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VII.3 NORESS real time processing performance for events in Western Norway and the North Sea

Our previous semiannual report contained a contribution (Mykkeltveit, 1985) on the performance of NORESS real time processing for events in Western Norway and the North Sea. The data base under consideration consisted of 132 events automatically located by the NORESS online processing package (RONAPP) and also reported independently by the University of Bergen, based on their network of six seismic stations located on the west coast of Norway. In the present study, we have extended our previous investigation by taking a different approach: The bulletin of events reported by the network was used as the starting point for a search in the RONAPP automatic detection log for all detections that could be associated with these events.

The events reported by the network are explosions and earthquakes within or near the network, in addition to events in the North Sea. The distance range to NORESS for these events was 250-700 km. Since the goal of our investigation was an evaluation of the performance of RONAPP with respect to locating regional events, it was necessary to carefully check the quality of the network locations. As a result of this process, all reported events within the network were accepted. In addition, the quality of the locations of all events outside the network but within 100 km of the nearest station was considered satisfactory. The British Geological Survey (BGS) publishes a bulletin for the North Sea region based on arrival times reported for stations in Norway, Shetland and Scotland. Events in this region for which the locations were constrained by station readings from both sides of the North Sea and reported by BGS were also added to our event list, which contains 251 events for the period April-September 1985.

The RONAPP detection log for the period April-September 1985 contains approximately 14,000 entries, each with information on detection time, phase velocity and direction of arrival, as well as other parameters. For the events in the list based on the network bulletin, expected arrival times at NORESS for the phases Pn, Sn and Lg were computed and compared with actual detection times in our detection log. The velocity-depth model used to generate these arrival times at NORESS is the one used in the RONAPP location algorithm: a three-layered crust of thickness 40 km overlying a half-space.

Fig. VII.3.1 shows the detection capability of NORESS/RONAPP for the events in our data base. The criterion for declaring a detection for a P- or S-phase for these events is the existence of an entry in the RONAPP detection log that can be associated with such arrivals. The requirement for accepting a P-phase association is a phase velocity exceeding 6 km/s, an arrival time deviating by less than 10 sec from the expected arrival time for Pn, and an estimated direction of arrival within 30^{o} of the "true" direction, determined from the reported location. Acceptance of an S-phase association results from a phase velocity less than 6 km/s, deviation from the expected arrival time for Sn <u>or</u> Lg less than 10 sec, and an estimated direction of arrival within 30^{o} of the true direction. The reported magnitudes M_D are duration magnitudes and are found to correspond well to the local magnitudes M_L automatically determined by RONAPP and included in the NORESS event bulletins. The epicentral distances for the events included in Fig. VII.3.1 range from 250 km to 700 km. The distribution within the data base is such that the detection probabilities inferred from this figure are representative for events at a range of approximately 400 km. At this range a detection probability of 50% is achieved at magnitude M_L of about 1.8. If the requirement is relaxed to detection of one phase (P or S) only, the detection probability increases to approximately 70% at magnitude 1.8.

Fig. VII.3.2 shows deviations from expected arrival times (based on the network locations) for all detections from RONAPP that can be associated with the 251 events (the criterion is again that the azimuth estimated for the detected phase must be within 30° of the azimuth from the network location). These detections are classified as P detections if the estimated phase velocity exceeds 6 km/s, and as either Sn or Lg if the phase velocity is below this value. The detections are classified as Sn if the signal arrives before a time corresponding to the mid-point between the expected arrival times for Sn and Lg, otherwise it is classified as Lg. Fig. VII.3.2 indicates that the class of P detections is composed of slightly early Pn detections and Pg arrivals typically 4 seconds after Pn. A closer examination of the RONAPP plots for these events showed that the P detections at 27 seconds and later correspond to true Sn and Lg arrivals, for which the f-k analysis resulted in a wrong phase velocity. Similarly, the Sn detections that are early by 20 seconds or more correspond to true P arrivals, for which the f-k analysis gave wrong velocities.

