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Problematic earthquake location from P-arrival times jointly used at near and distant stations

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Selected problems related to hypocenter location of the ∼1 km uncertainty are discussed in the difficult case that only accurate P-wave readings are available. Near stations are needed for a correct depth determination, but usually they are only few and/or have a poor azimuthal coverage. Thus, more distant stations are needed to improve the azimuthal coverage and obtain a correct epicenter. However, joint use of near and distant stations may yield a significantly incorrect depth estimate. It is because location algorithms prefer such a source position at which the travel-time residuals at near and distant stations are of a comparable size. If the crustal model is inappropriate, the depth optimally balancing the residuals differs from the true source depth. It holds also for the methods eliminating the origin time. Several location algorithms (Hypo71, Conjugated Gradients, Grid Search, EDT) behave in the same way. In particular, it applies also for the relative HypoDD location. The erroneous depths often remain unrecognized. We stress a need to recognize them by analyzing residuals at each individual station for a series of fixed source depths (not only at the 'best fitting' depth). If the inconsistency between the near and distant stations is detected, the near- and distant station effects should be decoupled: epicenter is calculated from distant stations and the depth is calculated from near stations while fixing the epicenter. Alternatively, a better crustal model is to be used. The ideas are applied to the Mw5.2 Efpalio (Western Greece) earthquake of January 18, 2010. The reference ('true') depth of 6 km was obtained from relative location with respect to a foreshock which depth near to 6 km was obtained using good quality S readings. Joint location of near and distant stations by several different algorithm systematically led to wrong depths 9∼10 km. The decoupled use of near and distant stations correctly returned the 6∼7 km depth. A few samples of a modified crustal model leading to the 6 km depth even in the case of the combined use of near and distant stations were found; e.g., the suitable models have an increased velocity gradient at and below the depth of ∼8 km. Some of the previously published models of the studied region fall into this category.