SUMMARY OF THE ISC BULLETIN OF EVENTS OF 2003

D.A.STORCHAK & M.K.Bolton

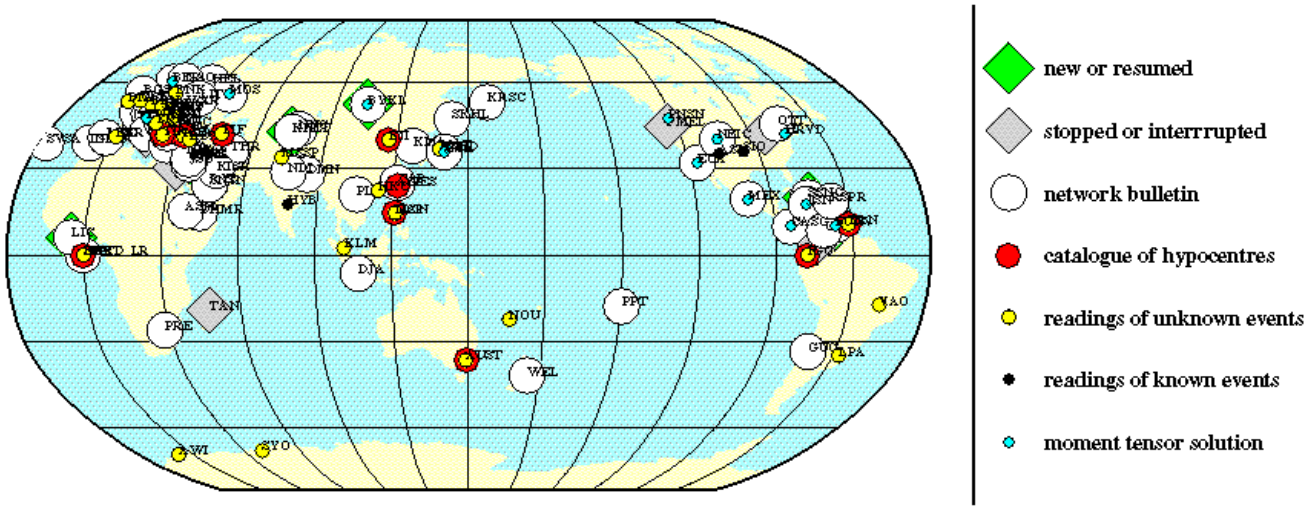
dmitry@isc.ac.uk

Presented at the EGU meeting, Vienna, April 2006

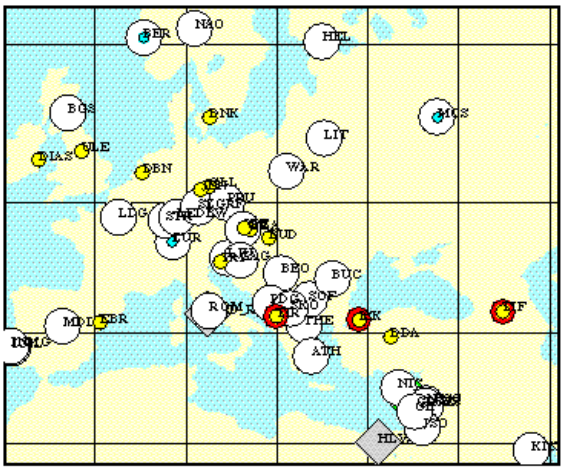
1. ABSTRACT

The ISC Bulletin for the year 2003 is now available on the Internet and the ISC CD Volume 14. In our presentation, we give an overview of the data published in the Bulletin. We describe the major sources of parametric data contributed to the ISC and compare the data sets from other global data centres with that of the ISC. We evaluate the importance of re-analysis on a global scale from the distribution of events for which the ISC associates independently reported phase readings or hypocentres. We discuss the overall and regional completeness of the Bulletin as well as completeness in the oceanic and continental areas. We exhibit and give explanation for the differences between locations and magnitudes computed by the ISC, IDC and NEIC. We also give a summary of "new" events discovered by the ISC from previously unassociated phase readings, and other events of special interest in the Bulletin. We discuss the magnitude threshold policy, which was applied to select events for manual review at the ISC and show the difference between the Collected, Published and Comprehensive ISC bulletins available on-line.

