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SCDetect: Near real-time computationally efficient waveform cross-correlation based earthquake detection during intense earthquake sequences

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Aftershock sequences or earthquake swarms generate a high number of seismic events that are not detected by standard regional network routine processes. Undetected earthquakes are mostly due to low signal to noise ratio, overlapping earthquakes, and a network configuration that targets earthquake detection with a homogeneous magnitude of completeness. Furthermore, the analyst's workload is increasing dramatically during an intense earthquake sequence, which results in prompt manual review of the largest events, only.

We present a computationally efficient and highly customizable tool (SCDetect) to detect earthquakes in near real-time by applying waveform cross-correlation in the time domain based on a set of template events. SCDetect is a free and open-source SeisComP extension module fully integrated into the SeisComP environment. It may be used to process both archived waveform data, when operated in playback mode, as well as real-time data. In either of the use cases, waveform data is accessed through SeisComP's standard RecordStream interface. Multiple template event based detectors may be configured. The individual detector configuration is fully stream based which allows for generic multi-stream event detection. Event parameter products for newly detected events (i.e. origins, picks, amplitudes, station magnitudes) may be sent to SeisComP's messaging system for further processing. In addition to earthquake detection, we implement amplitude calculation by measuring amplitudes on the horizontal components. SCDetect offers multiple magnitude estimation methods based on the amplitudes of the template earthquakes and the new detections (i.e regression, amplitude ratios). Magnitude estimation is configurable using SeisComP's bindings configuration.

We applied SCDetect to recent earthquake sequences in Switzerland between 2019 and 2021. The dense seismic network operated by the Swiss Seismological Service offers a unique opportunity to evaluate the performance of the proposed module. Our first results show that these extended earthquake catalogs contain at least ten times more earthquakes than the national earthquake catalogue.