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7.4 Magnitude estimation using the IDC Threshold Monitoring system

Introduction

Several recent papers have addressed the shortcomings of the currently available magnitude scales for the purposes of GSETT-3. Harjes (1995) has suggested that a "unified" magnitude scale should be developed for operational use at the IDC. Such a magnitude scale should have the following general characteristics:

- Consistent with current teleseismic m_b
- Applicable to "all" distance ranges
- Computed automatically
- Valid over large magnitude range (at least 2.0-6.5)

The primary purpose would be to develop a 'generic" magnitude scale that could be used as a first estimate of m_b. Subsequent refinements would then be possible by introducing station/region-specific correction factors in areas where adequate data is available.

This paper describes a possible approach to developing a unified magnitude scale, by using the IDC Threshold Monitoring system.

Threshold Monitoring approach

The global Threshold Monitoring (TM) system implemented at the IDC offers a data base that is directly applicable to m_b estimation. As explained in detail in previous publications (see, e.g., Ringdal and Kværna, 1992), the method consists of computing individual station STAs (short term averages) continuously in time for each point in a global grid system. The STA values are thereafter converted to "magnitudes" by using station-dependent calibration factors and applying a standard set of distance corrections. It is noted here that log (STA) and log (A/T) are usually quite consistent, as illustrated in Fig. 7.4.1.

In summary, the TM approach has the following basic features:

- STA data available for all stations
- Use of wide, "generic" filter bands
- Use of generic, global attenuation curves
- Simple extension to maximum-likehood magnitude
- Instrument response adjusted to be flat to velocity (A/T)
- No A/T computed for individual frequencies.

In the following, we give some initial results using the TM method for m_b estimation at the IDC.

Initial results

We have analyzed in detail individual station data of two events reported in the IDC Reviewed Event Bulletin (Table 7.4.1). The analysis has comprised:

- Measuring interactively m_b for all reported P-phases (0-100 degrees)
- Calculating TM m_b values for all available stations
- Comparing the individual m_b values for
  - analyst m_b (interactively measured)
  - IDC reported m_b (computed automatically)
  - TM m_b (computed automatically)

In the TM analysis, a wide band filter (0.8-4.0 Hz) was used for most stations, except for some cases where a more high-frequency filter was found more appropriate. The choice of filter settings is similar to, although not identical with the IDC TM estimates as currently implemented (Kværna et al, 1994).

The results for the three techniques are shown as histograms in Fig. 7.4.2 and 7.4.3, for Events 1 and 2, respectively. It is noted that the analyst-measure m_b and the TM m_b have about the same standard deviation, whereas the IDC m_b values have a couple of outliers that cause the standard deviation to be somewhat larger.

Fig. 7.4.4 shows scatter plots comparing the TM m_b and IDC m_b to the analyst m_b. The IDC station m_b values are mostly very consistent, but again a couple of outliers are noted. This problem is currently being investigated by the IDC, and is expected to be corrected in the near future.

We also attempted to apply a multiple-filter technique to measuring m_b at individual stations. This technique comprises:

- Adjust response to be flat to velocity
- Compute A and T for multiple narrow-band filters
- Select largest log A/T with "detection"
- Compute traditional m_b

Although we did this analysis interactively, the procedure is simple to automate. It has the advantage of being close to the traditional approach for m_b measurement. However, it may be less stable than m_b based on a broad-band filter, such as TM m_b.

Examples of the multiple-filter technique are shown in Fig. 7.4.5. These examples indicate that it may be possible to obtain a consistent automatic m_b measurement, including measurements of amplitude and period, by this method. However, more data must be analyzed to determine its potential.

Future plans

Future work, in this area should comprise:

- Apply TM technique to larger data base
- Investigate multiple-filter technique
- Develop generic global attenuation curves
- Investigate regional corrections
- Apply TM method to M_s measurements, including upper limits.

Besides providing more information on the potential to develop a consistent, "unified" magnitude scale, this research would also contribute to improving and tuning the application of the TM method itself at the IDC.

T. Kværna
F. Ringdal

References

Harjes, H.-P. (1995): Calibrating an IMS at regional distances, *in* Proceedings, CTBT Monitoring Technologies Conference 1995, ARPA, Arlington, VA.

Kværna, T., A system for continuous global seismic threshold monitoring, Semiannual Tech. Summary 1 October 93 - 31 March 94, NORSAR Sci. Rep. 2-93/94, Kjeller, Norway.