2. DATA CONTRIBUTORS

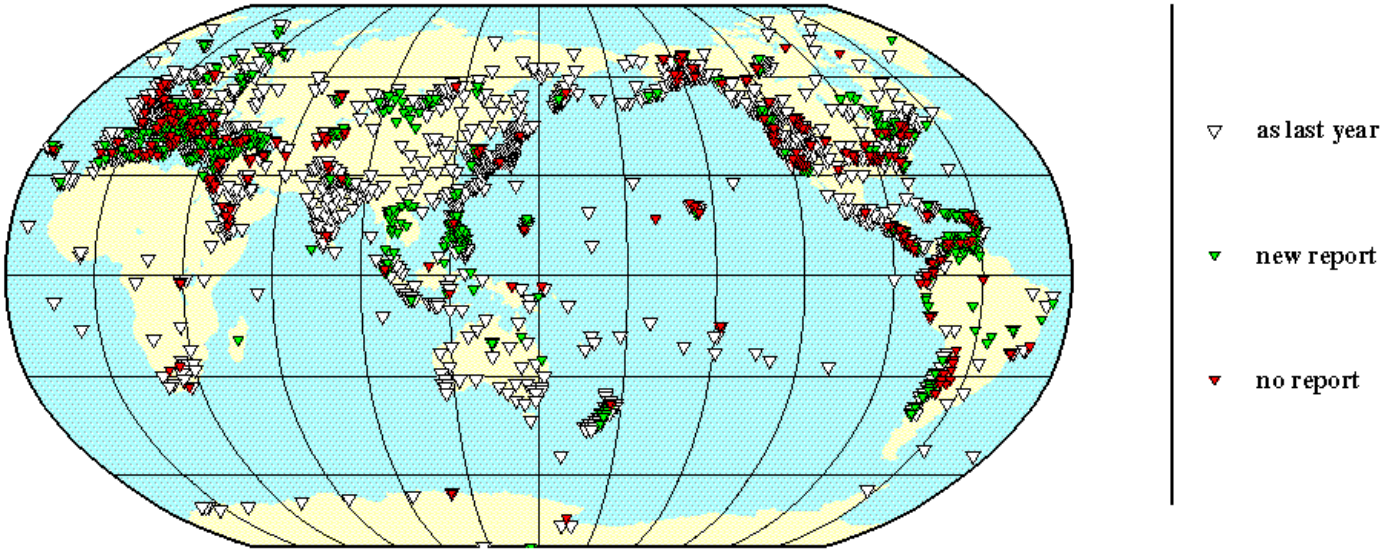


Europe & Mediterranean



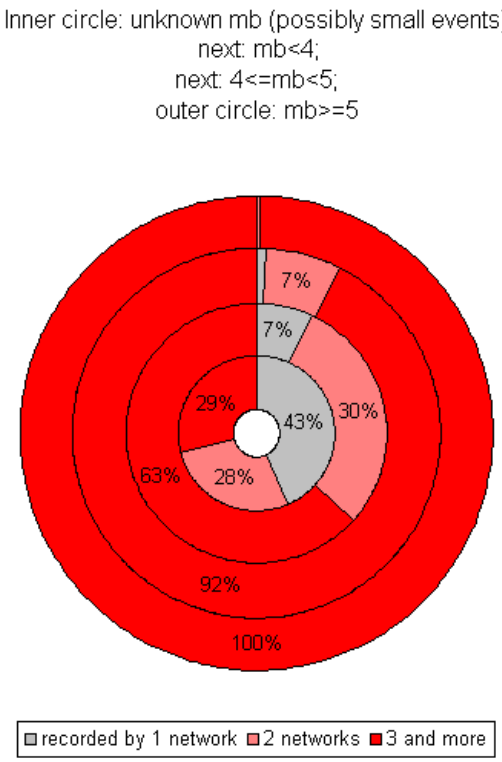
As many as 112 agencies contributed to the 2003 ISC Bulletin. The ISC generally accepts seismic data in the form of a bulletin (a collection of hypocentres and associated station readings), a catalogue of hypocentres, unassociated station readings, station readings associated to already known hypocentres and moment tensor solutions. Where possible the ISC prefers a "bulletin" as opposed to "catalogue plus unassociated readings". This allows us to produce the ISC Bulletin more efficiently and also guarantees the accuracy of associations. The maps show a considerable number of yellow on red circles, which indicate room for improvement. A number of contributions (grey diamonds) have been stopped or interrupted. This is either due the closure of operations at some places, or due to failure to obtain the data in time. The ISC continues searching for new possible sources of data. A number of new or previously interrupted contributions are indicated by green diamonds.

3. SEISMIC STATIONS REPORTING TO THE ISC



The value of the ISC Bulletin is totally dependent on the network of stations around the world, reporting their data to the ISC in time for analysis. The above map represents the stations which contributed at least one seismic phase reading, associated to an event in the ISC Bulletin. The total number of stations has been growing over the years and reached 3578 in year 2003. This is up 7% as compared to 2002. White triangles indicate those stations which reported in both 2003 and 2002. The turnover of the reporting stations is large. 14% of the total number have not reported during the previous year (green triangles). 7% of the stations, reported in year 2002, have not reported in 2003 (red triangles). This is due to various reasons. Some stations were closed or moved far enough to warrant another station code. In other cases the contact with a network was lost and the data had not been contributed.

