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6.1 Estimating global and regional IMS detection capability

Introduction

The primary seismic network of the International Monitoring System (IMS) for verifying compliance with the Comprehensive Nuclear Test Ban Treaty (CTBT) consists of 49 stations (see Fig. 6.1.1), out of which 35 are installed and operational as of July 2001. These stations are the key element of the IMS as they are used for detecting events that might be violations of the CTBT. We have in this study used the threshold monitoring (TM) method (Kværna and Ringdal, 1999, Ringdal and Kværna, 1989, 1992) to assess the detection capability of the IMS seismic network. The TM method is capable of using actual seismic data for a given time interval as the basis for the detectability calculations. In cases when a seismic station did not provide data during the time period under study, an estimated background noise level can be assigned. These noise estimates can be based on results from earlier studies, or they can be taken from stations assumed to have similar noise characteristics.

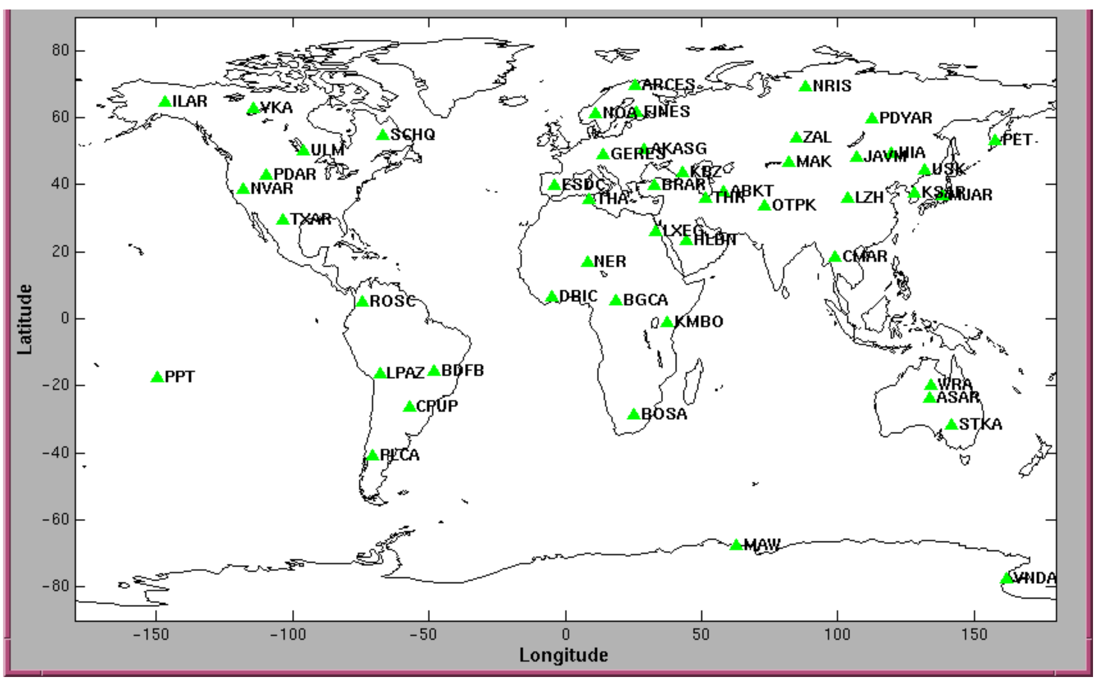

Fig. 6.1.1. Station configuration of the full IMS primary seismic network.

The detection capability of the full IMS primary seismic network

We have used the time interval 10:20-11:00 on 29 June 2001 as the basis for estimating the detection capability of the full IMS primary seismic network. This time interval does not contain any major seismic events and most of the stations have relatively quiet noise conditions. Fig. 6.1.2 shows the short-term-averages (STAs) representing the noise levels at each of the IMS primary seismic stations operational as of 29 June 2001. For stations not providing data during this time interval, a typical constant noise level has been assigned. These stations have the label *const* at the top of each panel.

The noise levels assigned for the planned primary seismic stations are shown in Fig. 6.1.3.