Ringdal, F. & T. Kværna (1992): Continuous seismic threshold monitoring, *J. Geophysics Int.*, 111, 505-514.

	Date	Origin Time	Lat	Long	Depth (km)	m_b	N (m_b)	Ndef
Event 1	1995/04/08	17.12.50.9	15.23S	173.46W	0	5.1	14	30
Event 2	1995/04/08	17.45.18.3	21.91S	142.58E	305	5.8	25	52

Table 7.4.1. Event parameters as reported in the IDC REB for the two events discussed in the text.

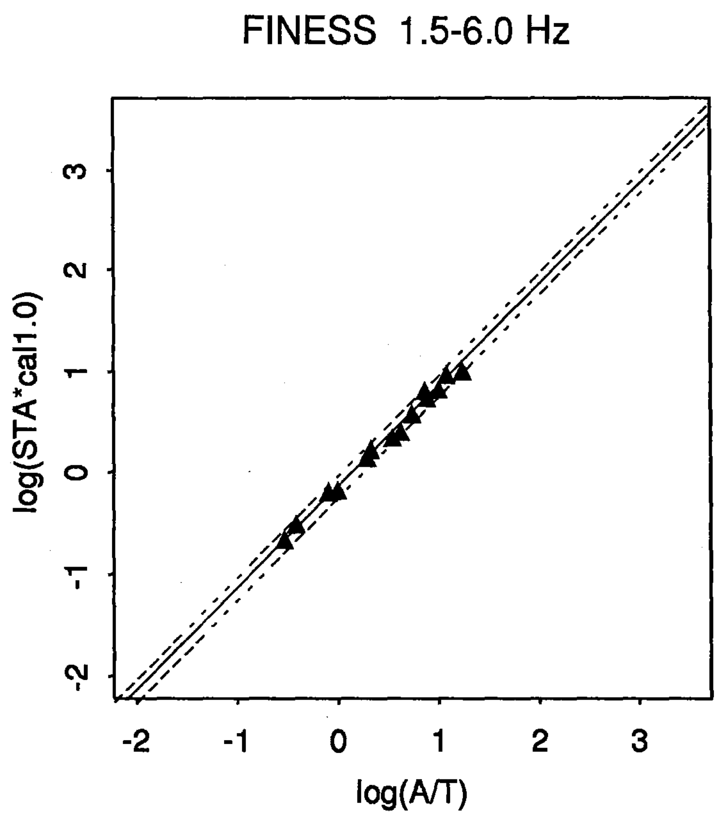


Fig. 7.4.1. Figure illustrating the linear dependency between log (A/T) and log (STA x cal). For the station FINESS and the frequency band 1.5-6.0 Hz, shown on the figure, the best-fitting straight line (with a restricted slope of 1.0) is:

log (STA x cal) = log (A/T) - 0.15

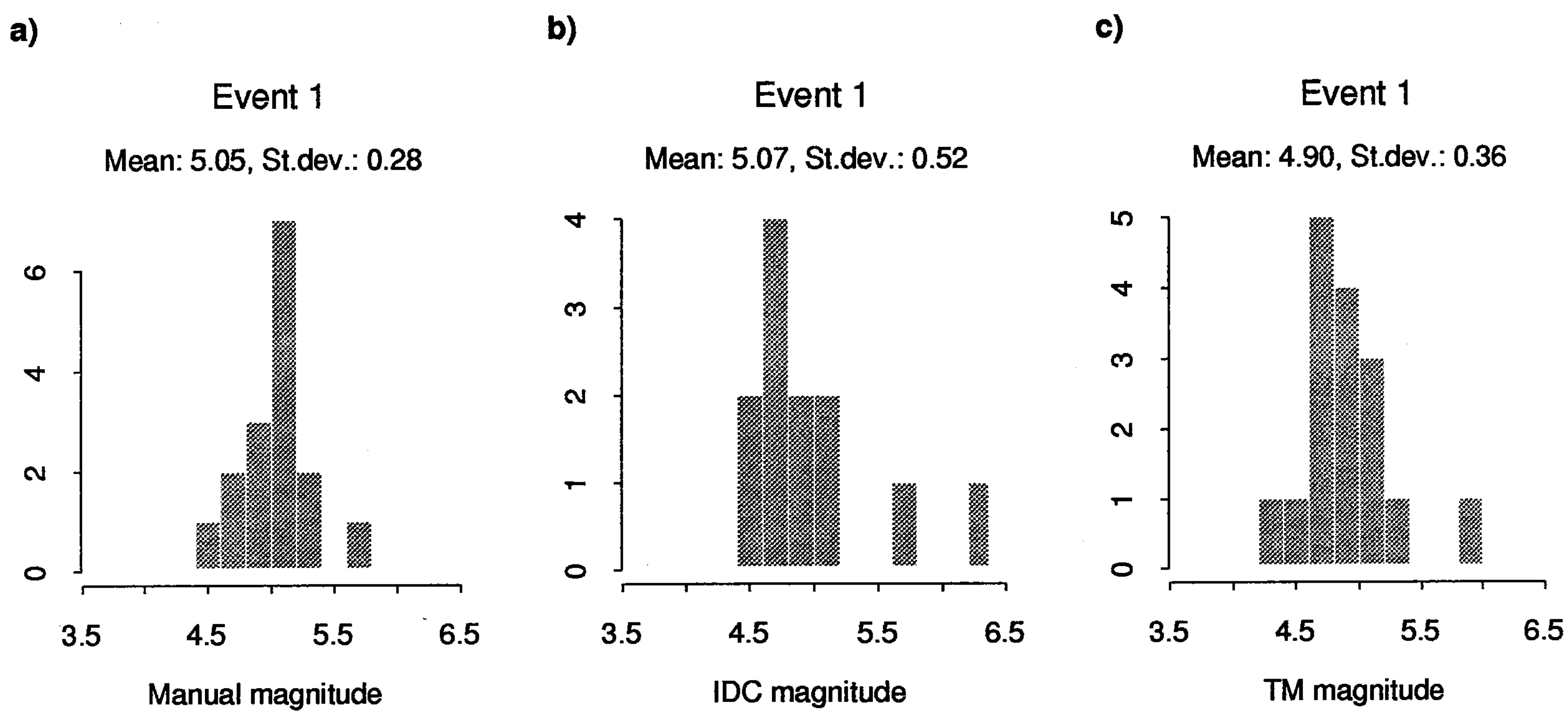


Fig. 7.4.2. Histograms of individual station m_b values mesured for Event 1 by each of the methods: (a) Interactive analyst measurement; (b) Automatically computed station m_b as listed in the IDC REB; and (c) Automatically computed m_b from IDC Threshold Monitoring system.

