Application of a probabilistic moment tensor inversion to data recorded above the North German gas fields

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Even if faults are not visible on geological outcrops, source mechanisms of earthquakes occurring on those faults may distinguish between different types of faulting. Moreover, the source mechanism of seismic events is one of the most important parameters to discriminate between natural and induced earthquakes and helps to understand the underlying cause. In addition, information on source mechanisms is important for hazard and risk studies, especially of shallow earthquakes. We implemented a novel, probabilistic full-waveform moment tensor inversion ("grond", [1]) for the application to shallow micro-earthquakes close to gas fields in North Germany. The method was previously applied successfully to investigate induced events in the Groningen gas field in the Netherlands ([2]; [3]). Due to the probabilistic approach, parameter trade-offs, uncertainties and ambiguities are mapped. The implemented bootstrap method implicitly accounts for modelling errors that may affect every station and phase in a unique way.

In addition to the stations of the BVEG network (http://www.seis-info.de/), we included nearby sensors of the GRSN (German Regional Seismic Network; https://www.seismologie.bgr.de/doi/grsn/) and GE (GEOFON; https://geofon.gfz-potsdam.de/doi/network/GE) networks into our study. Since instrument types differ between and even within networks, we carefully evaluated station quality using the AutoStatsQ toolbox ([4]). Due to the complexities in the subsurface structure including salt pillows and domes, we refrained from employing a regional velocity model and instead constructed a local velocity model by extracting 1-D models from a full 3-D model ([5]). We performed detailed tests of input data types and inversion parameters to derive rules of good practice. As test case, we employed the October 1st, 2018 M_L 3.6 earthquake close to Lastrup as well as the November 20th, 2019 M_L 3.0 event close to Kirchlinteln. Furthermore, event locations are provided by the algorithm. Such hypocentres, which are estimated simultaneously with moment tensors, are often less sensitive to uncertainties in crustal structure.

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