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Stability of the double-difference earthquake location method with respect to input parameters and data sub-sampling in South Iceland

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To improve earthquake locations, we have applied the double-difference (DD) relative location method of Waldhauser and Ellsworth (2000) to phase catalog data from the Icelandic Meteorological Office (IMO). Our motive is to obtain accurate sources to assist in constraining real temporal changes in velocity structure in the area leading up to the occurrence of large earthquakes in South Iceland. The method determines relative distances between earthquakes with high accuracy and tends to give sharper tectonic structures. An open question remains regarding the accuracy of the DD method in absolute locations. It should be emphasized that no a priori constraint is built into the method to locate earthquakes into sharper defined features. Diffused hypocenters may continue to be so after DD relocation, suggesting that the seismicity is truly diffused.

The application of the DD method to the IMO data does confirm its absolute location ability. This can be judged both 'by eye' and by looking at an ensemble of solutions obtained by running the algorithm with different boundary conditions, i.e. several combinations of input parameters. These parameters both control the selection of events to be located (that may correlate with data quality), and the workings of the inversion process. For such a multivariate process, it is difficult to get proper statistics, but some patterns emerge from the range of solutions. Mean and standard deviation of the shift of the DD solutions from the catalog locations tend to be similar or smaller than the reported location uncertainty of the catalog locations. Therefore, our limited tests suggest that using the DD absolute locations is equal or better than the catalog solutions even when using the catalog phase data only for the DD processing. We agree with Menke and Schaff (2004) that the DD method determines relative distances between earthquakes with high accuracy, but also constrains the absolute locations, at least with accuracy similar to that of routine locations.

It has become clear in our study, that the DD software is excellent in identifying bad quality data. The method does this by evaluating the internal consistency of travel time differences between clusters of earthquakes, and filters out inconsistent data. In most of our cases, it is better to let the DD software filter the data rather than filtering beforehand. We have seen several examples of clearly bad catalog locations, which seem to become quite reasonable after DD relocation. The sub-sampling of the data-sets for relocation gave encouraging results for our purpose to be able to constrain whether temporal changes in velocity structure occur in the crust. DD locations within a localized region neither shift significantly (<100 m) when located with neighboring regions nor with earthquakes in different time periods within the same region. More accurate differential times, obtained with waveform correlation, would undoubtedly give even better results with the DD method, and possibly also increase the absolute location accuracy.