4. EVENT MAGNITUDE AND THE NUMBER OF CONTRIBUTING NETWORKS

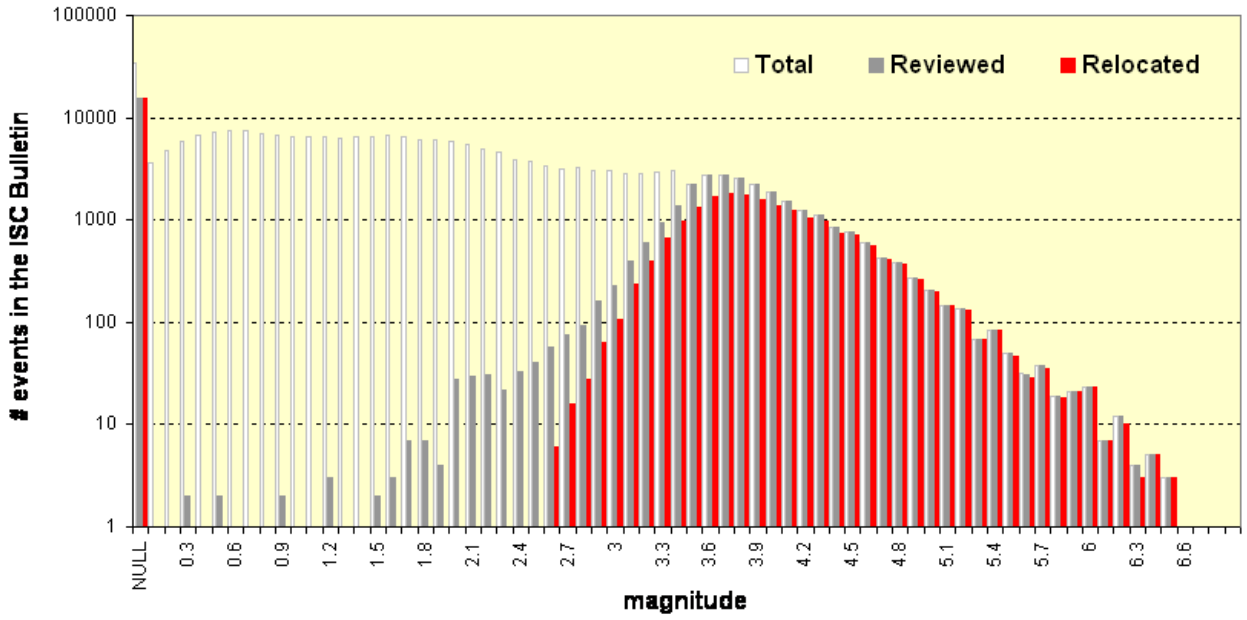


Generally the ISC locations are more reliable if phase readings of at least two different networks are used. The ISC hypocentre will almost always be less accurate than a local one if station readings from only one network are used. This is because the ISC uses Jeffreys - Bullen travel times as opposed to the more appropriate local travel times used by local agencies.

The figure shows a distribution of ISC events with magnitude and the number of distinct networks reported. The grey coloured part of the chart represents events based on station readings from just one network and therefore generally the least accurately located by the ISC. Dark and light red colour represent more accurately located events.

Only 57% of presumably small events with unknown ISC mb (inner circle), were relocated by the ISC using station data from at least 2 different networks. For events with mb<4 and 4<=mb<5 (next two circles) this number grows to 93% and 99%, respectively. Finally, almost 100% of events with mb>=5 (outer circle) were located by the ISC using data of at least 3 networks.

5. THRESHOLDS FOR MANUAL REVIEW



There has been no collection threshold applied at the ISC for data year 2003. All reported events, regardless of how small they were, have been parsed to the ISC database, processed automatically and made available to the ISC users.

For manual review of the automatic bulletin, the ISC had to apply certain magnitude threshold as it could not afford to review every event. This year we concentrated on events with magnitude 3.5 and greater. Apart from these, we also reviewed events with station readings reported at distances of more than 10 degrees, as well as events with reports from at least two different networks.

The ISC only attempts to relocate events from the reviewed part of the bulletin. 17% of the total number of reviewed events could not be relocated by the ISC due to the lack of required number of station reports of P- and/or S-arrivals or poor azimuthal coverage of those reports. One major problem is that some agencies still report hypocentres but not station readings on which those hypocentres were based.

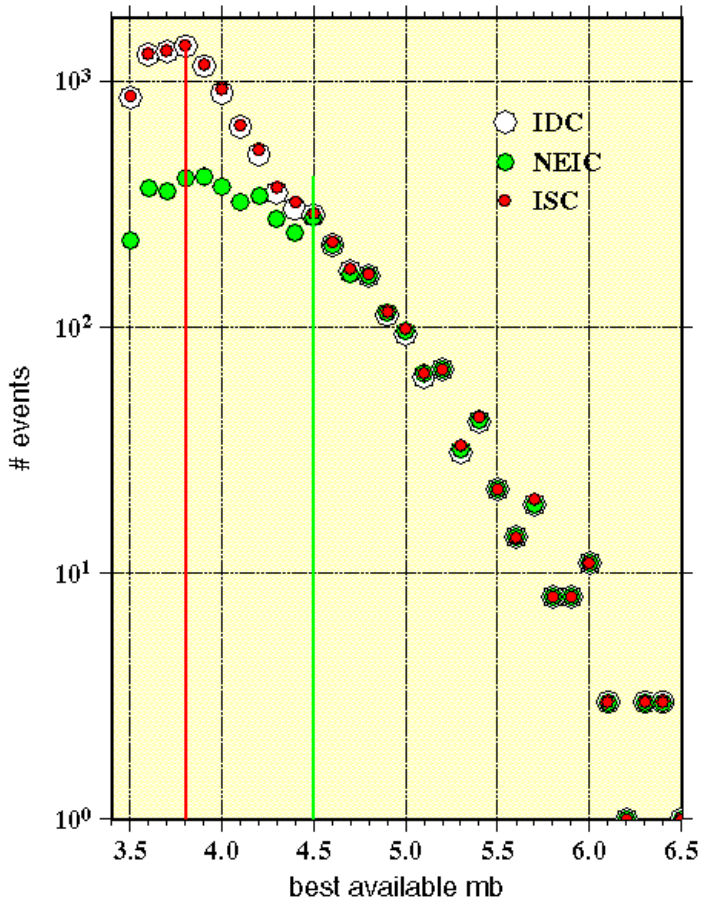
6. ON-LINE ISC BULLETIN

The ISC Bulletin is available on-line. A search tool allows users to select required data from the Bulletin. It is important to select an appropriate bulletin type in order to receive a desired outcome. The table below provides some guidance on the contents of each type of the ISC bulletin, it's variabilty, availability, typical total number of events along with drawbacks to be aware of when requesting data on-line.