Fig. VII.3.3 includes one arrival only for each phase type, namely, the earliest detection of type P, Sn and Lg, for each of the events in the date base. This figure shows that the Pn arrivals are typically a few seconds early relative to our model, that frequently Pn is missed and the first detected P is Pg, that Sn detection times are fairly close to expected ones, and that Lg onset detections are typically early by about 3 seconds. These observations suggest changes in the velocity-depth function embedded in our automatic location procedure, for events in this region. For example, the group velocity of 3.50 km/s used by RONAPP for the Lg onset in the range estimation should be changed to approximately 3.60 km/s.

Fig. VII.3.4 shows average phase velocities for all arrivals in Fig. VII.3.2, for which there are three or more detections within each one second interval, for each of the phases. All events have been "normalized" to an epicentral distance of 400 km, in the sense that expected arrival times of Sn and Lg have been set at 41 and 58 seconds after Pn, respectively, but the observed deviations from the expected arrival times of Sn and Lg have been retained. We see a fairly sharp drop in the phase velocity at travel time zero seconds, corresponding to the transition from Pn to Pg arrivals. It is also seen that on the average, Sn phase velocities are higher than those for Lg. The Lg phase velocities appear remarkably stable at about 4.1 km/s.

In conclusion, this study has shown that the RONAPP performance for events at a distance of 400 km from NORESS is very satisfactory for magnitude 2 and above for RONAPP's current beam deployment. The study has also provided statistics on the rate of failure of the f-k analysis in determining the phase type. Finally, the study has provided a basis for changes in the travel-time model that will lead to better precision in the automatically determined locations.

S. Mykkeltveit

References

Mykkeltveit, S. (1985): Evaluation of NORESS real time processing performance: Case study for 132 Western Norway/North Sea events. Semiannual Technical Summary, (ed. L.B. Loughran), 1 April - 30 September 1985, NORSAR, Kjeller, Norway.

