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VII.8 Autoregressive Modelling of Seismic Storms

A nonstationary autoregressive (AR) time series model given by

$$X(t) - a_1(t)\, X(t-1) - \ldots - a_{p(t)}\, X(t-p) = Z(t) \qquad (1)$$

has been fitted to the long period (LP) noise registered at NORSAR. Here $X(t)$ is the observed LP-noise while $Z(t)$ is a white noise residual process satisfying $E\{Z(t)\,\overline{Z(s)}\}=\sigma_z^2(t)\,\delta_{ts}$. The LP-noise is assumed to be approximately stationary within time intervals of duration 5 min. (300 samples), and time variation of the coefficients is introduced by fitting stationary models to a sequence of such intervals. The corresponding spectra are completely described by the AR coefficients and the variance σ_z^2, and are given by

$$P(f) = \frac{2\sigma_z^2}{\left|1-\sum_{k=1}^{p} a_k \exp(-2\pi i f k)\right|^2} \qquad 0 \le f \le \tfrac{1}{2} \qquad (2)$$

The order $p=p(t)$ of the model has been estimated using the Final Prediction Error criterion and is a function of time. The time variation of the spectrum is now determined by the behavior in time of $a_1(t),\ldots,a_{p(t)}(t)$ and $\sigma_z^2(t)$. Usually the time variation is described in terms of selected spectral peaks, but this leads to loss of information.

The autoregressive modelling was used to examine the changes in the LP-spectrum during two microseismic storms described by Korhonen and Pirhonen (1976). The first example is a cyclone center over the North Sea in the time period March 20-25 1972. An AR-model of order 7 produced a satisfactory approximation to the spectrum. However, most of the spectral information is contained in the first two coefficients. The white noise variance σ_z^2 acts as a scaling factor. The time development of the coefficient $\hat{a}_1$ and the variance $\hat{\sigma}_z^2$ for the vertical component of the LP-noise is shown in Fig. VII.8.1 a) and b) respectively. The parameter $\hat{\sigma}_z^2$ has a sharp peak on March 23 at about 18h00 for all three components. This corresponds to the maximum power of the first and second peak (Korhonen and Pirhonen, 1976) of the vertical component spectrum. It is also interesting to note that the wind velocity has a maximum between March 22 and March 23, which corresponds to the time interval of greatest change for the coefficient $\hat{a}_1$. For more details and for a discussion of the second example (a cyclone center approaching the North Atlantic in the time interval May 24-27 1972) we refer to Sandvin and Tjøstheim (1977).

O.A. Sandvin
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REFERENCES

Korhonen, H., and S.E. Pirhonen (1976): Spectral properties and source areas of storm microseisms at NORSAR. Scientific Report No. 2-75/76, NTNF/NORSAR, Kjeller, Norway.

Sandvin, O.A., and D. Tjøstheim (1977): Autoregressive modelling of seismic storms. Proceedings, 15th General Assembly of European Seismological Commission, Krakow, 22-28 September 1976, to appear.

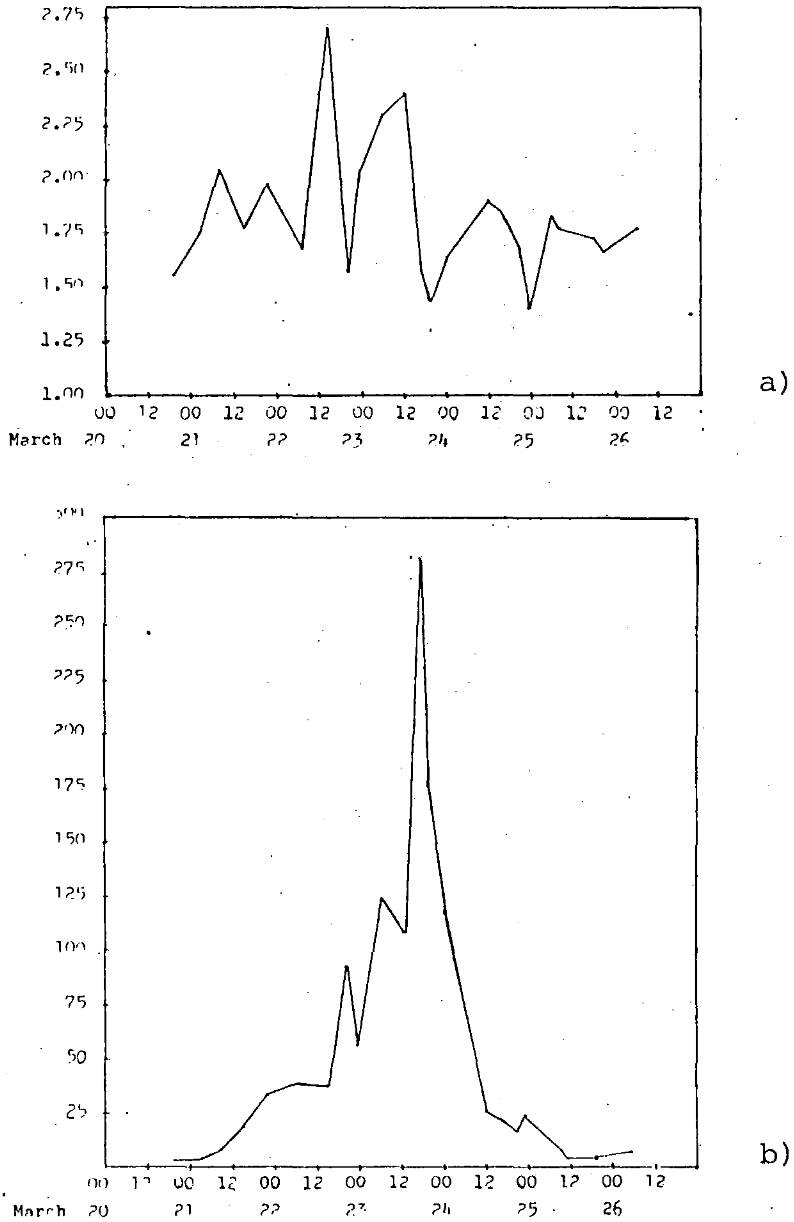

Fig. VII.8.1 a) Variation of coefficient $\hat{a}_1$ for vertical LP-noise from subarray 01A.

b) Variation of variance parameter $\hat{\sigma}_z^2$ for vertical LP-noise from subarray 01A.