Type	Collected	Published (Reviewed)	Comprehensive
Contents	• All events reported to the ISC along with associated station readings	• All events reviewed by the ISC seismologists • 83% relocated by the ISC, based on available station reports	• Both reviewed and un-reviewed (small) events • Events reported late • Events corrected after review was complete
Variability	Changes with every new report. Final reports replace provisional reports	Remains exactly the same after seismologist review	Changes with every new report or correction
Availability	Soon after an event reported	20 - 24 months after an event occurs	Soon after an event reported
Total,	348,884	42,085	234,271

events			
Warnings	• All events are un-reviewed. They appear exactly as they were interpreted by the automatic system. • Events are often duplicated as they can be reported by many agencies. These are not grouped.	17% of all events have not been ISC relocated due to insufficient station reports. In these cases, one of the reported solutions is chosen as prime	• 82% of events have not been reviewed by ISC seismologists • Event splits are common, especially with late reported data • Un-reviewed events are not relocated by the ISC.

7. OVERALL mb COMPLETENESS



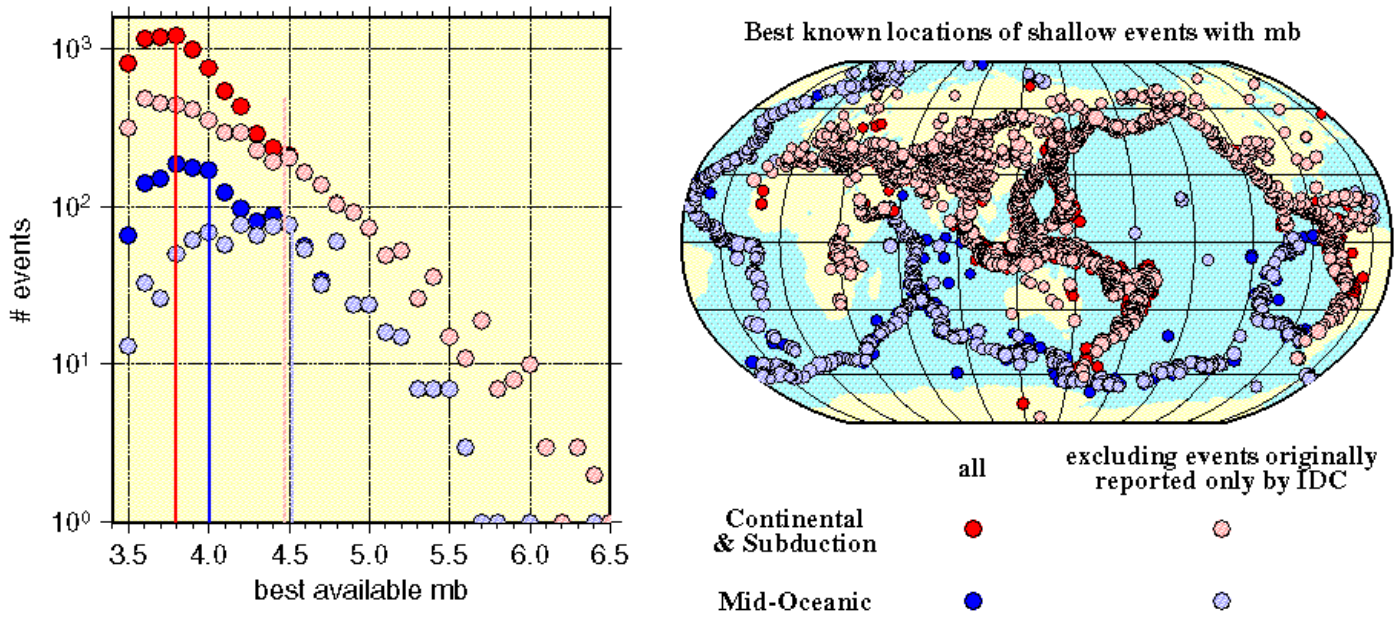
We tried to establish an overall mb completeness of the three most comprehensive global bulletins: IDC, NEIC and ISC. To compare thresholds of completeness like for like we did not simply use original IDC and NEIC values of depth and magnitude. Instead for each event from any of three bulletins we used the best available depth and magnitude estimate available to the ISC. Thus, the same physical event reported by all three agencies is represented by the same magnitude and depth. We only considered hypocentral solutions at depth less than 33km with reliable mb estimate available.