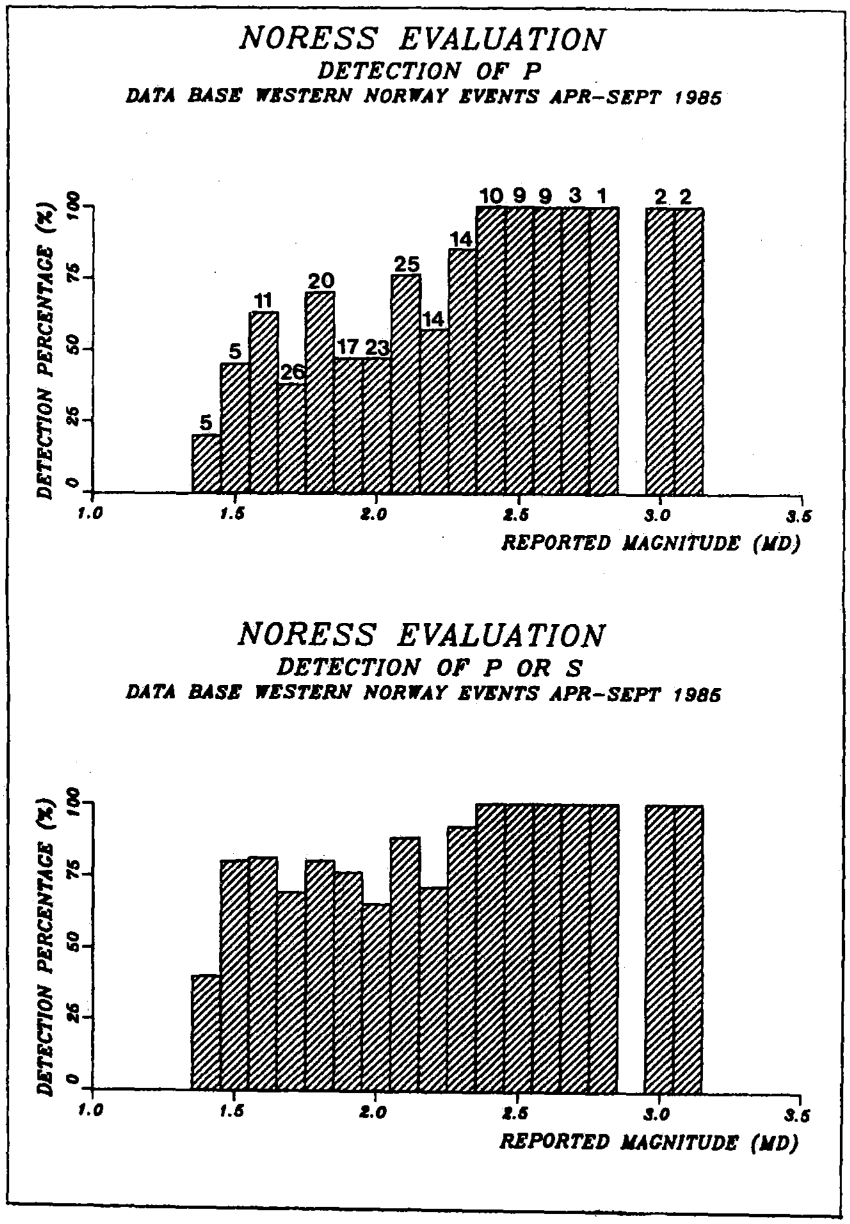

Fig. VII.3.1 NORESS detection probabilities for the events in our data base. The top figure shows probabilities for detection of a P-phase, while the bottom histogram shows probabilities of detection of a P- or S-phase. The numbers on top of the columns (top figure) give the number of events reported for each magnitude.

