NORSAR

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FINAL TECHNICAL SUMMARY

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VI. SUMMARY OF SPECIAL TECHNICAL REPORTS/PAPERS PREPARED

VI.1 Evaluation of the Current NORSAR Detection Capabilities

One year of analyzed data (Oct 77-Sep 78) is now available after the NORSAR array was reduced in size. This data base is considered sufficient to conduct a preliminary analysis of the capabilities of the new NORSAR configuration. In the present study, the current event detection capabilities have been estimated both by comparison with the old 22 subarray system and by recurrence analysis of the magnitude-frequency relationship of the reported earthquakes.

Table VI.1.1 and Fig. VI.1.1 show the monthly average number of reported events during the last four years of 22 subarrays operation as compared to the most recent year. All of these numbers are based upon events reported in the analyst-reviewed NORSAR seismic bulletin, and thus represent real seismic events with minimal occurrence of false alarms. Apart from one month, March 1978, during which a large earthquake sequence occurred, the picture is quite stable, and the average monthly number of reported events is now about 60% of what it was before the reduction from 22 to 7 subarrays. The ratio is about 65% if one compensates for the increased system downtime after the reconfiguration. From Table VI.1.1 it is further seen that the estimated degradation does not change significantly if one deletes all months that contain large earthquake sequences.

Assuming that the b-value of the magnitude-frequency recurrence relationship is independent of time, it is easily seen that the change in 50% incremental detectability threshold Δm_b corresponding to the ratio R of detected events (in per cent) can be expressed as (Pirhonen et al, 1976)

$$\Delta m_b = -\frac{1}{b} \cdot \log_{10} \left(\frac{R}{100}\right)$$

Assuming b=0.9, R=65 then gives Δm_b=0.21. This may be compared to the theoretical reduction in beamforming gain ΔG for 7 versus 22 subarrays, which is $10 \cdot \log_{10} 22/7$ = 5.0 dB or 0.25 m_b units. Thus the observed performance relative to the old configuration corresponds closely to what could be expected. It appears that the increased automation in the bulletin generation procedure has not significantly affected the detection performance, as far as the number of reported events is concerned.

We now turn to the problem of obtaining an independent measure of the current NORSAR detectability (i.e., a measure not relative to previous capabilities). Our progress so far has been rather limited, because the most reliable estimation method, namely, that of checking detections against an independent reference station (Ringdal, 1975) has not been possible to use after the only reference system of sufficiently high capability, the SDAC/LASA bulletins, has been discontinued. Therefore, we have resorted to the recurrence technique, analyzing the available one year of data (Oct 77 - Sep 78) in a way identical with what was done by Berteussen et al (1976) in their final evaluation of the NORSAR detectability before the reduction in array size. Only the results from the least squares cumulative method will be presented here, as shown in Table VI.1.2. The method is illustrated in Fig. VI.1.2, which shows the combined teleseismic data (Region 14). The results in Table VI.1.2 must be considered relatively uncertain for most regions, due to the limited data base. Nonetheless, we may take note of the 90% cumulative thresholds for regions such as Central Asia (3.6) and Japan-Kamchatka (4.0). It is also evident that the performance has decreased somewhat relative to that of the NORSAR system during 1972-75 (Berteussen et al, 1976), with a degradation varying in the range 0-0.3 m_b units. The uncertainties inherent in the estimation method should, however, not be forgotten, and in general we consider the number of reported events to be a more reliable indicator of the array performance than the results from the recurrence analysis.

Our future plans include developing new methods for a more reliable direct estimation of the detectability of the NORSAR array, in particular at regional and near-regional distances. As more data are accumulated, it should also be possible to obtain better estimates of event detectability in selected seismic regions.

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References

Berteussen, K.-A., H. Bungum and F. Ringdal (1976): Re-evaluation of the NORSAR detection and location capabilities. Scientific Report No. 3-75/76, 20 June 1976.

Pirhonen, S.E., F. Ringdal and K.-A. Berteussen (1976): Event detectability of seismograph stations in Fennoscandia. Phys. Earth Planet. Inter., 12, 329-342.

Ringdal, F. (1975): On the estimation of seismic detection thresholds. Bull. Seism. Soc. Amer., 65, 1631-1642.

	(a) 4 yrs 72/76	(b) 1 yr 77/78	(c) Ratio (R) (%)	(d) log R	(e) Swarms Removed (%)
Oct	483	380	79	-0.10	79
Nov	430	214	50	-0.30	49
Dec	505	235	47	-0.33	54
Jan	658	210	32	-0.49	48
Feb	499	263	53	-0.28	53
Mar	513	855	167	0.22	-
Apr	555	316	57	-0.24	60
May	550	337	61	-0.21	65
Jun	769	387	50	-0.30	76
Jul	659	361	55	-0.26	59
Aug	692	301	43	-0.37	57
Sep	442	276	62	-0.21	62
Average	563	345	61	-0.24	60
Average Compensated for DP Down-Time	576	373	65	-0.22	64

Average DP uptime 1972/76: 97.7%

Average DP uptime 1977/78: 92.7%

TABLE VI.1.1

Monthly averages of the number of NORSAR-reported events (a) for the four years Oct 72 - Sep 76, (b) for the year Oct 77 - Sep 78, (c) the ratio R (%) between the numbers, (d) $\log_{10} R$, (e) the ratio R modified by deleting months during which significant earthquake swarms occurred.

