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Automated seismic event location by arrival time stacking: Applications to local and micro-seismicity

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Locating seismic events is one of the oldest problem in seismology. In microseismicity application, when the number of event is very large, it is not possible to locate earthquake manually and automated location procedures must be established. Automated seismic event location at different scales is very important in different application areas, including mining monitoring, reservoir geophysics and early warning systems. Location is needed to start rescue operations rapidly. Locating and mapping microearthquakes or acoustic emission sources in mining environments is important for monitoring of mines stability. Mapping fractures through microseimicity distribution inside hydrocarbon reservoirs is needed to find areas with an higher permeability and enhance oil production. In the last 20 years a large number of picking algorithm was developed in order to locate seismic events automatically. While P onsets can now be accurately picked using automatic routines, the automatic picking of later seismic phases (including S onset) is still problematic , thus limiting the location performance. In this work we present a picking free location method based on the use of the Short-Term-Average/Long-Term-Average (STA/LTA) traces at different stations as observed data. For different locations and origin times, observed STA/LTA are stacked along the travel time surface corresponding to the selected hypocentre. Iterating this procedure on a three-dimensional grid we retrieve a multidimensional matrix whose absolute maximum corresponds to the spatio-temporal coordinates of the seismic event. We tested our methodology on synthetic data, simulating different environments and network geometries. Finally, we apply our method to real datasets related to microseismic activity in mines and earthquake swarms in Italy.
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