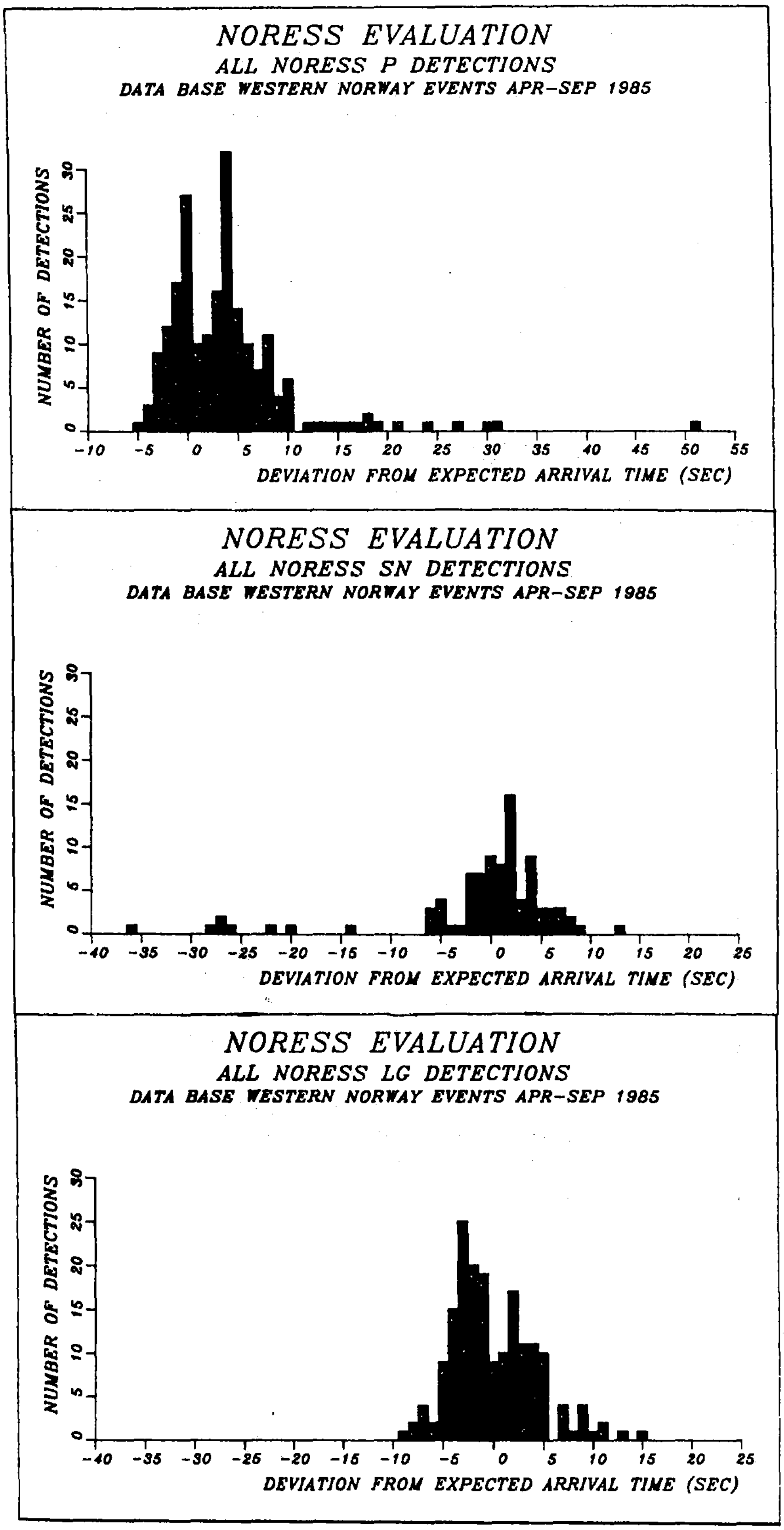

Fig. VII.3.2 Deviations from expected arrival times for P (top), Sn (middle) and Lg (bottom) for NORESS detections corresponding to the 251 Western Norway events.