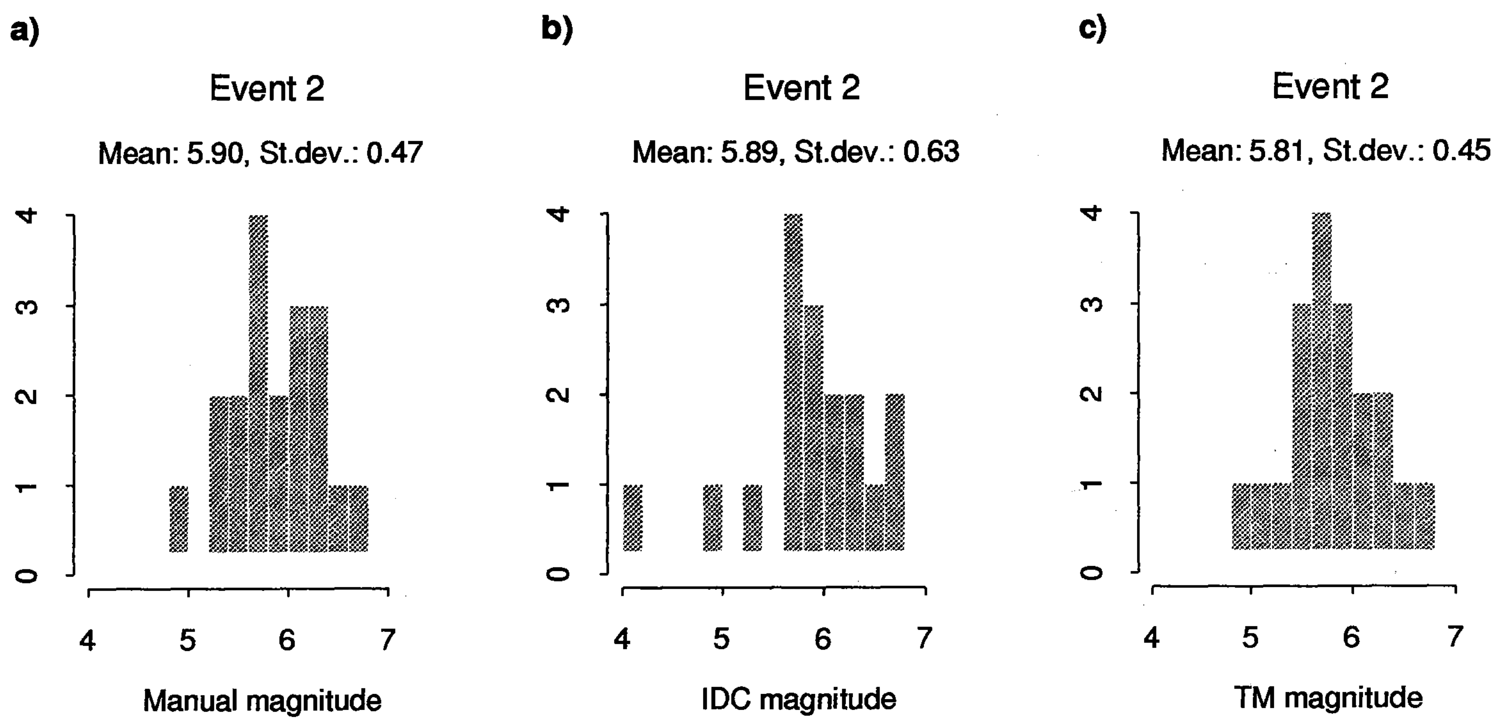


Fig. 7.4.3. Same as Fig. 7.4.2, but for Event 2.

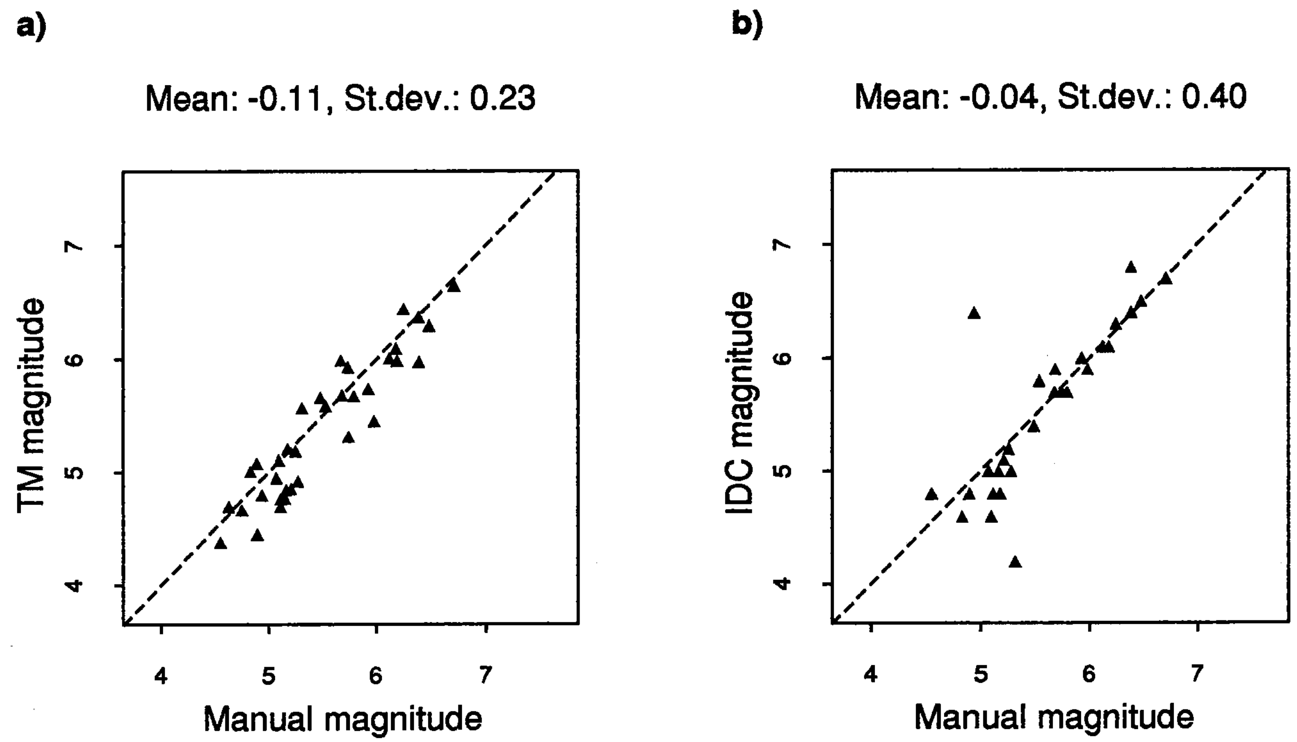
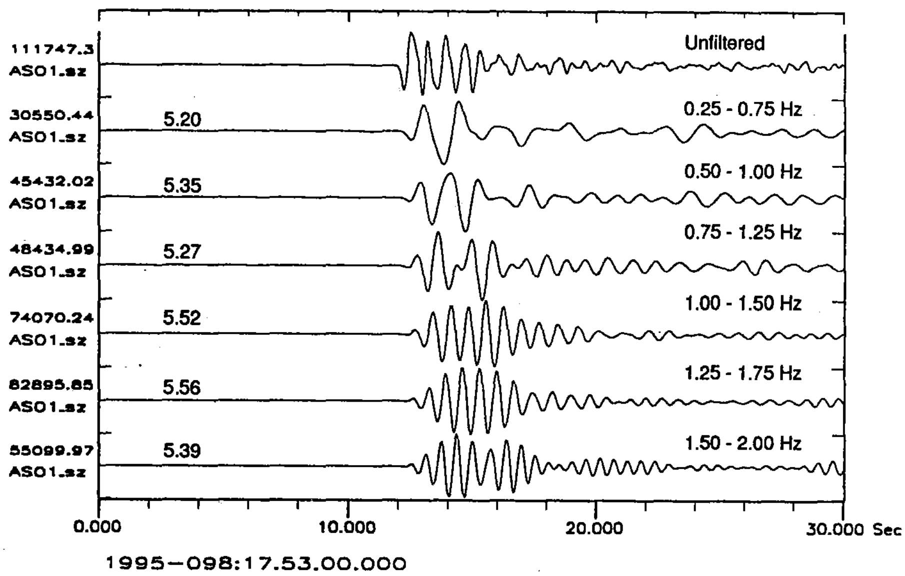


