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VII.8 Epicenter location scenarios

Traditionally, P-wave arrival time observations from 4 stations are required for the estimation of the four focal parameters epicenter location (σ, λ), focal depth and event origin time. The computational techniques in use are well documented in the scientific literature, although an occasional severe practical problem is that of proper phase association. The latter difficulty stems from inadequate grouping of event P reportings when several events "overlap" in a given time window. Such ambiguities are easily resolved when array/3-comp. station estimates are available. In this section three scenarios for event location will be discussed, namely: i) single station (3-comp.) array event location; ii) two station/array event location; and iii) precise event location using a regional network of high quality stations.

i) Single station/array event location

The problem is illustrated in Fig. VII.8.1a and VII.8.2, and obviously the accuracy in the epicenter location estimate reflects precision in azimuth and distance estimates. As demonstrated in Section VII.7, a single 3-comp. station can provide azimuth estimates within 5 degrees or even within 2 degrees in good cases. Distance estimates are more problematic unless secondary phases confidently can be identified. This is indeed feasible at local (Pn, Sn, Lg, etc.) and regional (400 km and 650 km travel time triplication curves) distances, while slowness estimates are not too accurate at teleseismic distances. Using 3-comp. recordings, the measured angle of incidence can provide distance estimates which appear to be more precise than those stemming from slowness measurements say via F-k analysis of dat afrom small aperture arrays. Another advantage with 3-comp. data analysis is that phase identification becomes more objective, and may even provide a means for focal depth estimation via "detection" of the pP-phase.

ii) Two station/array event location

The problem is illustrated in Fig. VII.8.1b and VII.8.3, and the most important parameters needed are azimuths and relative P arrival times as a substitute epicentral distance estimates. With reasonable geometries, epicenter location should be within a few hundred kilometers or even less.

Comments. Gjøystdal et al (1973) have extensively dealt with one- and two-array event location capabilities and their techniques naturally apply to azimuth and distance estimates extracted from the 3-comp. station data. Naturally, the accuracy in the epicenter locations made depends on geometry (see Fig. VII.8.1), as wavefront angles scale differently with distances. An interesting problem here, now under investigation, is whether the pattern of secondary arriving phases as derived via our new 3-comp. data analysis can be used for refining epicenter distance estimates.

iii) Use of regional networks for event locations

In the context of a potential comprehensive test ban treaty, precise event locations are a necessity, and this can only be achieved by having access to recordings from a network of regional stations (for small events). A number of computer schemes, such as HYPO 75, exist for solving this kind of problems, but a general drawback here is that the crustal model used is considered a bit crude. For example, what is the velocity distribution in the crust? Is it constant, depth dependent only; is lateral variation significant or do we have to take potential anisotropy into account? A related problem is which phases are actually observable in the seismogram and what are their respective ray paths. Do we actually see waves refracted from the Conrad discontinuity; the Pn phase may be a head wave or perhaps better modelled as a diving wave? Likewise, reflections from Conrad and/or Moho if observable would constrain focal depth estimates. Clearly, precise event locations using regional recordings are much dependent on the velocity distribution in the crust and lithosphere and our ability to model it properly, and equally important, extract relevant phase information from the seismogram. Extensive use of S-phases is clearly an advantage here in view of their short wave lengths.

A long-term research project is now under way at NORSAR for solving these kinds of problems; the principal goals are those of inverting available travel time information for a multitude of phases in order to produce a tomographic image of the crust and lithosphere structures and, important, jointly extract relevant focal parameters. The research strategy here is outlined in some more detail by Gubbins (1985), while Christoffersson et al (1985) have presented a novel approach to both quantitative and qualitative extraction of significantly more phase information from 3-comp. seismogram recordings (e.g., see Section VII.7).

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References

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Gjøystdal, H., E.S. Husebye and D. Rieber-Mohn (1973): One-array and two-array location capabilities, Bull. Seism. Soc. Amer., 63, 549-569.