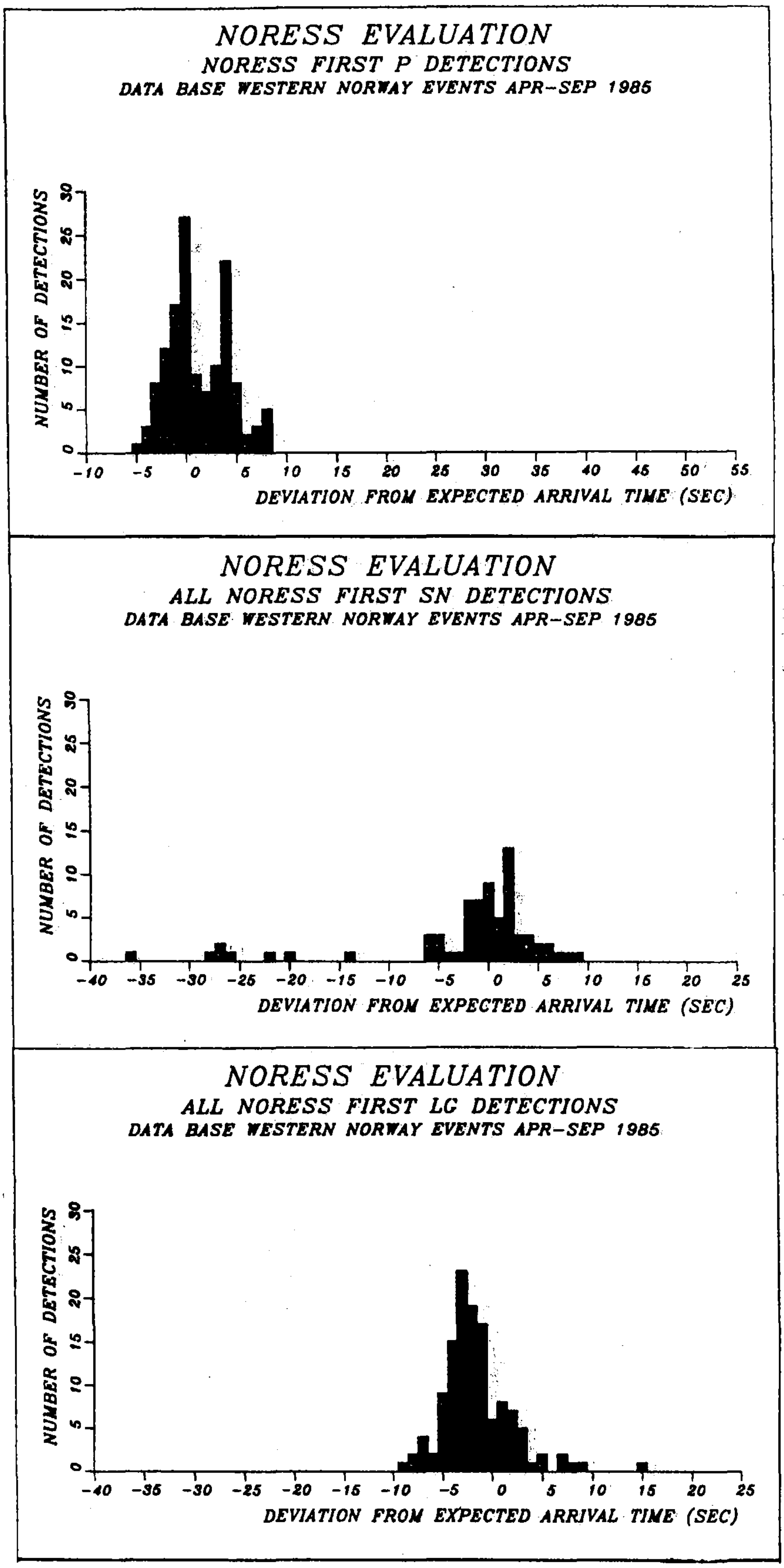

Fig. VII.3.3 Same as VII.3.2, but now only the first detection is included for each phase type.

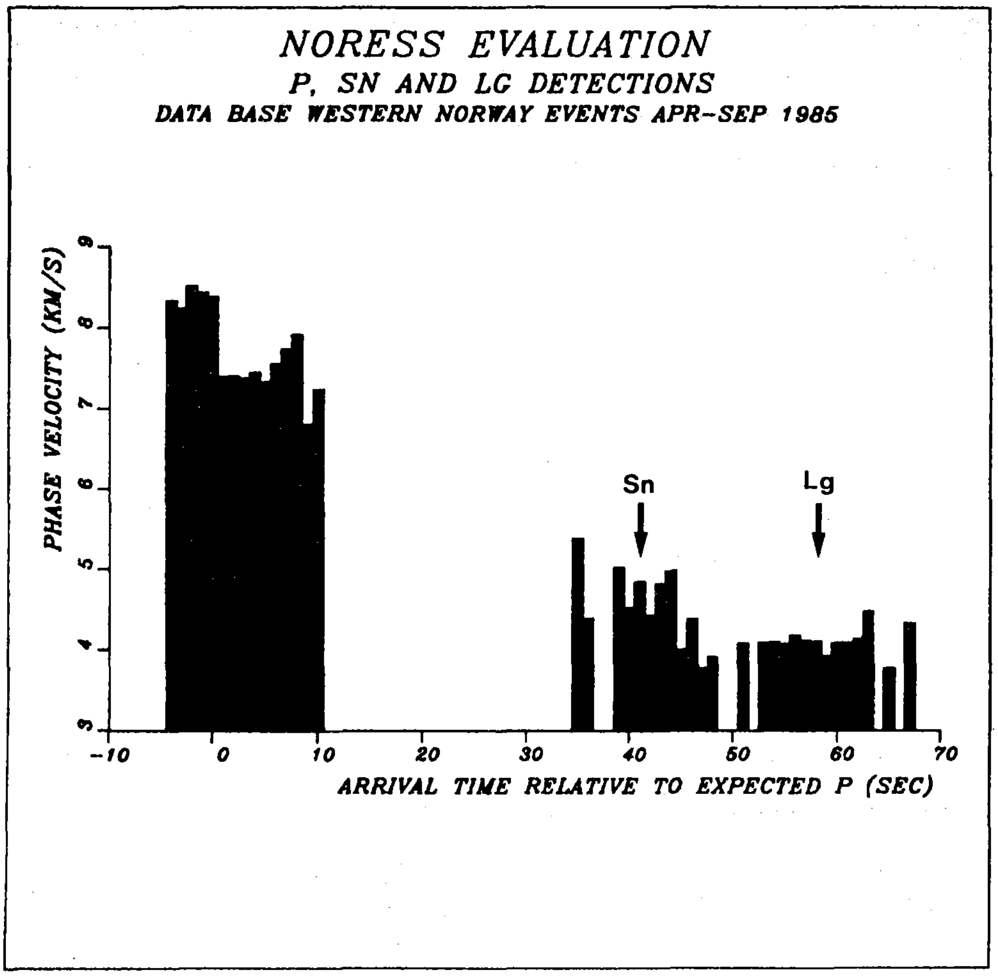

Fig. VII.3.4 Average phase velocities for the detections in Fig. VII.3.2. All events have been "normalized" to an epicentral distance of 400 km, with expected arrival times for Sn and Lg as indicated by the arrows.