The ISC bulletin is the most complete by default, as nearly all IDC and NEIC events become part of the ISC bulletin. The IDC bulletin is almost as complete as that of the ISC. The magnitude threshold is approximately 3.8 mb. NEIC bulletin is a lot less complete with a threshold of 4.5 mb. The reason for such difference is that the IDC forms an event if at least three primary station/array data are available, however, the accuracy of these locations is low. Such locations, with rare exceptions, get adopted by the ISC as the best available estimates. NEIC does not routinely include such events in its bulletin.

Here we only use events with an available mb estimate. One has to remember that if magnitudes of smaller events were taken into consideration,

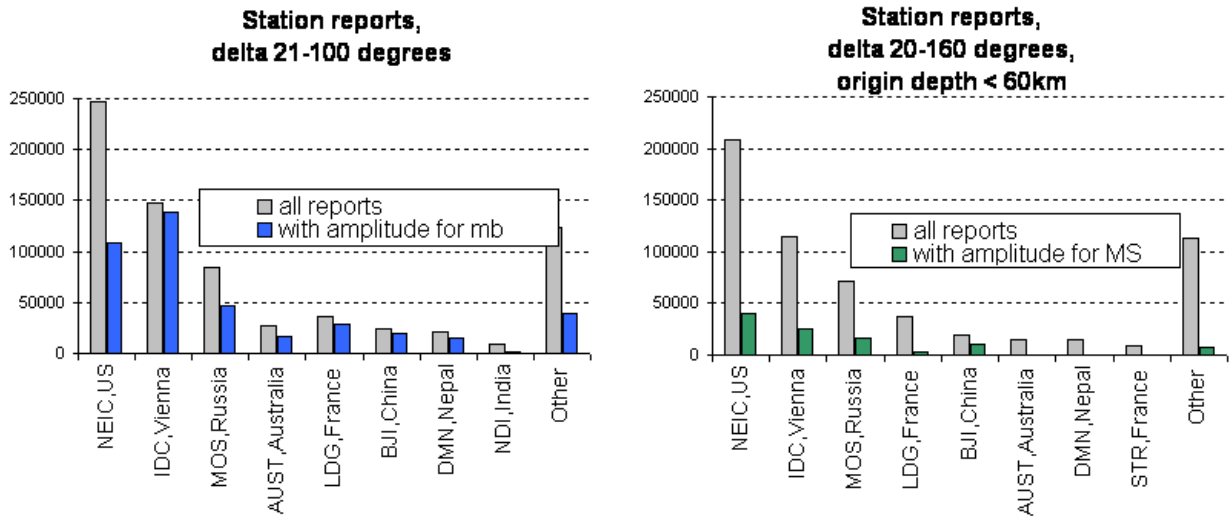
the ISC bulletin would then appear as a profoundly more comprehensive source of data than either IDC or NEIC.
One should expect large regional variations of completeness due to predominent continental position of seismic networks.

8. BULLETIN COMPLETENESS in CONTINENTAL and MID-OCEANIC REGIONS



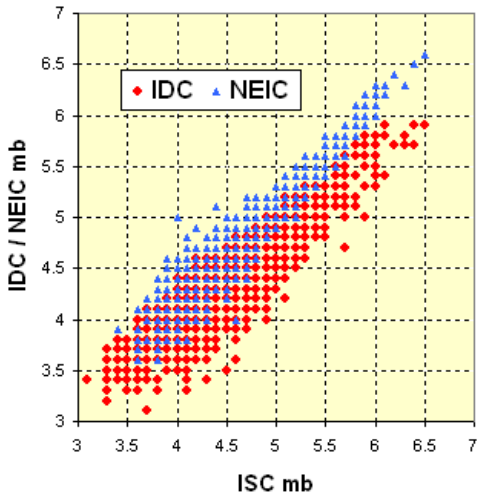
As many of the contributing seismic networks have predominant continental positions there is a difference of about 0.2 units of mb in completeness of the ISC bulletin in continental and mid-oceanic regions.
In this connection, it is essential to underline an importance of the IDC (CTBTO) contribution. Dark colours on the graph indicate all shallow ISC events with mb estimate available. Light colours exclude those events originally reported to the ISC solely by IDC. In both continental and oceanic regions the IDC contribution makes an improvement in mb completeness of the ISC bulletin of at least 0.5 units.
Note that the accuracy of additional event locations, provided by the IDC, is usually poor due to an extremely small number of contributing array/station readings. Some of these events appear on the map as dark circles that stand out from normal seismic areas. At times the ISC is able to improve the accuracy of such events by using additional readings reported by non-IDC stations.

