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VII.8 An Improved Discriminant using Spectral Estimates for Surface Waves

In Bungum and Tjøstheim (1976) an improvement of the m_b:M_s discriminant was obtained by combining the m_b:M_s data with some parameters resulting from modelling the short period data, noise as well as main signal and coda, as 3rd order autoregressive time series. The new two-dimensional Z1:Z2 discriminant was defined as

$$\begin{aligned} Z1 &= m_b - 0.4\ \hat{a}_1(S) \\ Z2 &= M_s + 0.4\ (\hat{a}_1(C) - \hat{a}_1(N)) \end{aligned} \qquad (1)$$

where $\hat{a}_1(S)$ is the first order autoregressive coefficient from the main signal and C and N denote coda and preceding noise respectively.

We have now investigated the effect of replacing the surface wave magnitude M_s by a long period power spectrum estimate. More precisely, we adopted $\hat{P}_{20}$, the value of the estimated spectral density (using maximum entropy spectral estimation over suitable group velocity windows) at a period of 20 sec as an estimate of the incoming energy. Using correction formulae for ordinary M_s measurements, we constructed the distance corrected energy estimates

$$E_{20} = \tfrac{1}{2} \log_{10}(\hat{P}_{20}/\pi^2) + 1.66 \log_{10}(\Delta)$$

for distances Δ larger than 25° and

$$E_{20} = \tfrac{1}{2} \log_{10}(\hat{P}_{20}/\pi^2) + \log_{10}(\Delta) + 0.92$$

for distances Δ less than 25°. These quantities were computed for a Eurasian data set consisting of 43 earthquakes and 46 explosions. This data set is identical to the main data set

of Bungum and Tjøstheim (1976) with the exception of two earthquakes for which no digital long period data could be found. The parameters $\hat{P}_{20}$ and E_{20} were computed not only for Rayleigh (RV) vertical component waves but also for Rayleigh (RH) radial component waves and Love (L) transverse component waves. Furthermore, a number of different group velocity data windows were used. The information of interest for discrimination purposes is summarized in Table VII.8.1, where mean values have been computed for three of the windows studied. On the basis of the information in this table we constructed the quantities

$$Y2 = E_{20}^{(1)}(\text{Love}) + (E_{20}^{(2)}(\text{Love}) - E_{20}^{(3)}(\text{Love})) \qquad (1)$$

where the superscripts refer to the windows used. Replacing M_s with Y2 we arrive at the X1:X2 discriminant given as

$$\begin{aligned} X1 &= m_b - 0.4\ \hat{a}_1(S) \\ X2 &= Y2 + 0.4(\hat{a}_1(C) - \hat{a}_1(N)) \end{aligned} \qquad (2)$$

Our results indicate that the discriminant (2) works significantly better than the discriminant in Bungum and Tjøstheim (1976). In Figs. VII.8.1 and VII.8.2 the discriminant (2) is compared with the m_b:M_s discriminant. The m_b:M_s diagram has two explosions within the earthquake population and the separation between earthquakes and explosions is not particularly good. In the X1:X2 diagram these two events are now moved well into the explosion population and the separation between the two populations is substantially improved.

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REFERENCES

Bungum, H., and D. Tjøstheim (1976): Discrimination between Eurasian earthquakes and underground explosions using the m_b:M_s method and short period autoregressive parameters, Geophy. J.R. Astr. Soc., in press.

Table VII.8.1

The mean values of the energy estimates E_{20} and of surface wave magnitude M_s as obtained by averaging over the 46 explosions and 43 earthquakes respectively.

	1	2	3
Group Velocity Windows (km/s)	8.0-2.2	3.3-2.7	4.2-3.4
$\overline{E_{20}}$ Rayleigh vertical, explosions	3.88	3.89	3.61
$\overline{E_{20}}$ Rayleigh vertical, earthquakes	4.48	4.56	4.05
$\overline{E_{20}}$ Rayleigh horizontal, explosions	3.85	3.81	3.54
$\overline{E_{20}}$ Rayleigh horizontal, earthquakes	4.40	4.47	3.99
Group velocity windows (km/s)	8.0-2.2	3.7-3.1	4.6-3.8
$\overline{E_{20}}$ Love, explosions	3.77	3.76	3.51
$\overline{E_{20}}$ Love, earthquakes	4.55	4.69	4.00
$\overline{M_s}$, explosions		3.72	
$\overline{M_s}$, earthquakes		4.39	