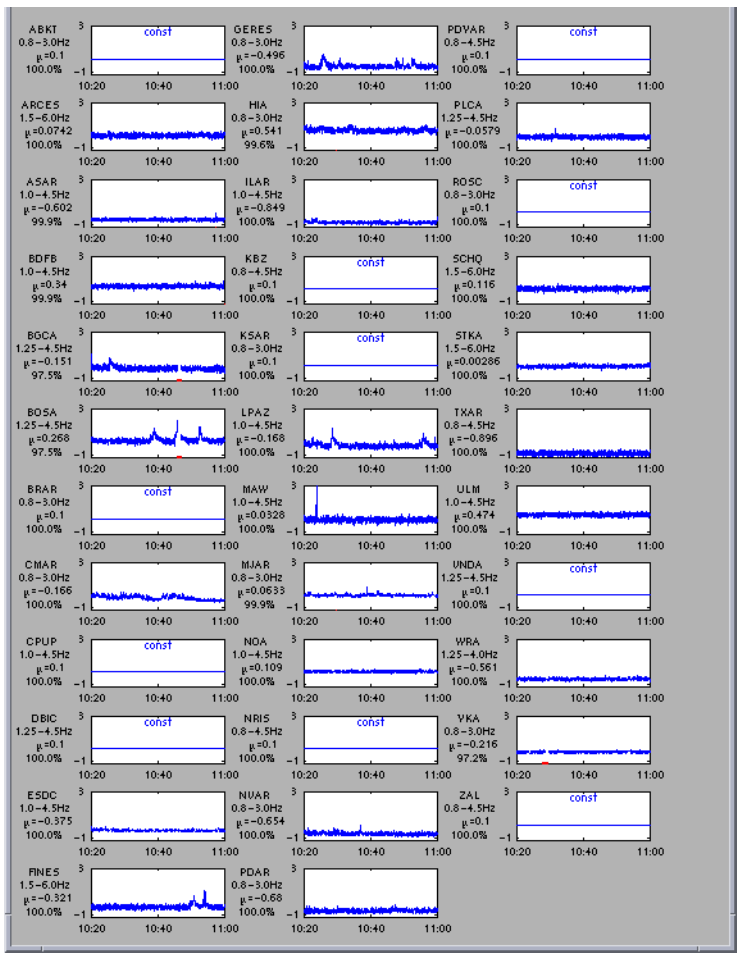

Fig. 6.1.2. Real or estimated noise levels of current IMS primary seismic stations for the time period 10:20-11:00 on 29 June 2001.

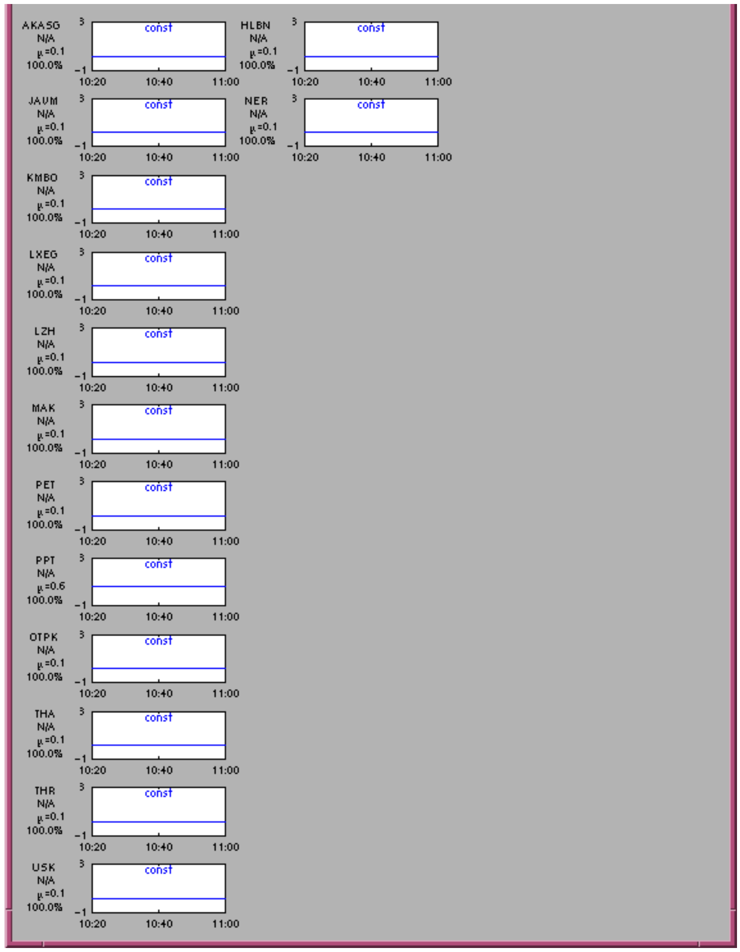

Fig. 6.1.3. Noise levels assigned for the planned IMS primary seismic stations.

