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Real time monitoring of induced seismicity in the Insheim and Landau deep geothermal reservoirs, Upper Rhine Graben, using the new SeisComP3 cross-correlation detector

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Real time information on the locations and magnitudes of induced earthquakes is essential for response plans based on the magnitude frequency distribution. We developed and tested a real time cross-correlation detector focusing on induced microseismicity in deep geothermal reservoirs. The incoming seismological data are cross-correlated in real time with a set of known master events. We use the envelopes of the seismograms rather than the seismograms themselves to account for small changes in the source locations or in the focal mechanisms. Two different detection conditions are implemented: After first passing a single trace correlation condition, secondly a network correlation is calculated taking the amplitude information of the seismic network into account. The magnitude is estimated by using the respective ratio of the maximum amplitudes of the master event and the detected event. The detector is implemented as a real time tool and put into practice as a SeisComp3 module, an established open source software for seismological real time data handling and analysis.

We validated the reliability and robustness of the detector by an offline playback test using four month of data from monitoring the power plant in Insheim (Upper Rhine Graben, SW Germany). Subsequently, in October 2013 the detector was installed as real time monitoring system within the project “MAGS2 – Microseismic Activity of Geothermal Systems”. Master events from the two neighboring geothermal power plants in Insheim and Landau and two nearby quarries are defined. After detection, manual phase determination and event location are performed at the local seismological survey of the Geological Survey and Mining Authority of Rhineland-Palatinate. Until November 2015 the detector identified 454 events out of which 95% were assigned correctly to the respective source. 5% were misdetections caused by local tectonic events.

To evaluate the completeness of the automatically obtained catalogue, it is compared to the event catalogue of the Seismological Service of Southwestern Germany and to the events reported by the company tasked with seismic monitoring of the Insheim power plant. Events missed by the cross-correlation detector are generally very small. They are registered at too few stations to meet the detection criteria. Most of these small events were not locatable. The automatic catalogue has a magnitude of completeness around 0.0 and is significantly more detailed than the catalogue from standard processing of the Seismological Service of Southwestern Germany for this region. For events in the magnitude range of the master event the magnitude estimated from the amplitude ratio reproduces the local magnitude well. For weaker events there tends to be a small offset.

Altogether, the developed real time cross correlation detector provides robust detections with reliable association of the events to the respective sources and valid magnitude estimates. Thus, it provides input parameters for the mitigation of seismic hazard by using response plans in real time.