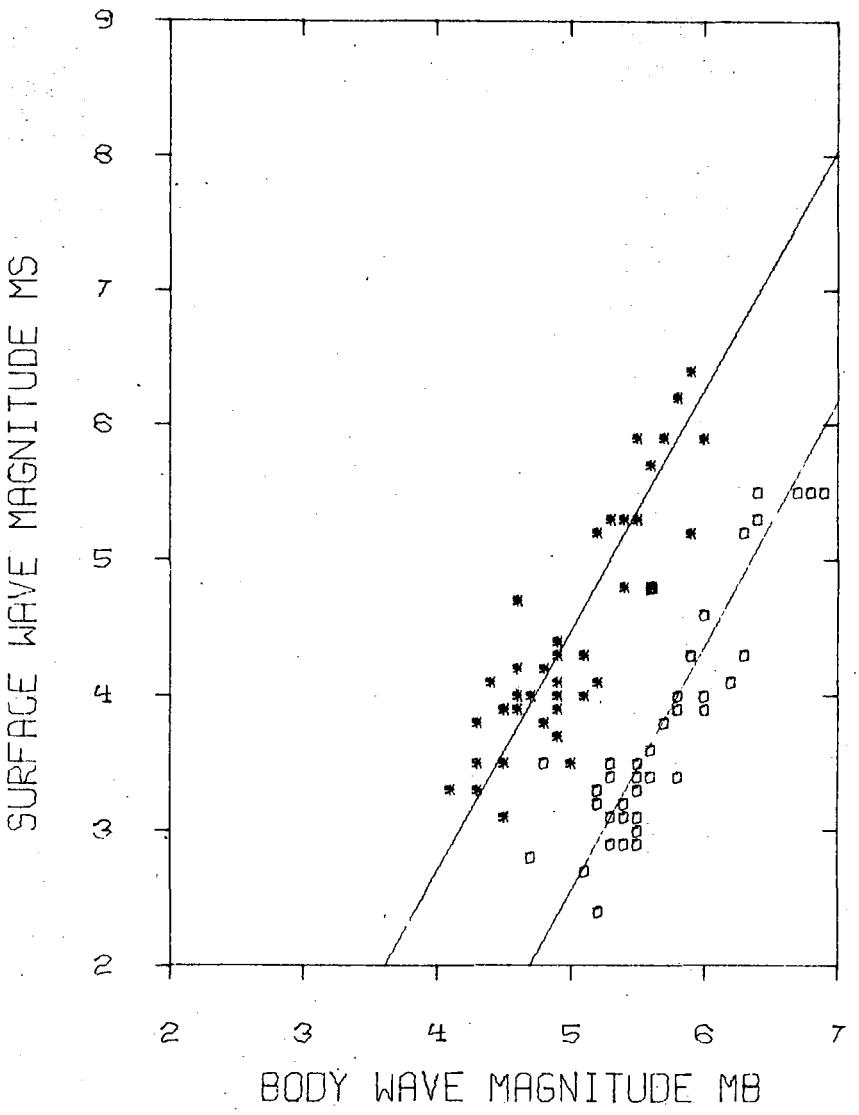

Fig. VII.8.1 m_b:M_s diagram for the 46 explosions and 43 earthquakes. PDE m_b and NORSAR M_s values (rounded to the first decimal) have been used. The regression lines have been fitted using the same maximum likelihood procedure as in Bungum and Tjøstheim (1976).

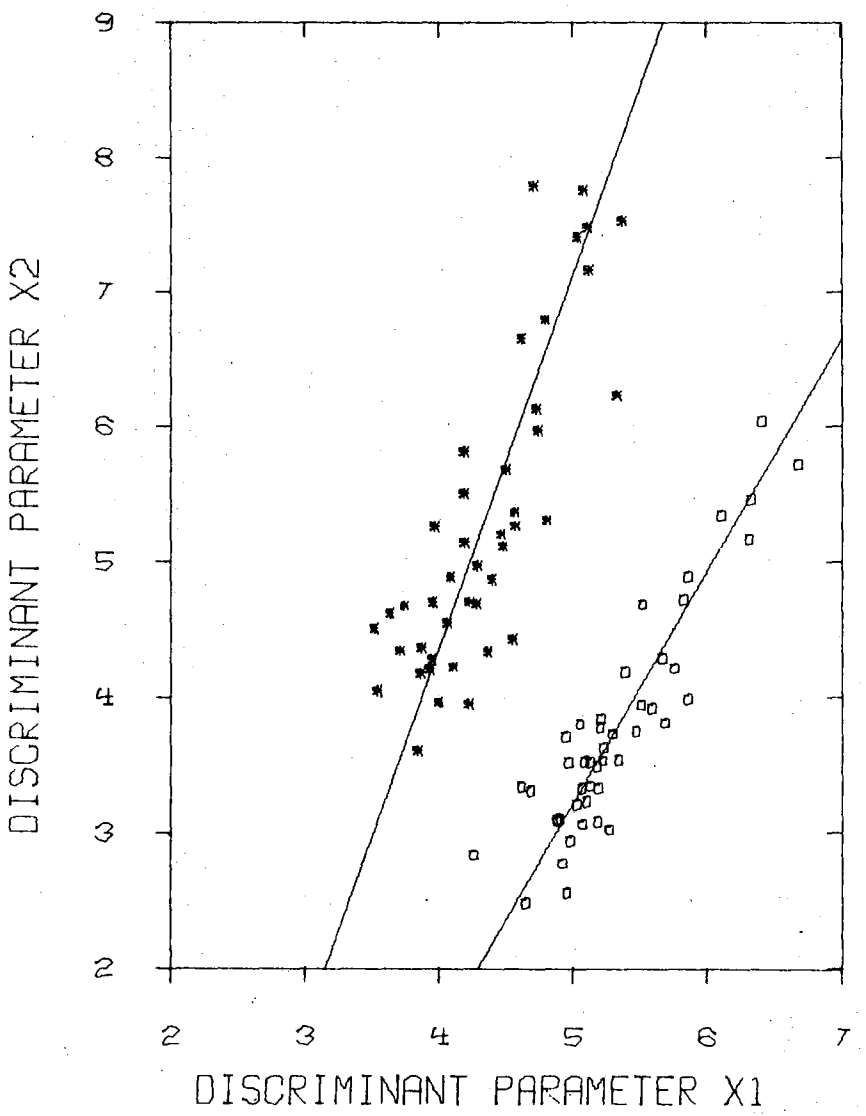

Fig. VII.8.2 X_1:X_2 diagram for the 46 explosions and 43 earthquakes.