We have used the average noise levels shown in Figs. 6.1.2 and 6.1.3 to calculate the three-station network detection capability at the 90% confidence level of the full IMS primary seismic network. The results are shown in Fig. 6.1.4. Very good detection capability is found in northern Europe and North America where several high performance seismic arrays are installed. The results shown in Fig. 6.1.4 agree well with the statistical simulations provided by the NetSim program (Sereno et. al, 1990).

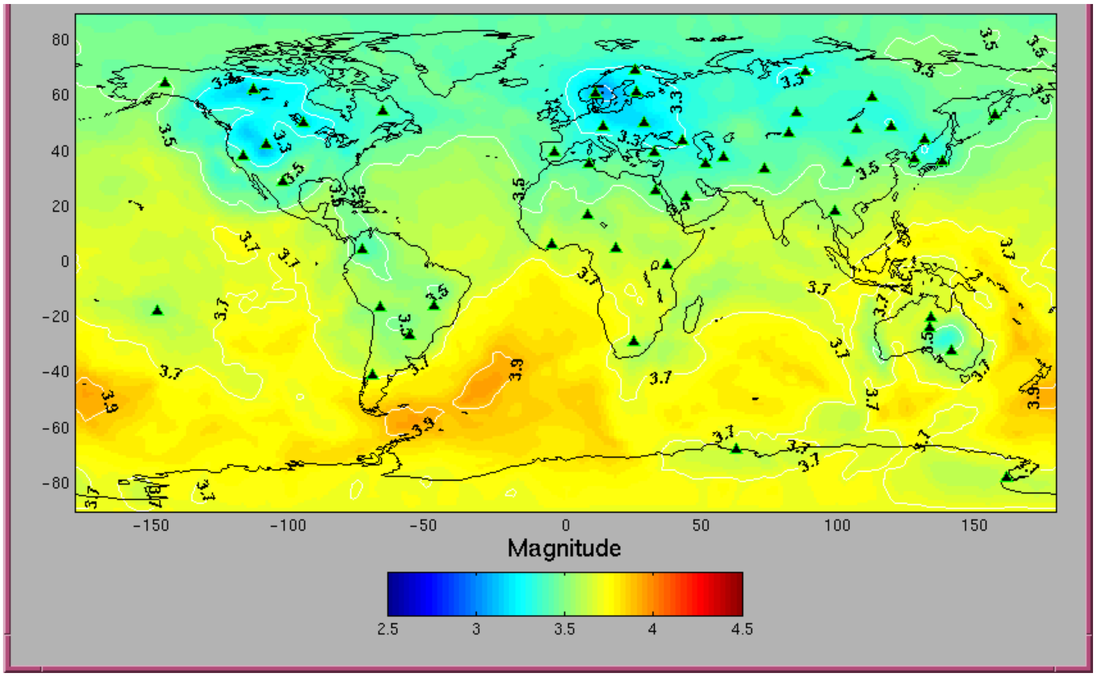

Fig. 6.1.4. Three station detection capability of the full IMS primary network.

The detection capability of the IMS primary seismic network as of July 2001

It is of particular interest to compare the detection capability of the current IMS network with the projected performance of the 49 stations of the full network. As of 7 July 2001 the primary seismic IMS network consisted of 35 stations, but several of these stations did not provide any data. We have in Fig. 6.1.5 plotted the background noise levels for a time interval without any significant seismic signals, and we see that several stations are down or providing data gaps. The corresponding three-station detection capability is shown in Fig. 6.1.6, and we again notice the good detectability associated with the high performance arrays in northern Europe, North America and Australia.