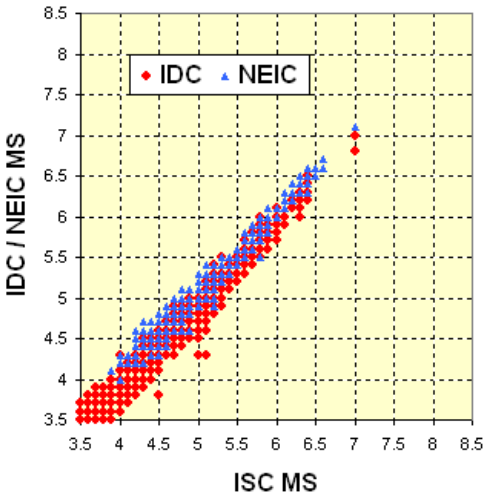
9. CONTRIBUTORS TO THE ISC mb AND MS



The majority of station reports, eligible for ISC mb, come from only a few sources. By far the largest are IDC(CTBTO), 33%, NEIC, 26% and MOS(Russia), 11%. Nearly every station report of IDC, DMN (Nepal), BJI(China) and LDG (France) comes with an amplitude for mb. Approximately a half or more of reports from NEIC, MOS and AUST (Australia) contain an amplitude reading for mb.
Of all station reports, eligible for ISC MS, only 17% contain amplitude readings. This is largely due to a limited frequency band of majority of seismic stations. As much as 89% of all amplitude reports eligible for ISC MS came from just four sources: NEIC, IDC, MOS (Russia) and BJI (China).

10. HOW CONSISTENT ARE THE ISC, IDC, NEIC mb AND MS ?





Values of the ISC network mb and MS are heavily dominated in almost equal shares by contributions of amplitudes by IDC and NEIC. It is important to know how consistent the ISC mb and MS values are with those of IDC and NEIC.

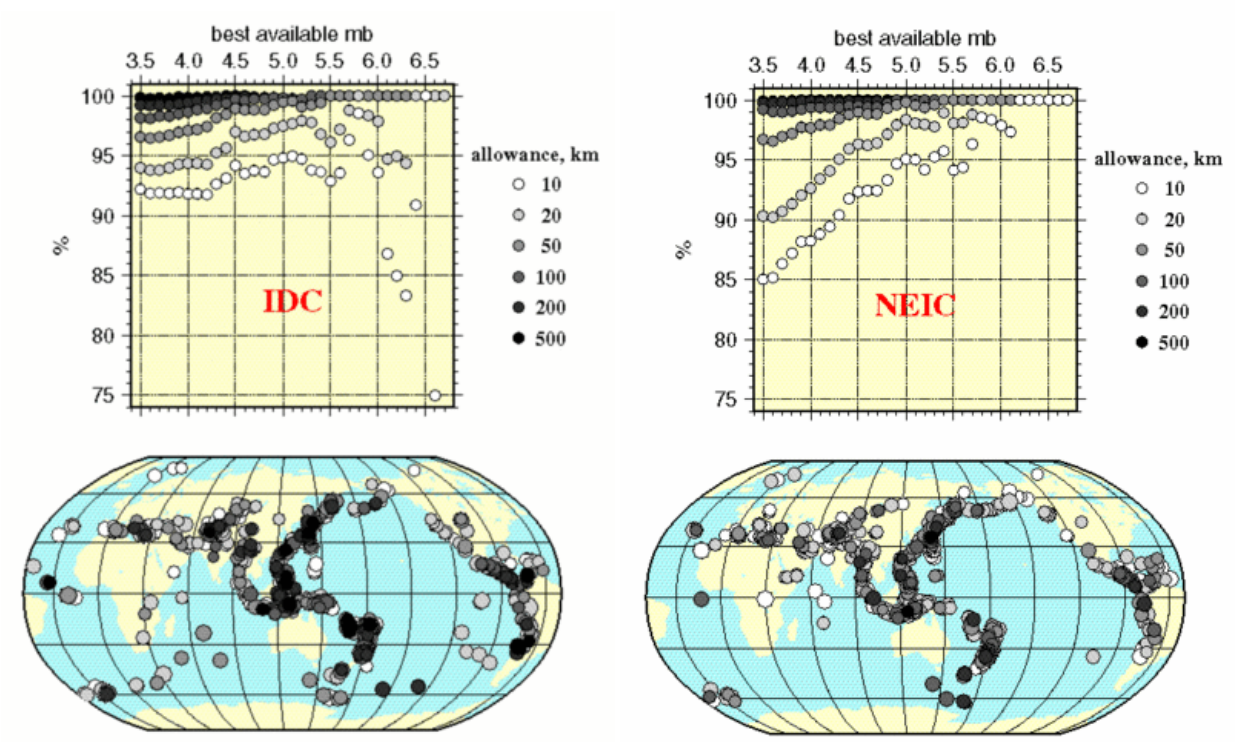
Above we only considered shallow events common to ISC and IDC/NEIC, where both ISC and IDC/NEIC mb and MS estimate are available. Such estimate were only considered reliable if based on more than 5 station measurements.

It is evident that the IDC mb and MS values are generally smaller than those of the ISC. This discrepancy is likely to be caused by certain deviation from conventional procedures at a number of agencies including the IDC. In particular:

- non-standard digital filtering of waveforms prior to taking measurements;
- non-standard measurement procedures;
- constant use of arrays;
- predominantly low noise station siting.

As opposed to IDC, NEIC mb and MS are generally more consistent with those of the ISC.

11. LOCATION DISCREPANCY BETWEEN ISC AND IDC/NEIC



The IDC produces its bulletin within a few days of an event occurence using a small number of high quality arrays and stations. NEIC is progressively moving towards preparing its bulletin closer to near real time, using digital stations available on-line as well as external station reports delivered at appropriate time.

Alternatively, ISC deliberately waits for 20-24 months to collect all available parametric information in order to produce the most definitive global bulletin based on a wealth of contributed data. Both IDC and NEIC bulletins are integral and most important subsets of the ISC bulletin.

