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# Detecting weak seismicity in urban areas using waveform stacking and cross correlation: Application to a stimulation experiment

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Urban noise often prevents the detection of microseismicity ($M_L < 2$). The problem is well known from many geotechnical production sites, where the need to perform reliable hazard assessment has increased the interest in small seismic events. We study the microseismicity ($M_L < 2$) in the region of Landau, SW Germany. Here, due to thick sediments ( approx. 3 km) and high cultural seismic noise, the signal-to-noise ratio is in general very low for small earthquakes.

To gain new insights into the occurrence of very small seismic events we developed a 3-step detection approach and are thus able to identify 207 formerly unknown microseismic events ($-1 < M_L < 1$) with signal-to-noise ratios smaller than three. We use the recordings from a unfavourable broadband network installed for a teleseismic study with station distances of approximately 10 km.

First, we apply a short term average to long term average detection algorithm for data reduction. The detection algorithm is affected severely by transient noise signals that do not differ in frequency content, duration and amplitude from the microseismic events searched for. Therefore, the most promising detections, selected by coinciding triggers and high amplitude measures, are reviewed manually. In this way we are able to identify 13 seismic events. Finally, we conduct a cross correlation analysis. As master template we use the stacked waveforms of five manually detected seismic events with a repeating waveform. This search reveals additional 194 events with a cross correlation coefficient exceeding 0.65 which ensures a stable identification. Our analysis shows that the repeating events occurred during the stimulation of a geothermal reservoir within a source region of only about $(0.5 \text{ km})^3$.