RELATIVE LOCATIONS IN 3D VELOCITY MODELS

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Abstract

By comparing travel times station by station from similar events, located reasonably close to each other, important information on the location of these events relative to each other can be derived. This may be obtained with either the "normal" travel time picks, or after cross correlation of waveforms recorded at the same stations. The former procedure is commonly referred to as "joint hypocentral locations". When relative travel times based on waveform correlations are used, the term "relative event locations" is commonly used. Another term referring to the above procedures is "double difference" locations. In most instances "double difference" event locations imply what we here have referred to as joint hypocentral locations, even though sometimes relative travel-times based on waveform correlations are used. In this case the event locations are to be considered as relative locations using the above definitions. If both travel time picks and relative times based on waveform correlations are used when solving for the locations, it is important that the data are weighted properly. Whereas normal travel time picks may be accurate to the order of the sampling interval, relative travel-times based on waveform correlation techniques may be significantly better – a not unrealistic estimate of the accuracy may be one tenth of the sampling interval. The accuracy obtained of course depends on the data quality, but also on the technique used for waveform correlation. For a group of similar events, all events may be correlated to each other, or a "master event" is selected and all events in a group are correlated to this event. The point of performing joint or relative locations is the improved accuracy compared to normal single event locations that is obtained in the hypocentral parameters. For relative event locations the relative position of individual earthquakes may be known to within 10 m. The absolute location of the events (or the entire group of events if one wish) is commonly far less accurately known, even though the consensus is that it is improved compared to single event locations. It has been shown that the relative event locations are not very dependent of the velocity model used. For the absolute locations (or the group location), however, the locations are much more dependent on the velocity model used. Even if the one-dimensional (1D) velocity model that is used for the locations is as good as one can possibly expect it to be, the real world is rarely 1D. Neither are earthquakes occurring everywhere with the same probability. Earthquakes are thus unusual phenomena, and it is not uncommon that earthquakes occur also where the velocity structure is uncommonly heterogeneous. In such heterogeneous regions, to compute accurate absolute event locations, a three-dimensional (3D) representation of the velocity structure is needed. This is commonly not done, except in the application of "double difference tomography", in which a 3D velocity model is inverted for along with the relative event locations. In this presentation we examine the effects of unknown 3D velocity variations may have on the absolute locations, even if joint (or relative) event locations are used. We also suggest how relative event locations in 3D models may be implemented in the routine analysis of events.