Fig. 7.4.4. Scatter plots comparing (a) TM station magnitudes and (b) IDC station magnitudes to magnitude determined by the analyst. The data in the plots comprise the combined station data for Events 1 and 2.

ASAR - analyst mb=5.67



MBC - analyst mb=6.39

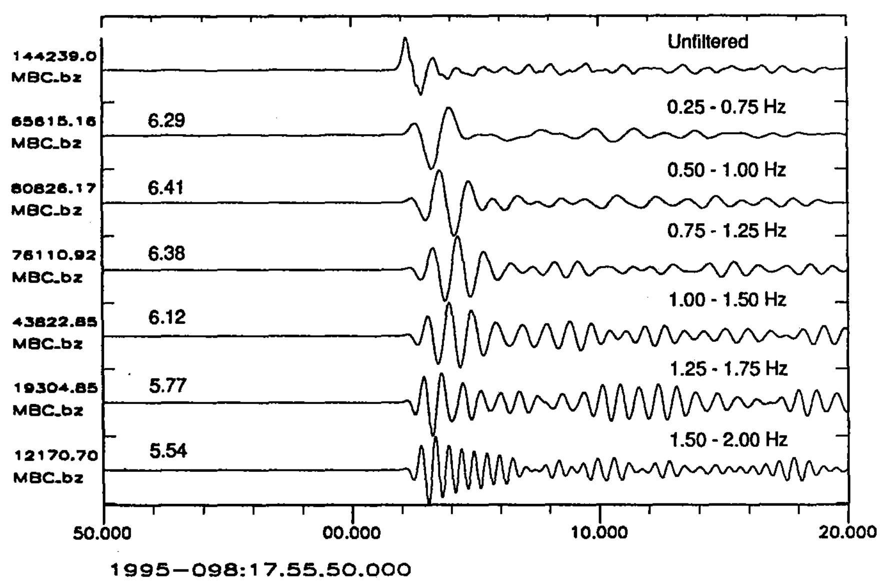


Fig. 7.4.5. Examples illustrating the multiple narrow-band filter technique for measuring m_b. For each plot, the largest m_b value would be selected as representing the station m_b. For station ASAR (top), the max "narrow-band" m_b is 5.56 (compared to analyst m_b of 5.67) and for station MBC (bottom) the corresponding numbers are 6.41 and 6.39. Thus, the correspondence is quite good in these two examples.