We have in Fig. 6.1.7 plotted the difference in detectability between the current IMS primary seismic and the projected performance of the full network. The average difference is only 0.06 magnitude units, and the largest differences are found in southwest Asia with a maximum value of 0.47. The constant noise levels assigned to the planned or non-operational stations are taken from typical noise levels at stations assumed to have similar noise characteristics. The relatively large uncertainty associated with the assigned constant noise levels is also reflected in the detectability estimates.

Fig. 6.1.5. Noise levels of current IMS primary seismic stations on 7 July 2001.

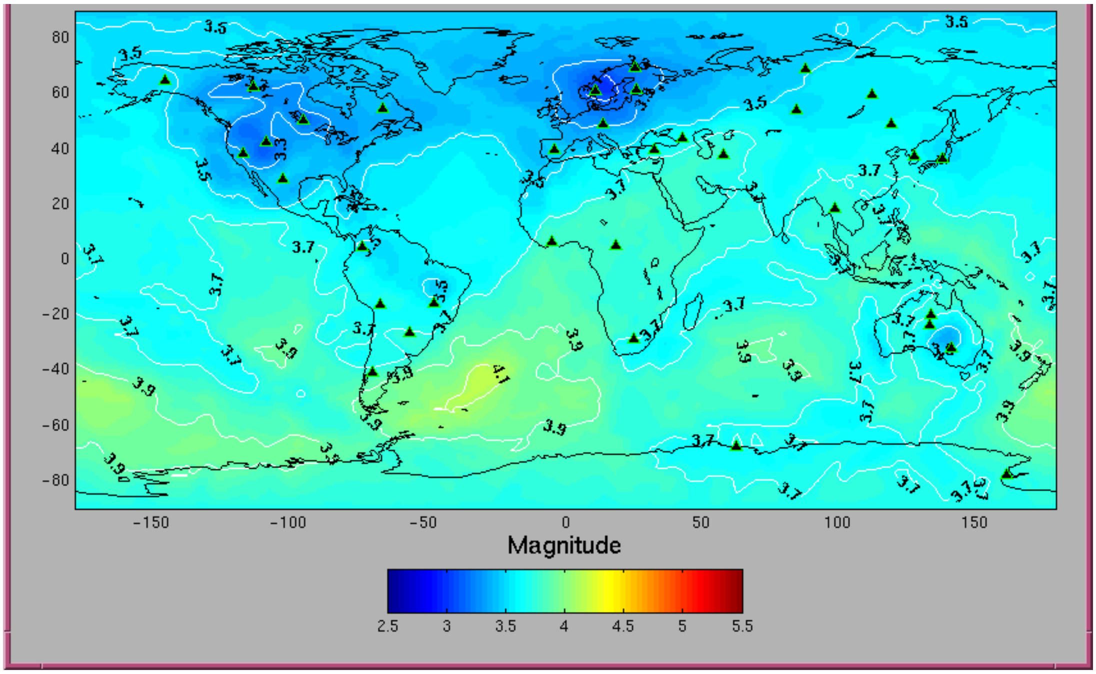

Fig. 6.1.6. Three-station detection capability of IMS primary stations on 7 July 2001.

