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Seismic Event Location Using the Value of the Cross Correlation Coefficient

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We present a seismic event location procedure that exploits the dependence of waveform similarity on event separation. Given an initial set of precise absolute earthquake locations, the maximum waveform cross correlation coefficients for all possible pairs of events are calculated and a relation between event separation and cross correlation coefficients is established. This is used to stepwise determine the hypocenters of further events by calculating their waveform similarity relative to all located events and finding the event parameters that best fit the empirical relation between event separation and cross correlation coefficient. An advantage of this approach is, that it is rather insensitive to the number of observational components: It can already be applied to a single seismic sensor. This is in contrast to standard location methods which rely on a minimum number of time measurements per event. The method is applied to microseismic data recorded during a hydraulic experiment at the Continental Deep Drilling Site (KTB), Germany. It is shown that the number of determined hypocenters increases by a factor of about 8 compared to standard location methods, using the waveform recordings of a nearby borehole geophone alone to locate the additional events.
Our case study indicates that the proposed location method is particularly well suited to locate small earthquakes within dense event clouds in cases, where too few observations for most of the events are available and traveltime based location methods fail.