NORSAR

ROYAL NORWEGIAN COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH

Scientific Report No. 6-73/74

SEMIANNUAL TECHNICAL REPORT
NORSAR PHASE 3

1 January – 30 June 1974

Prepared by
H. Bungum

Kjeller, 1 September 1974

L. FALSE ALARM AND NOISE STABILITY AT NORSAR

The large arrays LASA and NORSAR represent in general the most efficient tool available for detecting small seismic events. The basic operational principle of the array is beamforming; the array is regularly pointed towards a large number of prefixed points in all active seismic regions. The most commonly used detector is based on a continuous comparison between a certain parameter η and a preset detection threshold, η being the ratio between the linear array beam power measured in a short (STA) and a long time window (LTA).

The problem of declaring a signal detection represents a hypothesis test based on the test statistic η: declare a detection whenever η is equal to or exceeds a preset detection threshold (TH), i.e., choose hypothesis H_1. Otherwise, decide that H_1 is false, i.e., hypothesis H_0 is chosen. This binary decision model has two conditions: the false alarm or choosing H_1 when H_0 is true, and the missed detection or choosing H_0 when H_1 is true.

The design of the NORSAR detector was primarily governed by its computational simplicity and not derived from any optimum criteria, especially because the noise likelihood function was not exactly known. However, we know that the noise exhibits both diurnal and seasonal fluctuations. This means that the test statistic η is unstable, which implies a variable false alarm probability for a given detection threshold. As of today, a fixed threshold value is used in the array's detector causing a larger number of false alarms during night time as compared to day time operation. As the detector is insensitive to noise level fluctuations (Bungum and Ringdal 1974), this phenomenon has to be attributed to changes in noise variance. A study to investigate the effect of noise field variations on the

NORSAR event reporting performance and ways to improve the detectability of the array has been accomplished.

The most successful false alarm indicator considered, called the noise stability, is defined as

$$S = \frac{\overline{STA}^2}{\sigma^2 (STA)} \qquad (1)$$

where bar indicates averaging and σ^2 is the variance of STA. S is a generalized measure of the spread in the η observations and is likely to be a sensitive indicator for phenomena of the type investigated here (Lacoss 1972).

Fig. L.1 shows the false alarm rate as function of S for different detection thresholds. The false alarm rate is defined as the sum of all detections reported to have an STA/LTA ratio larger than 8.5, 9.0, 9.5 and 10.0 dB respectively. "True" detections were defined as STA/LTA larger than 10.5 dB and henceforth removed from the sample population. Noteworthy, the noise stability-false alarm relationship was found to be independent of whether the noise field varies naturally or artificially by using bandpass filters. The results of Fig L.1 are used to find a mathematical relation between TH, S and false alarm rate, i.e.,

$$TH(dB) = 12.08-(0.89 \pm 0.10) \log FA + (0.18 \pm 0.02) \cdot S \qquad (2)$$

where FA is number of false alarms per hour. This relation makes it possible to fix the false alarm rate and let the threshold vary as function of noise stability. It can be shown that implementation of a floating threshold will imply an average gain in the number of reported events of a few per cent relative to a fixed threshold procedure. Other advantages are avoidance of system saturation during extremely noisy time periods, and a more economical use of the computer capacity. The floating threshold procedure is at present tested out in parallel with the present (fixed) on-line detection threshold.

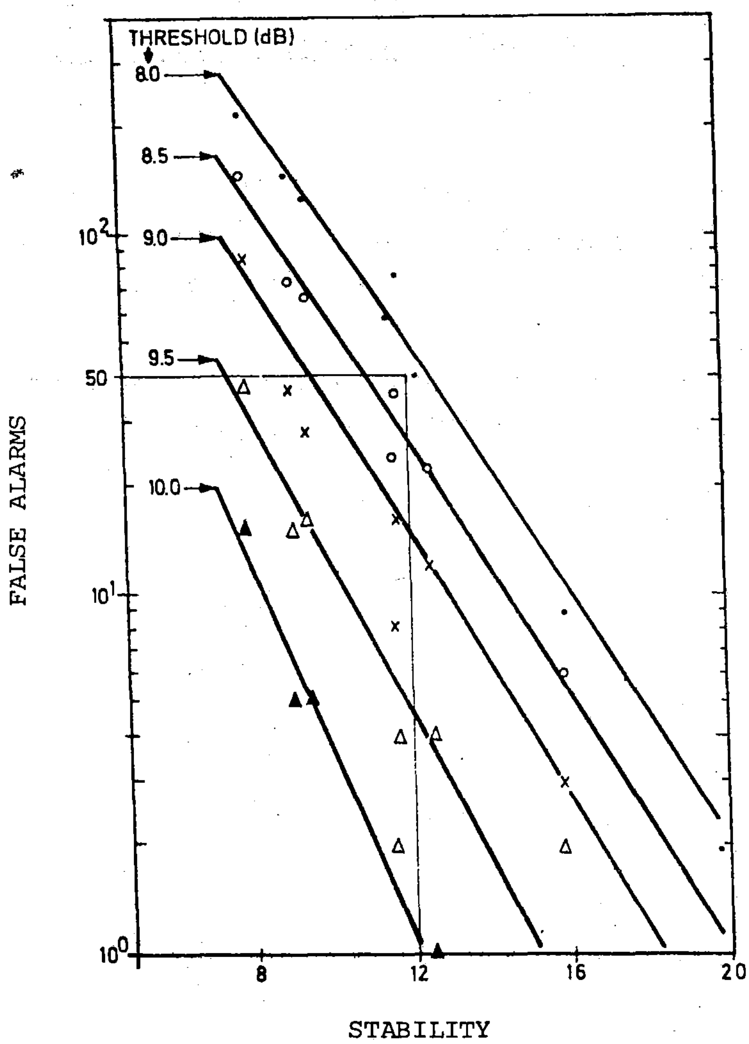

Fig. L.1 False alarm rate versus noise stability for different event detector threshold values. Three different noise situations were analyzed, each corresponding to 1 hour of NORSAR on-line processing. For further variations of the noise structure, 3 different bandpass filters were also used.

For further details on this topic we refer to a forthcoming paper authored by Steinert et al (1974).

O. Steinert
E.S. Husebye
H. Gjøystdal

REFERENCES

Bungum, H., and F. Ringdal (1974): Diurnal variation of seismic noise and its effect on detectability, Scientific Report 5-73/75, NTNF/NORSAR, Kjeller, Norway.

Lacoss, R.T. (1972): Variation of false alarm rates at NORSAR, Semiannual Technical Summary, Seismic Discrimination, M.I.T. Lincoln Lab, Mass. Inst. of Tech., Cambridge, Mass., June 1972.

Steinert, O., E.S. Husebye and H. Gjøystdal (1974): False alarm rate and noise stability at NORSAR, in preparation.