Gubbins, D. (1985): Use of arrays to determine crustal and upper mantle structure, and locating events using travel times. Unpublished note.

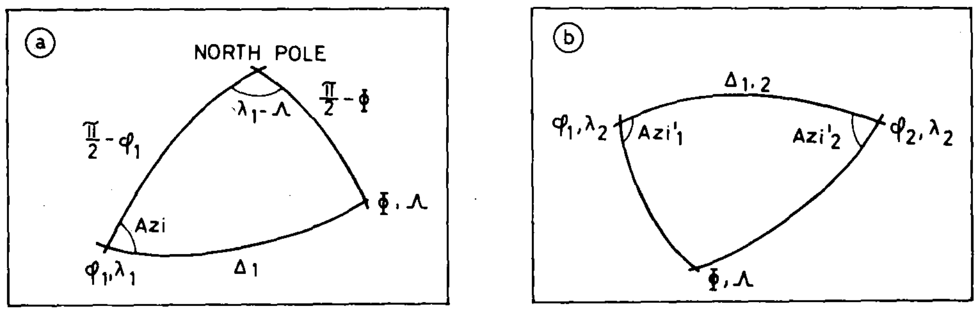

Fig. VII.8.1 Principles for epicenter locations using one and two arrays, or one and two three-component stations. In each case, at least two sides and angles, etc., are known in the given spherical triangles. Array (station) and epicenter coordinates are denoted by (σ, λ) and (Φ, Λ), respectively. The indices 1 and 2 denote different arrays (stations).

