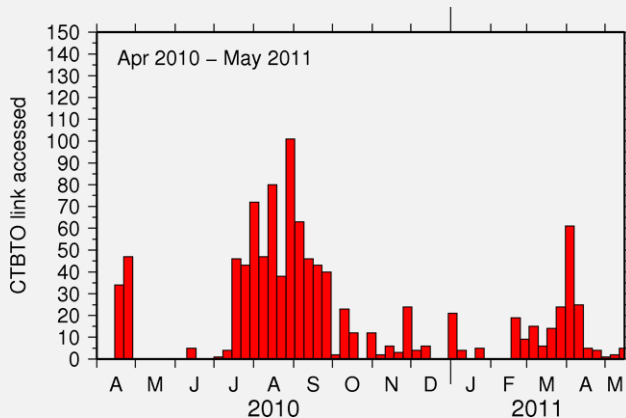
Summary

- ❑ The IDC REB is globally complete to magnitude ~ 4.2
- ❑ Within 2006-2008 period 90% of the REB event locations were within 57 km of the ISC ($\sim 63,000$ events, median discrepancy 15 km) and 90% - within 50 km of the IASPEI GT (97 events, median discrepancy 16 km)
- ❑ REB is a **critical integral part** of international global seismicity monitoring operations. CTBTO input is **invaluable** because of:
 - ✓ Event reports in **oceanic** and other remote areas;
 - ✓ Reports of **surface reflections** to constrain event depth;
 - ✓ Reports of **amplitude** measurements for MS and mb;
 - ✓ Use of globally distributed **high quality** certified **instruments**;
 - ✓ Data being **100% reviewed**;
 - ✓ **Consistency** in procedures over a long period of time;
 - ✓ On average, **high accuracy of arrival picking** due to array processing;
 - ✓ Provision of alternative set of picks from IMS stations co-located with non-IMS research or operational stations;
 - ✓ **Well documented procedures**.
- ❑ We are asking the **PTS** to consider providing an **additional** routine **high profile** yet **low (one-off) cost** service by producing an additional set of automatic amplitude measurements according to the IASPEI Standard to be used in civil applications.

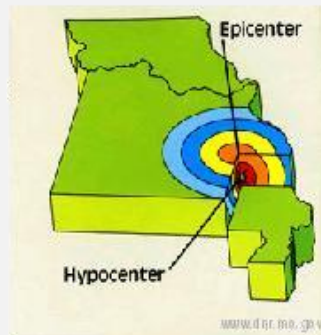
Appendix: **CTBTO Link** to the **ISC database**



- The **United Kingdom Foreign and Commonwealth Office** along with partners from four Nordic countries initially funded the project of making the ISC Bulletin available to PTS and NDCs through dedicated selection software; this software was designed to offer the ISC data in a way convenient for monitoring and verification studies.
- From April 2011, the **PTS (IDC)** took over the maintenance, upgrade and further development of the Link for one further year.
- Detailed info is available from the **dedicated ISC poster**.



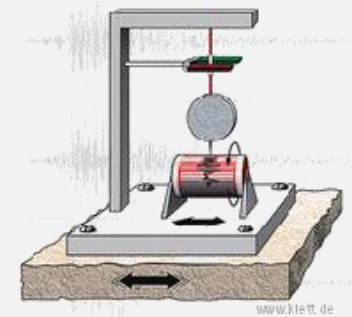
Statistics of access via the Link



Area based Search



REB event based Search



Station Based Search