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Source Characterization of Microseismic Events using Empirical Green's Functions at the Basel EGS Project

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The Empirical Green's Function (EGF) method uses pairs of events of high wave form similarity and adjacent hypocenters to decompose the influences of source time function, ray path, instrument site, and instrument response. The seismogram of the smaller event is considered as the Green's function which then can be deconvolved from the other seismogram. The result provides a reconstructed relative source time function (RSTF) of the larger event of that event pair. The comparison of the RSTFs at all stations of the observation systems produces information on the rupture process of the event based on an apparent directivity effect and possible changes in the RSTFs complexities.
The Basel EGS dataset of 2006–2007 consists of about 2800 localized events of magnitudes between $0.0 < M_L < 3.5$ with event pairs of adequate magnitude difference for EGF analysis. The data has sufficient quality to analyse events with magnitudes down to $M_L = 0.0$ for an apparent directivity effect although the approximate rupture duration for those events is of only a few milliseconds. The dataset shows a number of multiplets where fault plane solutions are known from earlier studies. Using the EGF method we compute rupture orientations for about 190 event pairs and compare them to the fault plane solutions of the multiplets. For the majority of events we observe a good consistency between the rupture direction found there and one of the previously determined nodal planes from fault plane solutions. In combination this resolves the fault plane ambiguity. Furthermore the rupture direction fitting yields estimates for projections of the rupture velocity on the horizontal plane. They seem to vary between the multiplets in the reservoir from 0.3 to 0.7 times the S–wave velocity. To our knowledge source characterization by EGF analysis has not yet been introduced to microseismic reservoirs with the data quality found in Basel. Our results show that EGF analysis can provide valuable additional insights on the distribution of rupture properties within the reservoir.