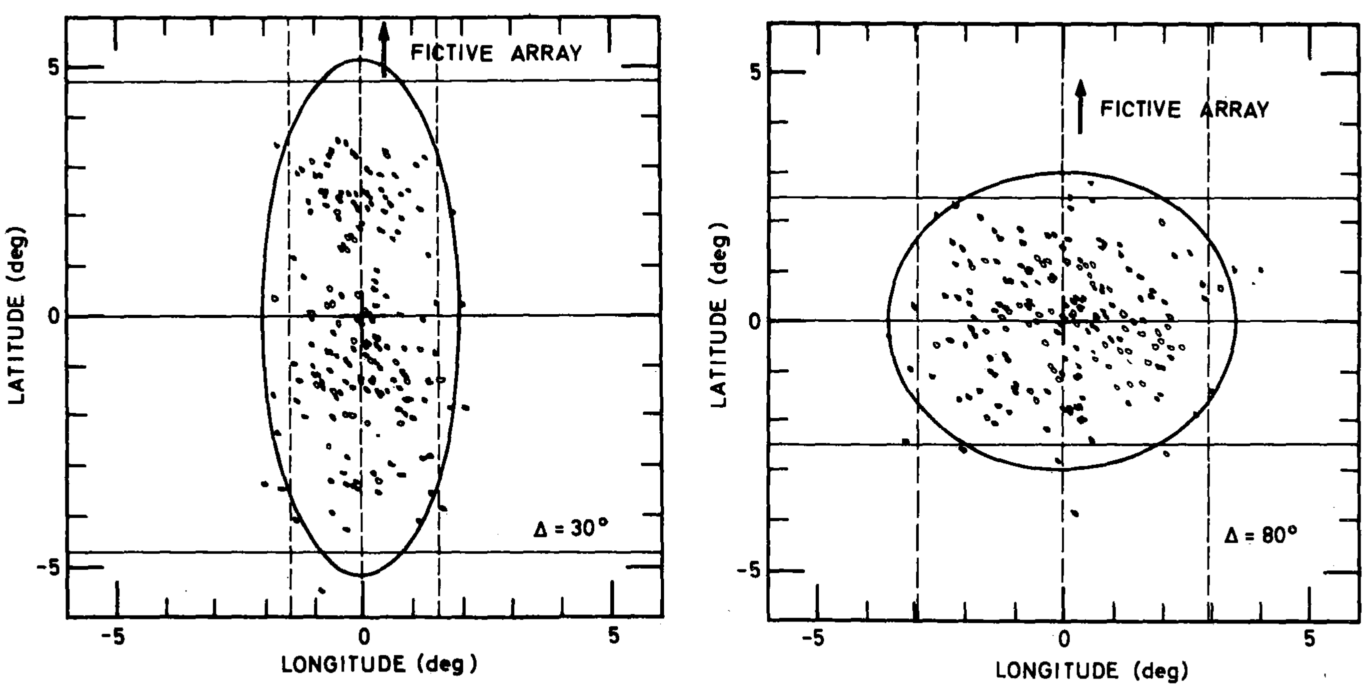

Fig. VII.8.2 The 95 per cent confidence ellipses of simulated one-array (or one 3-comp. station) location capabilities for epicentral distances of 30° and 80°. Standard deviations of azimuth and slowness are 1.5° and 0.10 sec/deg, respectively, and the number of trials is 200. Note how the axis of the error ellipse changes with distance (figure after Gjøystdal et al, 1973).

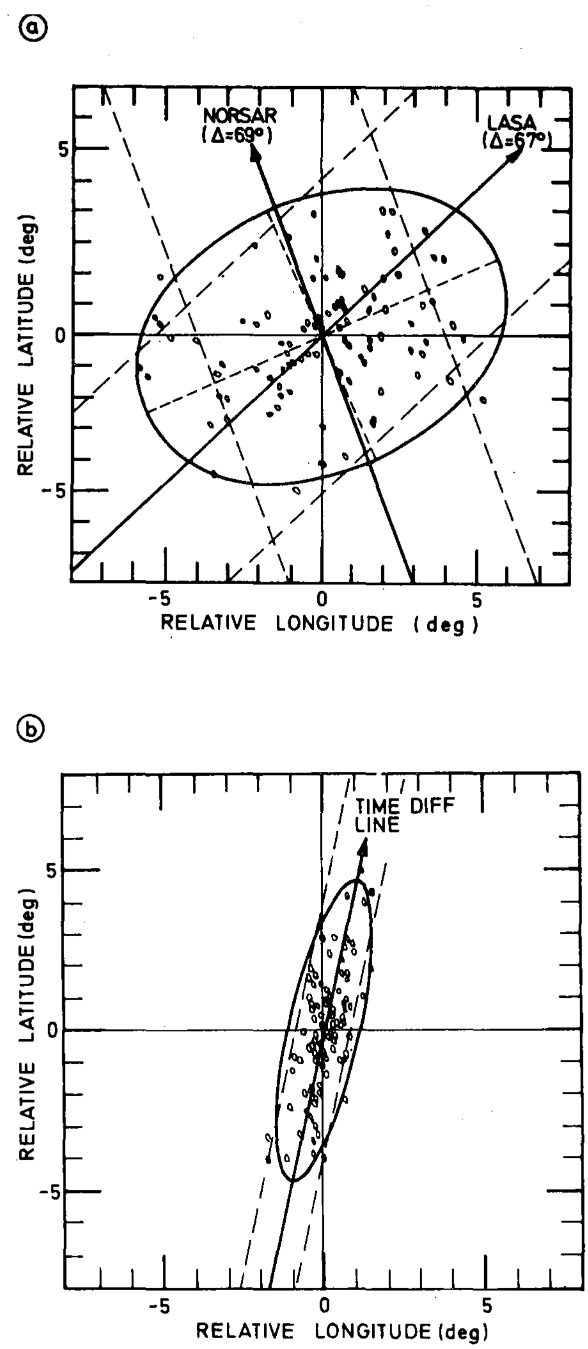

Fig. VII.8.3 Simulated 2-array (or two 3-comp. stations) event locations at 45.3°N; 149.3°E for NORSAR and LASA. In case a) only azimuth observations are used (σ = 2 deg), while in case b) further constraints are added by using P arrival time differences (σ = 2.0 sec).