Here we tried to estimate the differences in final locations between ISC and IDC/NEIC. We have considered a magnitude distribution of a number of common events with mb estimate available, for which the location discrepancy between ISC and IDC/NEIC is in excess of a certain

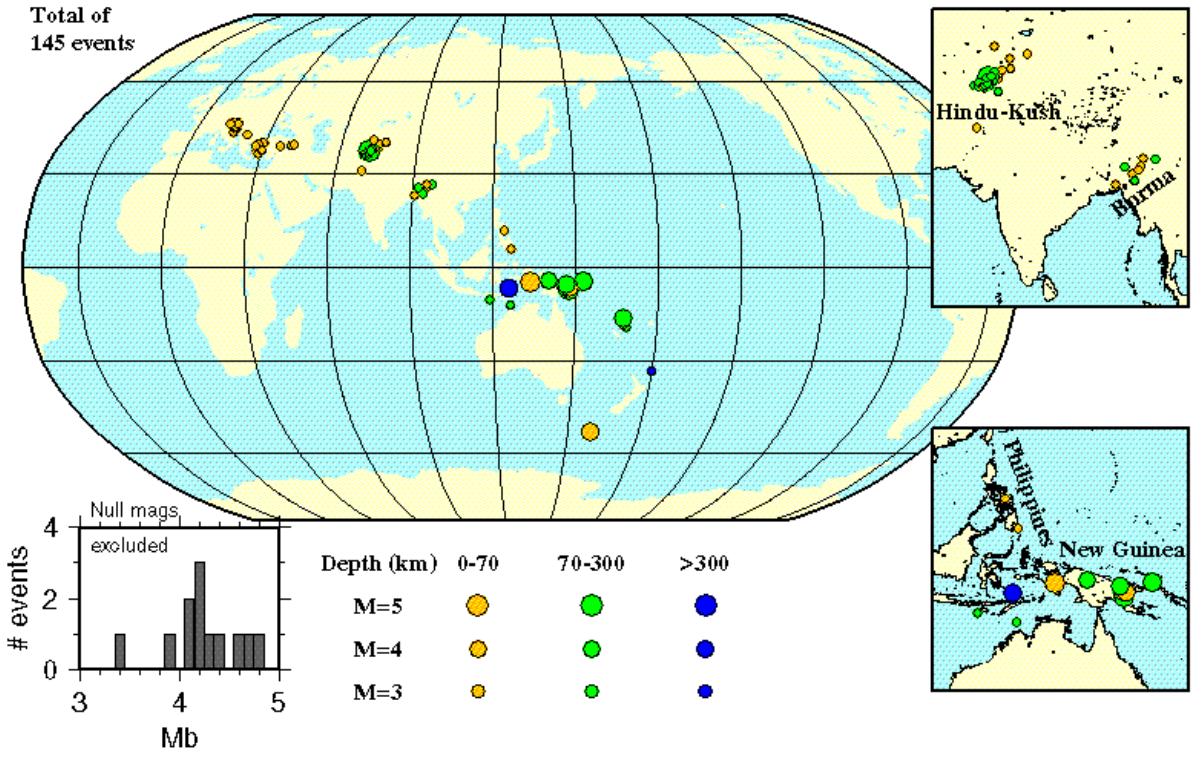
allowance [km]. Due to a comparatively short period of time under consideration, certain magnitudes were artificially misrepresented. We have used a 3-point filtering to smooth the curves.

With an exception to several cases in large magnitudes, more than 85-90 percent of events appear to be located with error ellipses being no further than 10 km from each other. As the allowance gradually grows to 100km, an absolute majority of locations above magnitude 4.5 start matching. A rather abnormal behaviour of the curves for IDC for large magnitudes is due to the fact that only a few events are involved within a year period. A single problematic event location causes an overall percentage to drop dramatically even with smoothing applied.

The maps present those events, which do not qualify as match for every value of allowance, i.e. the events with position discrepancy between each two agencies higher than an allowance. These maps clearly show that as the value of allowance goes up, the "event-outliers" gradually concentrate to the areas with sparse networks as well as areas where ISC has an advantage of using comprehensive local reports.

In computation of location discrepancy we have used an event position along with its values of uncertainty (error ellipse). The mb completeness threshold of 2003 ISC bulletin was found to be approximately 3.8. Overall 79(87)% of ISC and NEIC(IDC) error ellipses for mb>3.8 events overlap. The difference in percentage can be attributed to the different set of events in each case as well as to incompleteness of the IDC network, which leads to large uncertainties in IDC locations. Therefore despite several degrees of distance between some ISC and IDC epicentres, the formal error ellipses still overlap.