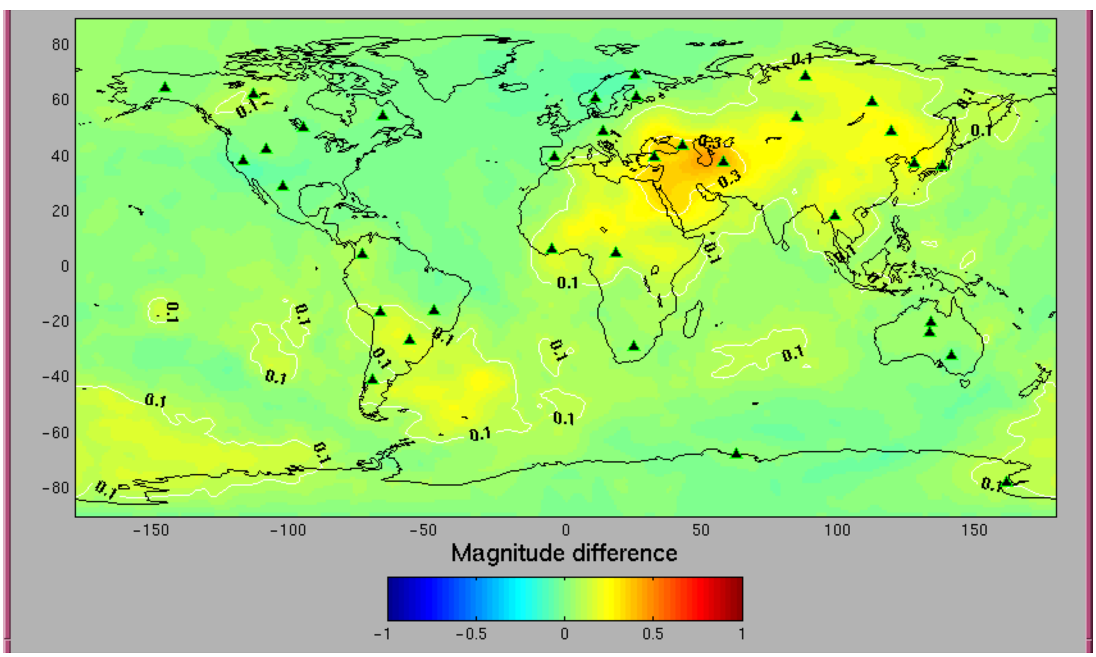

Fig. 6.1.7. Difference in detection capability between the current operational primary seismic network (Fig. 6.1.6) and full network (Fig 6.1.4).

The detection capability of the IMS primary seismic network in the coda of a large earthquake

At 09:38:43.5 on 7 July 2001 a m_b 5.7, M_S 7.6 earthquake occurred near the coast of Peru. Fig. 6.1.8 shows the average three-station network detection capability for a five minute time interval that starts 1 minute and 20 seconds after the origin time of the event. Notice the reduced detectability for the areas around the epicenter.

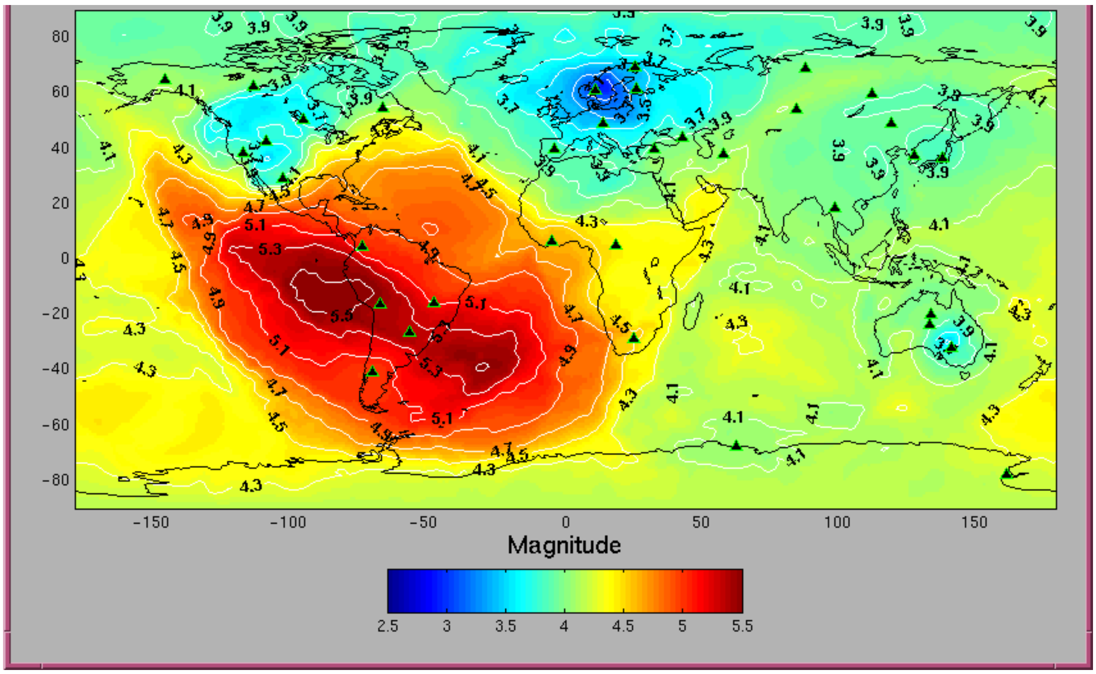

Fig. 6.1.8. Three-station detection capability of IMS primary stations 1 minute and 20 seconds after the occurrence of a m_b 5.7 earthquake near the coast of Peru.

