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7.7 An assessment of the estimated mean mislocation vectors for small-aperture arrays

Introduction

The objective of this study was to test the applicability of the estimated mean mislocation vectors for small-aperture arrays (Schweitzer, 1994; Schweitzer & Kværna, 1995) for use with different event-location procedures. The mean mislocation vectors were calculated in the slowness space and are now available for automatically estimated fk-results over a large range of azimuth and ray-parameter values. Additionally, mean standard deviations for the mislocation vectors could be defined as a function of the measured slowness values. All this information can now be used to increase the stability and quality of both phase association and event location based on automatically estimated fk-results.

Single-array locations

For the four arrays, ARCESS, FINESS, GERESS and NORESS, the data base of slowness correction vectors was sufficiently dense that these corrections could be applied for locating local and regional seismic events. In this way, the correction vectors could be used to improve the single-array locations.

The single-array location procedure RONAPP (Mykkeltveit & Bungum, 1984) uses the TTAZLOC algorithm (Bratt & Bache, 1988) and locates events with travel time and azimuth information as input data. Apparent velocities of the detected onsets are only used to identify the different seismic phases. The uncertainties of the estimated parameters (onset time, azimuth and apparent velocity) were calculated from the SNR and the quality of the fk-analysis. Therefore, correcting automatically estimated fk-results with mean mislocation vectors mainly influences the location algorithm in changing the azimuth of the observed phases. Only in some cases does correcting the apparent velocities lead to a change of the estimated phase type (and thereby also a shift to another travel-time table). The standard deviations of the mean mislocation vectors were not taken into account in this study.

To assess the mean mislocation vectors for the four arrays mentioned above, the whole data set for 1994 was reprocessed. Fig. 7.7.1 shows all 25,612 events defined and located by the four small-aperture arrays in the original single-array data analysis. The map clearly shows the concentration of the seismicity at known source regions. Additionally, we can see a more scattered distribution of events located at larger distances from the arrays. The two circles of events around NORESS and ARCESS are an unexplained artefact of the RONAPP recipes for these two arrays.

Fig. 7.7.2 shows the 24,946 relocated events after correcting the automatically estimated slowness values (phase velocity and azimuth) with the mean mislocation vectors. For the phases where a mislocation vector was unassociable, the original slowness values remained unchanged. The reduction of the number of defined and located seismic events by about 2.5% is mostly caused by a reduction of events far away from the arrays (to see the reduced number of artificial events scattered in the background, compare with Fig. 7.7.1).

Because most of the events located by the regional arrays are due to man-made activity, this large number of relocated events cannot be compared with independent bulletins. Therefore an evaluation of the results can only be done in a more qualitative way. It is clearly seen that the concentration of events around known source regions in Europe is much higher after introducing the slowness corrections. Especially the azimuthal scatter is smaller. This clearly shows the positive effect of correcting the observed apparent velocities and azimuth values with mean mislocation vectors.

Slowness residuals in the REBs

After 10 months of operating GSETT-3, the Reviewed Event Bulletins (REBs) contain a huge amount of (automatically) estimated ray parameter and azimuth values observed for the small-aperture arrays ARCESS, FINESS, GERESS and NORESS. Although these values are not always used in the final location of seismic events, ray parameter and azimuth play an important role during the identification and association process at the IDC. It is known that the single ray parameter and azimuth observation of a small-aperture array show a relatively large scatter and additionally often a systematic mislocation. For seismic events with only a few well-defined observations, this scatter will influence the starting location of the event location procedure. In addition, the phase association process will be influenced by the systematic array mislocations. Estimating mean mislocation vectors is part of a needed calibration of all GSETT-3 stations (Harjes et al, 1994). In this study such mean mislocation vectors were tested for application at the IDC.

All REB-events (1 Jan - 31 Oct 1995) located with at least 10 defining phases were investigated for onsets of the four small-aperture arrays. These events were assumed to have a location precision that allowed for investigation of slowness residuals. The ray parameter and azimuth residuals were transformed in a slowness-error vector. Whenever this vector was smaller than 6 sec/° and the travel time residual of the onset was smaller than 6 sec, this onset was defined as a valid association and the slowness vector was corrected with the mean mislocation vector. Fig. 7.7.3 shows the results for each investigated array. The blue line always shows the distribution of the slowness errors without any correction and the red line shows the distribution of the slowness errors after applying the corrections. The two distributions are normalized relative to the maximum of the occurring slowness errors. The corrected slowness values clearly show smaller errors and should therefore be used in the data processing at the IDC (see Table 7.7.1).

