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Detecting induced seismicity caused by a deep EGS stimulation in Espoo, Finland, using a network of surface and borehole stations

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In June and July 2018 St1 Deep Heat Oy (ST1DH) performed hydraulic stimulation between 6 km and 7 km depth beneath the Aalto University campus in Otaniemi, Espoo, Finland, to establish an Enhanced Geothermal System (EGS) doublet for district heating. The remarkable depth of the stimulation can be attributed to the shallow geothermal gradient intrinsic to the geologically stable Fennoscandian shield. The Institute of Seismology from University of Helsinki (ISUH) monitored the stimulation stage using a network of surface seismic stations and geophones.

ISUH operates 7 semi-permanent seismic station network Helsinki and Espoo area within 10 km of the EGS well; all recording at 250 Hz. ISUH also installed a temporary $\sim$100 station network to monitor the stimulation and post-stimulation stage. This network consisted of three-component 4.5 Hz PE-6/B-geophones connected to DATA-CUBE3 digitizers recording at 400 Hz. The geophones were organized in 3 large arrays consisting of $\sim$25 stations, 3 small 4-station arrays, and 8 single stations. ISUH was also granted access to data from 12 semi-permanent borehole seismometers registering at 800 Hz installed by ST1DH at depths between 238 m and 1620 m.

In this study we focus on the detection capability of induced seismicity using various combinations of borehole and surface stations and arrays. We compare station quality, noise levels, signal-to-noise ratios, and STA/LTA detection thresholds. Detection sensitivity will be studied as a function of number of stacked traces and compared with the borehole detection level using data from a co-located borehole sensor and 25 geophone array. Testing is performed on waveforms of seismic signals with good SNR (230 events of M$\geq$0.5) and the methods will be applied to continuous data from the stimulation period.

The results have important implications for the equipment, design, and configuration of networks and arrays for the monitoring and analyzing of future stimulation experiments and EGS operations in similar environments.