Region	Area of Coverage	Events 1977/78	90% Cumulative	Down from 1972/75
1	Aleutians-Alaska	214	4.0	0.3
2	Western North America	36	-	-
3	Central America	62	4.4	0.1
4	Mid-Atlantic Ridge	52	3.9	0.1
5	Mediterranean-Middle East	259	3.7	0.1
6	Iran-Western Russia	147	3.7	0
7	Central Asia	276	3.6	0.1
8	Southern-Eastern Asia	187	3.9	0.3
9	Ryukuo-Philippines	325	4.5	0
10	Japan-Kamchatka	1255	4.0	0.2
11	New Guinea-Hebrides	105	4.6	0.1
12	Fiji-Kermadec	605	4.1	0.2
13	South America	31	-	-
14	Distance range $30^{o}-90^{o}$	2815	3.9	0
15	Distance range $110^{o}-180^{o}$	802	4.7	0.1

TABLE VI.1.2

Detectability statistics for the reconfigured NORSAR array for 15 geographic regions (see Berteussen et al, 1976). Within each region the table gives the number of reported events, the estimated cumulative 90% detection threshold in terms of NORSAR m_b (from recurrence analysis) and the corresponding degradation relative to the 1972/75 performance (as estimated by Berteussen et al, 1976).

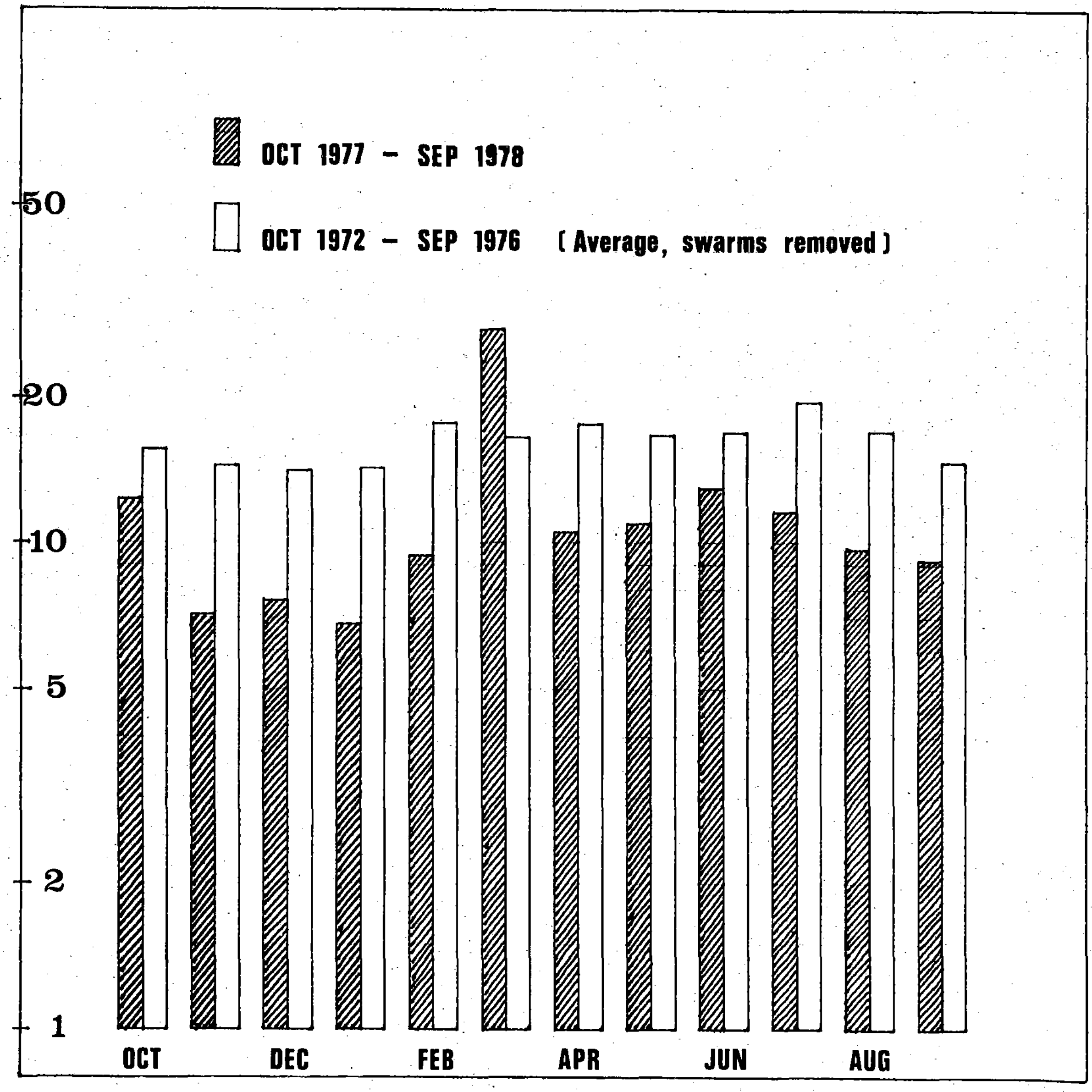

Fig. V.1.1 Monthly averages of reported events at NORSAR, corresponding to the last column of Table VI.1.1. Note that in computing the averages for the period Oct 1972 - Sep 1976 all months with significant earthquake swarms have been ignored. According to the same criterion, the month of March 1978 should be ignored when comparing the two periods.

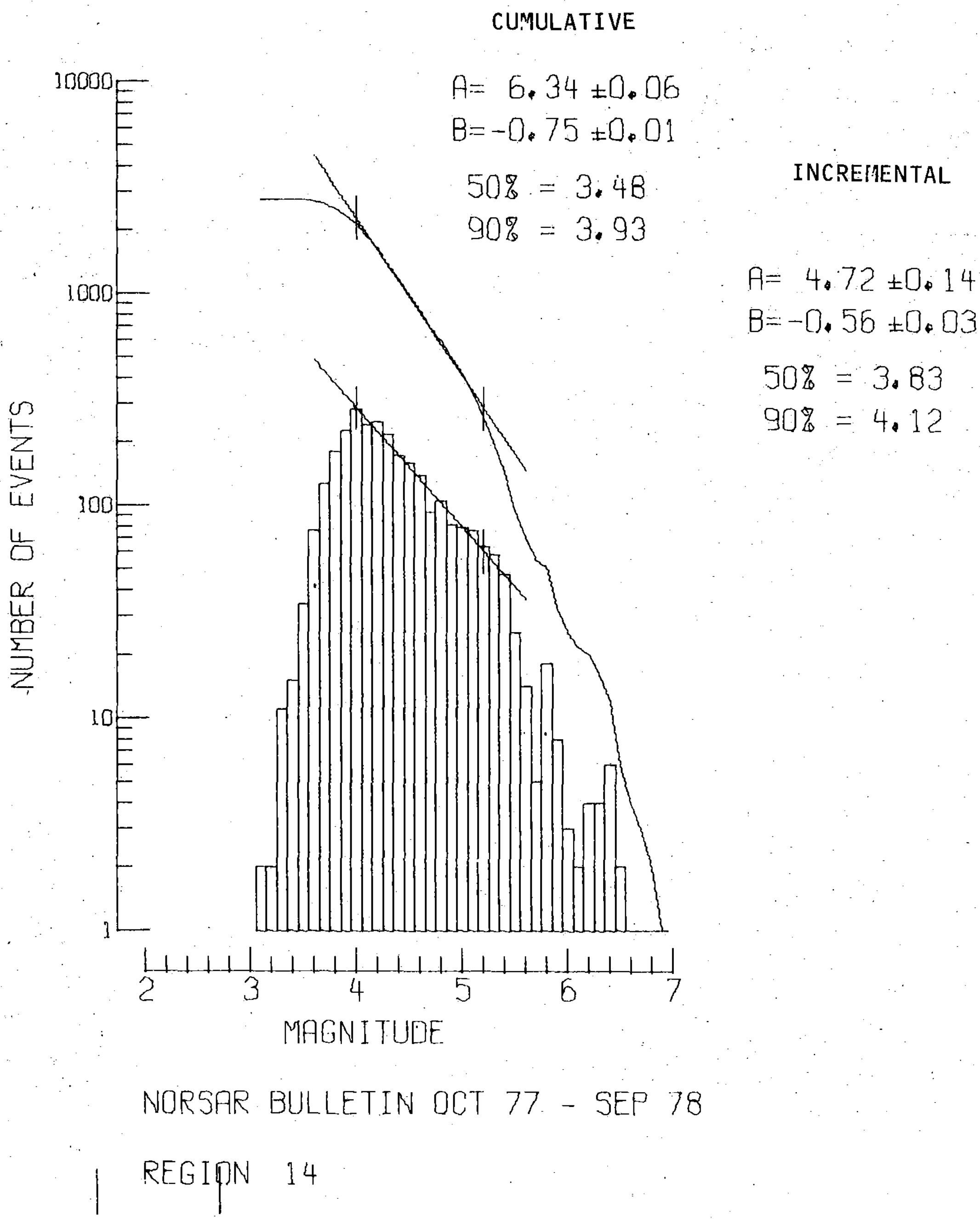

Fig. VI.1.2 Frequency-magnitude distribution for events reported in the NORSAR seismic bulletin for the one-year period October 1977-September 1978. The figure covers events in the distance range 30^{o}-90^{o} from NORSAR. Estimated cumulative and incremental detection thresholds are indicated.