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Absolute and relative location errors in double-difference relative earthquake locations in Southwest Iceland

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The double-difference (DD) earthquake location method of Waldhauser and Ellsworth (2000) has means to estimate the uncertainties of relative earthquake locations. The singular value decomposition (SVD) inversion option of their software (hypoDD) calculates formal errors, but can only be used for much smaller datasets than the conjugate gradient LSQR option. When applied to good quality earthquake data in Southwest Iceland, recorded by the Icelandic Meteorological Office (IMO) over a quarter of a century, we generally find a significant decrease in the relative DD location uncertainties vs the average uncertainties of the single event locations as reported by the IMO. Uncertainties usually decrease by an order of magnitude or more laterally, but usually half an order of magnitude or more in depth. As an example of the excellent ability of the DD method: In an area where the coverage of the IMO network is not the best, a mainshock with single event location, that is offset ∼250 m laterally from the aftershock zone, is shifted right into the zone after DD relocation. The same effect is observed whether the SVD or the LSQR inversion option is used in the DD relocation. Part of this decrease in uncertainties is perhaps due to our approach to weight the excellent shear wave phases higher than generally done in the routine analysis by the IMO, thus obtaining better constrained locations. However, absolute and relative uncertainties are not comparable parameters. Therefore, to evaluate informally the absolute uncertainty of DD relocations, we compare the shifts in the centroids of groups of earthquakes relocated with the two inversion options of the DD software, SVD and LSQR. We use these shifts as a proxy for absolute location uncertainty for differential data. This comparison shows that the centroid shifts are considerably larger, even an order of magnitude, than the average relative location uncertainties. However, they are always within the reported average uncertainty of the single event locations, and often considerably less. The majority of the single event locations has higher uncertainty in hypocenter depth than in epicenter location, while differential data does not suggest such a firm parttern as shown in the centroid shifts. However, the relative uncertainties are usually higher in depth than laterally. Earthquake groups with well constrained single event locations remain well constrained after DD relocations. We conclude that absolute earthquake locations are in general improved using differential data, and that the formal relative location uncertainties calculated with the SVD inversion option of the DD software also apply well to relocations with the LSQR option, which can not reliably estimate formal errors. Future work involves the use of these relocated earthquakes in 4D seismic tomography of SW Iceland.