In Fig. 6.1.9 we have plotted the difference in detectability between the time interval with the earthquake signals (Fig. 6.1.8) as compared to the detectability during quiet background noise conditions (Fig. 6.1.6). For large regions, including South America and adjacent areas, the detection performance is reduced by more than 1 magnitude unit. The maximum difference is 1.925 units in the vicinity of the epicenter. As time passes, the seismic signals will propagate to longer distances and reduce the detectability for larger regions of the Earth. However, due to the signal attenuation the degradation of the detection capability will be less than for regions closer to the event.

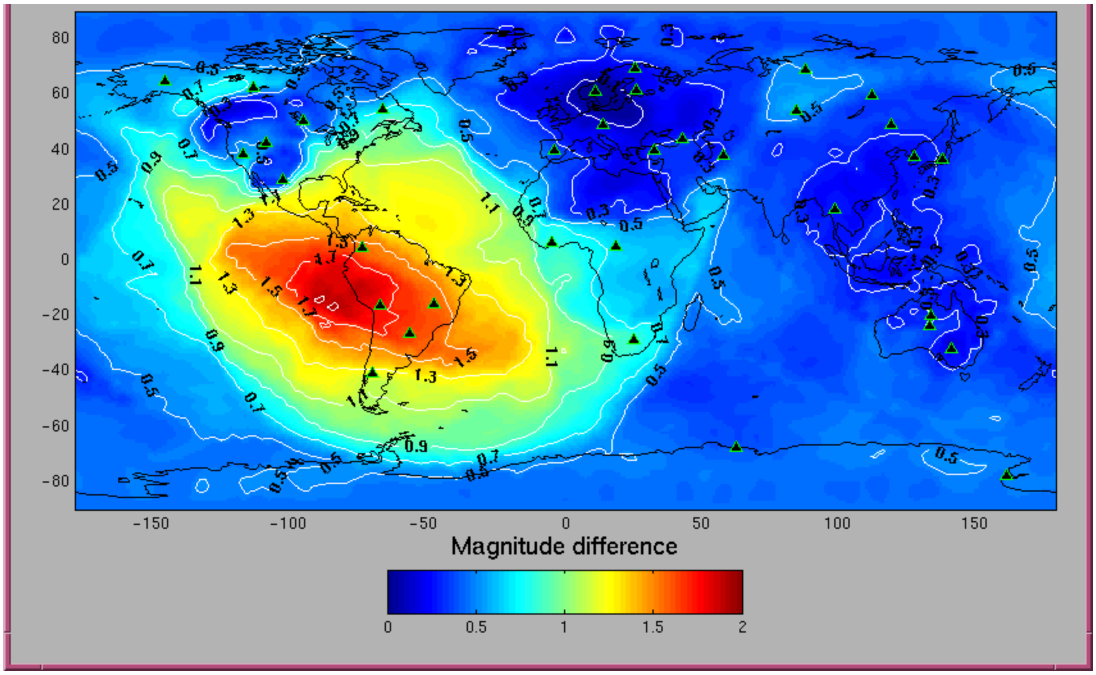

Fig. 6.1.9. Difference in detection capability between the levels given in Fig. 6.1.8 and 6.1.6.

Conclusions

We have found that the 35 stations of the primary seismic IMS network operational as of July 2001 have a three-station detection capability that is quite close to the projected performance of the 49 stations of the network. The largest difference of about 0.5 m_b units is found in southwest Asia. This can be explained by the fact that most of the sensitive array stations of the network are already in place. Another uncertainty is the noise levels assigned to the planned stations and to the stations that did not provide real noise data during the period under investigation. The assignment of realistic noise levels for planned stations is therefore a topic requiring additional studies.

This study also confirms the results provided by Kværna and Ringdal (1999) that large earthquakes and the corresponding coda energy can temporarily, over tens of minutes, significantly reduce the detection capability of the IMS network. During such conditions the use of high-frequency regional data, combined with less stringent event formation criteria (1 or 2 station only) will be important for CTBT verification purposes.

References

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