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Application of 3-D Empirical Travel Times to routine earthquake location

T. Nicholson (1)

(1) Victoria University of Wellington, New Zealand

The Empirical Travel Time (ETT) technique of Nicholson et al. (2004) uses a large arrival time database to characterise the 3-D heterogeneity of the Earth as seen by a given seismic station. A unique feature of the resulting 3-D travel time map is that it contains all of the spatially coherent signal in the original dataset (used in its construction), and none of the spatially uncorrelated noise. In the context of earthquake location, 3-D empirical travel times can be cast as spatially varying corrections to a 1-D model to directly incorporate the effects of lateral heterogeneity.

Here the ETT approach is optimised for fast routine location with corrections calculated as they are required. This allows the travel time prediction to be improved easily by simply updating the underlying database as more observations are made. This feature allows the estimate of the effect of heterogeneity on travel time to be based on a continuously updating database without requiring any large computation such as that required for constructing a new 3-D model.

We use ETT to relocate the 155 G0-G5 events in the test dataset of Bondar (2004). Particular emphasis is placed on improving the location of small events (with between 3 and 10 observations) and the inclusion of multiple phases (e.g. P, S, pP and pwP). We show that the use of ETT reduces average event mislocation by 30 percent, and is particularly effective for small events and events that are poorly located using the conventional approach.