12. ISC EVENTS BASED ON UNASSOCIATED STATION REPORTS



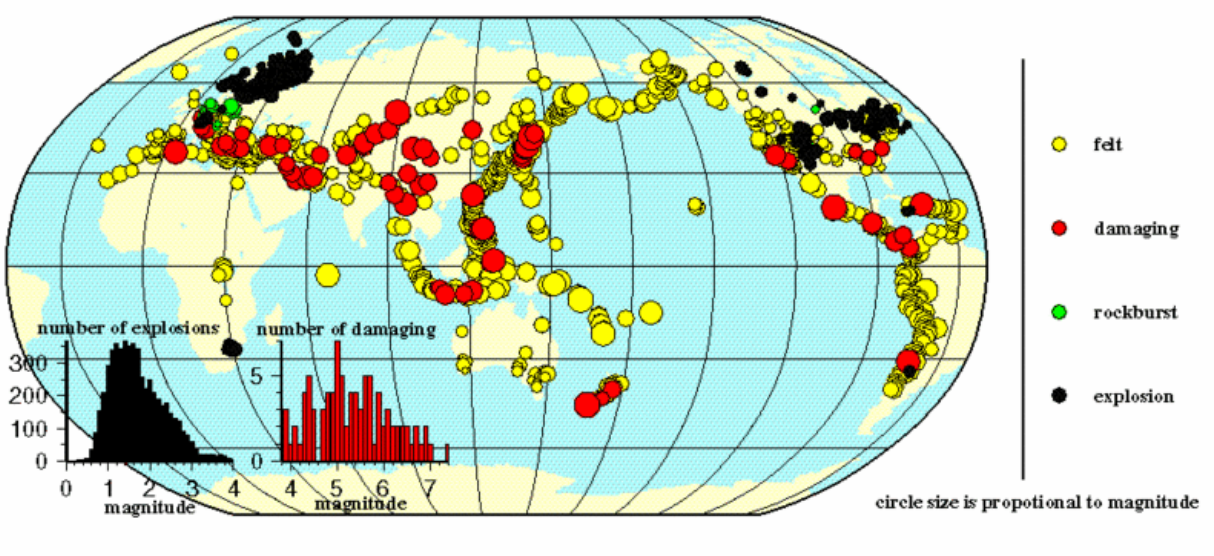
Since 1974 the ISC has searched its unassociated phase readings to find events not reported by other agencies, so called "search events". These were either moderate events in remote areas and border regions or events of small magnitude elsewhere.

In the past, the local reports of hypocentre solutions of small events were often initially ignored by the ISC data collection to help reducing the load on the ISC data management and analysis system. The station arrival times for these events were nevertheless often filtering through into the data collection.

Since the ISC has entirely removed all data collection thresholds starting with data year 1999, the number of search events dropped as a result. This is because comprehensive local reports already contained many of those events. Now we believe that in a majority of cases the ISC search events are genuinely new. The areas usually include border regions in Balkan peninsula (often explosions or rockbursts), Eastern Turkey, Hindu Kush, Burma, Indonesia and the Pacific Rim.

It is possible to assign magnitude to those search events, where at least one amplitude reading was reported to the ISC within a distance range of 21 to 100 degrees. Understandably these magnitude estimates are not as accurate as magnitudes of events already reported to the ISC. Apart from small events in border regions, search events have a magnitude between 3.5 to 4.5 mb. Events in this magnitude range are usually reported by the IDC, but were missed on this occasion. In some of these cases the strictly observed event definition criteria would have prevented IDC from publishing these events.

13. EVENTS OF SPECIAL INTEREST



Above we have reproduced those events which were either caused by human activities (green/black) or felt by people (yellow) or caused damage (red). The distribution of the felt events generally matches the areas where both the level of seismicity and population are high. The distribution of explosions and rockbursts generally matches the areas of industrial activities. One could, for instance, observe a large number of explosions/rockbursts in Scandinavia, North West Russia, Germany, Poland, Slovenia, France, South Africa, Canada and the United States.

Unfortunately there are no reports from other areas with comparatively high level of industrial activities. In fact some agencies prefer to exclude artificial events from their catalogues as opposed to marking them as artificial.

This is not always the best approach. Such events are likely to be reported by neighbouring agencies or even by international data centres, who generally will not have precise information on the nature of the event. Having appreciated the sensitive nature of this issue, the ISC asks where possible to report artificial events along with natural ones.

14. FINAL COMMENTS

- The 2003 ISC Bulletin remains the most comprehensive global source of seismic parametric data. The overall mb completeness threshold for shallow events is found to be close to 3.8. This threshold is nevertheless subject to a large regional variation.
- Overall, the ISC bulletin would have been at least 0.5 units of mb less complete without the IDC contribution.
- As much as 87% of the ISC events with mb magnitude above the mb completeness threshold are located based on station readings from at least 3 different networks.
- The ISC mb values are dominated by the body wave amplitudes from IDC (33% of the total number), NEIC (26%) and MOS (11%). As much as 89% of surface wave amplitudes for ISC MS are contributed by only 4 sources: NEIC, IDC, MOS (Russia) and BJI (China). The ISC Bulletin would benefit from other agencies contributing amplitudes.
- The ISC mb / MS are generally consistent with those of NEIC. IDC mb / MS are generally smaller than ISC.
- 79(87)% of the ISC and NEIC(IDC) error ellipses for common mb>3.8 events overlap. The percentage difference can be attributed to the different set of events in each case as well as to the incompleteness of the IDC network, which leads to large uncertainties in IDC locations.
- A small number of new events with mb 3.5-4.5, discovered by the ISC using unassociated station reports, are missing from the original IDC and NEIC bulletins.
- The ISC Bulletin would benefit from station reports contributed as associated to known hypocentres.