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Table 7.7.1. Some statistical parameters of observed and corrected slowness errors

Array	Number of events	Observed slowness errors		Slowness errors after correction	
		mean [sec/°]	median [sec/°]	mean [sec/°]	median [sec/°]
ARCESS	7183	1.767	1.476	1.350	0.963
FINESS	7746	2.164	1.897	1.830	1.407
GERESS	5142	1.732	1.404	1.547	1.135
NORESS	5308	2.071	1.812	1.783	1.351

RONAPP locations 1994 (25,612 events), original

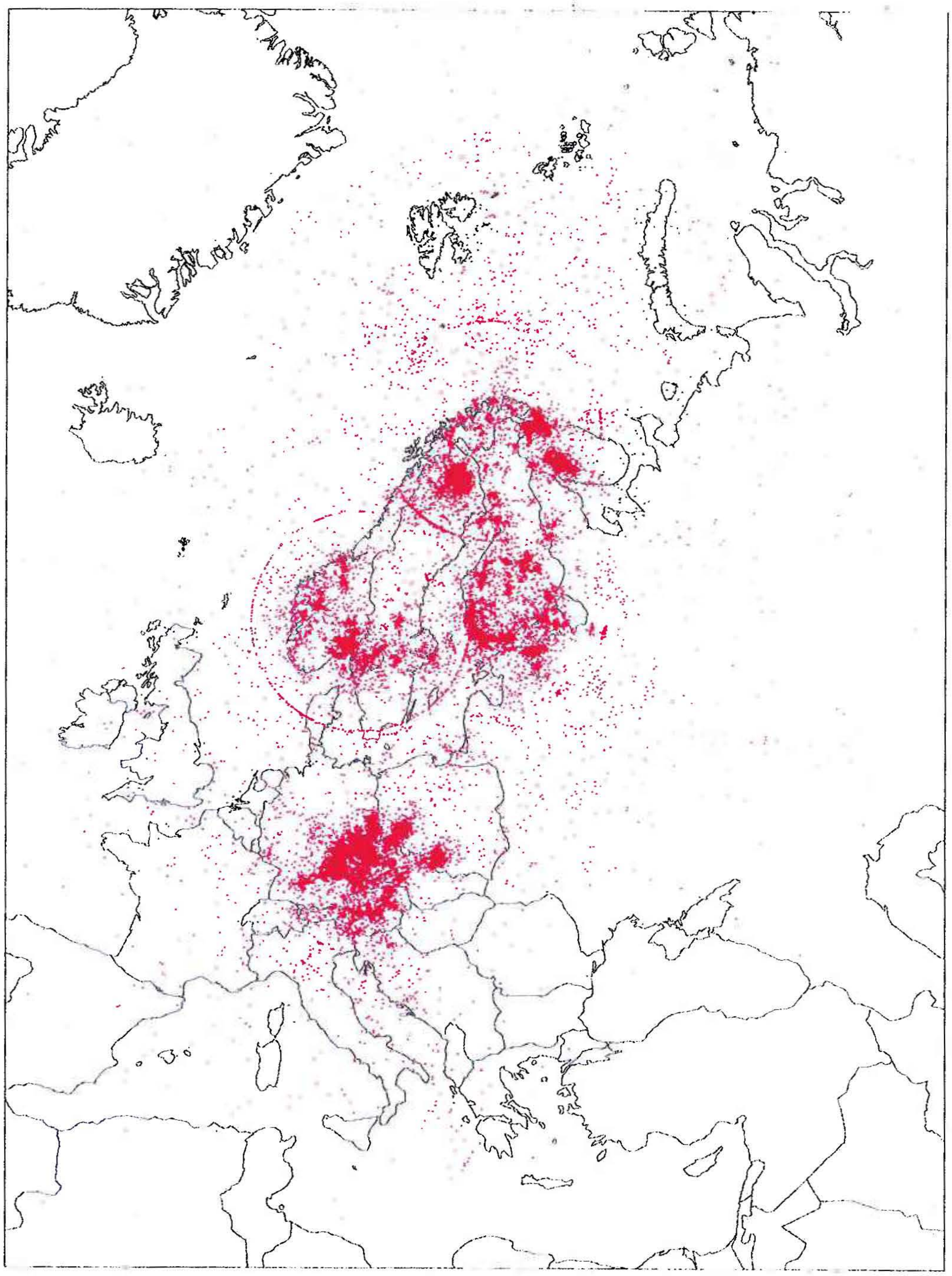

Fig. 7.7.1: All 25,612 events located during 1994 by ARCESS, FINESS, GERESS, and NORESS using the originally estimated apparent velocities and azimuth values.

