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Location and Depth Estimation of the North Sea Earthquake 30 June 2017

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30 June 2017 a magnitude 4.5 mb earthquake occurred in the Viking Graben of the North Sea. When recorded, the event was the largest in the area for several decades. This is an area with several offshore platforms related to oil and gas production, and an accurate location and depth estimate of this event is therefore important for risk assessment. However, applying standard location procedures to P- and S-phase arrival times observed at station network surrounding the North Sea leaves the event depth rather unconstrained, and we are seeking alternatives for constraining the location and depth estimate.
Different from most other events in the North Sea, this relatively large event has been recorded by stations at both regional and teleseismic distances, with depth phases observed at several of the far field stations. Depth phases like pP and sP are phases which are reflected at the surface from below in the source region, and the difference in arrival time between the first arriving P and the depth phase can be used to better constrain the depth of the event.
We localized the event using different methods: The HYPOSAT algorithm, a grid search algorithm using the LLNL-3D velocity model and a grid search using the global ak135 1D velocity model. For calculation of more accurate pP and sP travel times, the HYPOSAT algorithm was extended to accommodate the use of local velocity models for the source region, combined with global models (as ak135).
In the HYPOSAT algorithm we included P, S and depth phases (at various distances and azimuths) and tested three different local and regional 1D velocity models. The local model most representative for the source region included local low velocity sedimentary layers. This resulted in a depth estimate of approximately 4 km. Secondly, the event was localized using a standard grid search with the LLNL-3D velocity model. For this localization only P and depth phases at teleseismic distances were included. However, this resulted in a depth of approximately 8 km. A new grid search was done using the ak135 velocity model with the same phases as for the previous grid search. This gave a depth of 15 km. The grid search using the LLNL 3D velocity model gave a 20% lower residual than for the ak135 1D velocity model.
Thus, from this study it is concluded that depth estimation is challenging. The estimation strongly depends on choice of method, velocity models and phases used for localization. However, we reckon that the HYPOSAT algorithm which includes a local model provides the best solution, since this estimation includes the velocity model that best represents the source region.