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Automated detection and location of picoseismicity of hydraulic fracturing experiment using continuous waveforms

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The geothermic Fatigue Hydraulic Fracturing (FHF) in situ underground experiment (Nova project 54-14-1) took place in the Äspö Hard Rock Laboratory, Sweden. The basic idea was to validate the FHF concept under controlled conditions at the -410 depth level. Conventional versus cyclic, and pulse hydraulic injection schemes were monitored with three different monitoring arrays (Acoustic Emission [AE], Microseismic Monitoring and Electro-Magnetic) in the near- and far-field. The network was designed for high sensitivity in order to observe very small seismic events. The AE sensors allow for sensitive recording in the frequency range 1 to 100 kHz; the system measuring is capable to operate in trigger and continuous mode with a sampling of 1 MHz. In this work we consider continuous recordings and apply recently developed automated full waveform detection and location algorithms which are based on the stacking of characteristic functions calculated from squared amplitudes. We significantly increase the detection rate in comparison to trigger mode routines, because overlapping and weak events are resolved with our method. However, the location accuracy is not as high since waveforms are low pass filtered. Most detection concentrated during the fluid injection occurred around the fracking stages. Frequency-magnitude distribution characteristics are investigated using a magnitude scale estimated from the amplitude recorded at AE sensors. We demonstrate that the stacking of characteristic functions yields to a significant improvement of the detection and location also in presence of noisy records, supporting the adoption of similar techniques for other induced and natural seismic activity monitoring systems.

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