RONAPP locations 1994 (24,946 events), corrected

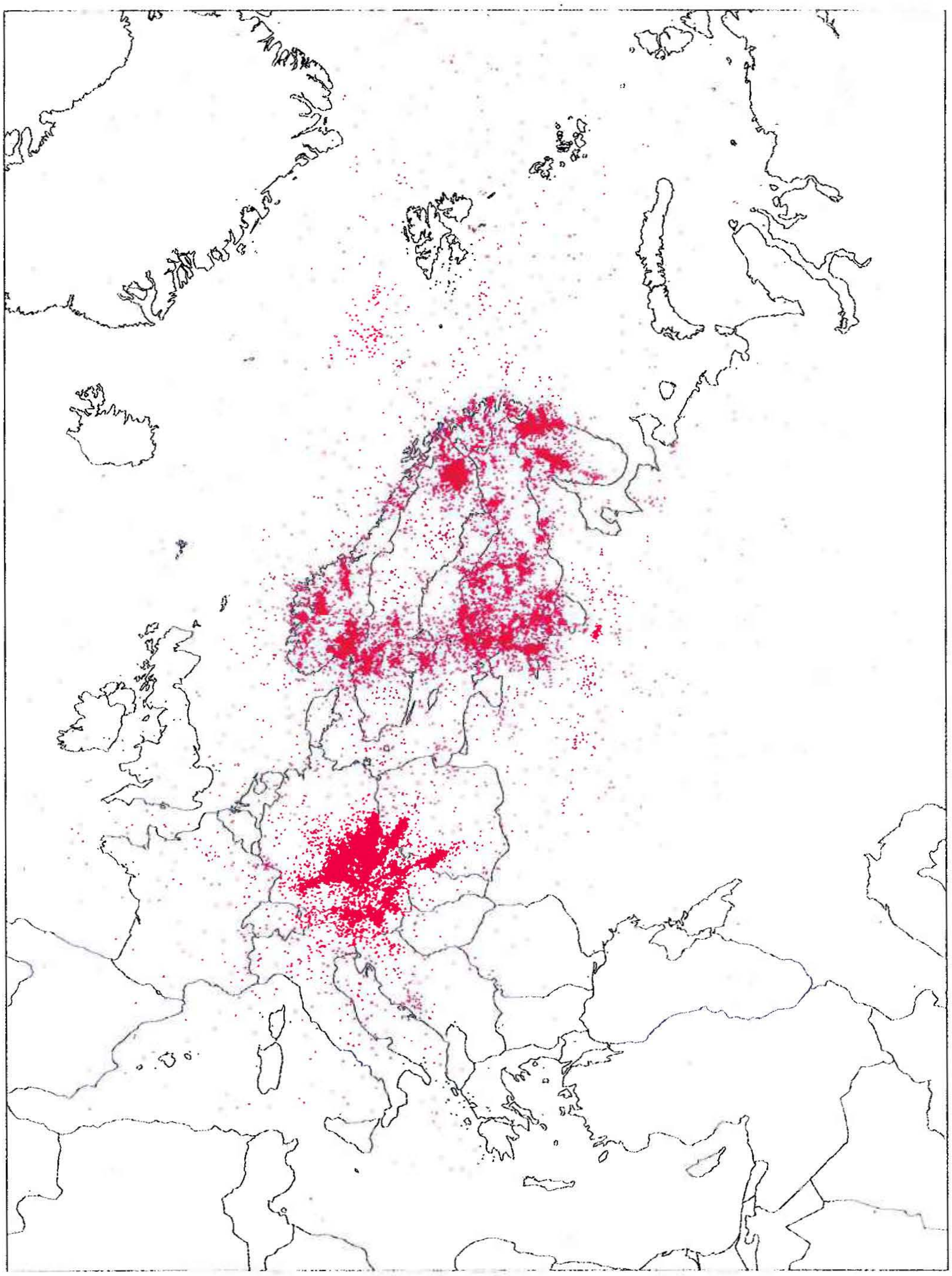

Fig. 7.7.2: All 24,946 events for 1994 located after correcting the apparent velocities and azimuth values with the mean mislocation vectors of ARCESS, FINESS, GERESS, and NORESS.

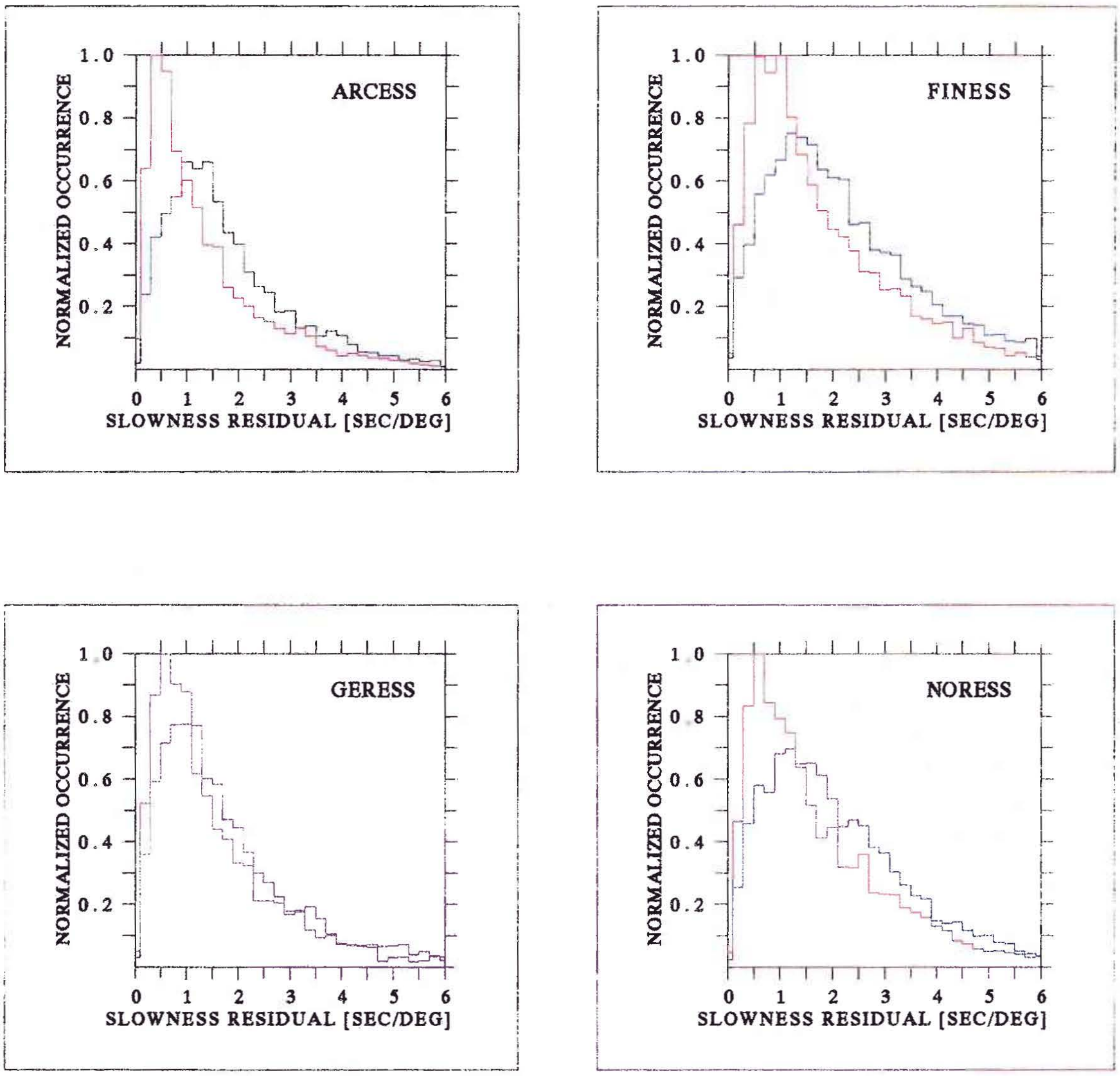

Fig. 7.7.3: Slowness residuals in the REBs for each of the investigated small aperture arrays. The blue line shows the original residuals and the red line shows the remaining residuals after applying the mean mislocation vectors. All distributions were normalized for each array separately.