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Event detection in ambient seismic noise by means of robust outlier detection

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Analysis of seismic noise has emerged as a cost effective method to characterize landslide dynamics and hydrogeological processes such as surface water infiltration and groundwater flow, among other relevant subsurface processes. However, the low signal amplitudes in the signatures demand a careful analysis of the data, in particular for the detection of seismic events. For seismic detection, the STA/LTA algorithm is commonly used, yet in case of shallow sensor installations (depth $\sim$ 1 m) its performance is limited, due to airborne signatures, causing false positives. However, near-surface sensors are integral parts of mobile stations, which permit flexible investigations in landslides, where deformation rates could strongly vary in different locations and periods. Thus, a proper discrimination of subsurface sources and the removal of airborne events are mandatory for an adequate processing of seismic noise. Hence, we present here an alternative approach to seismic detection in passive seismic data, relying on the additional information provided by acoustic data. Our detection algorithm is based on a generic definition for seismic sources, which considers that for shallow installation depths, the waveforms of seismic and acoustic data should exhibit similar behavior and patterns. We demonstrate that the ratio of seismic and acoustic amplitudes follow a right-skewed distribution and can be used to quantify the similarity between the seismic and acoustic waveforms. In the case of seismic events, high amplitude ratios are obtained and the corresponding signals can be discovered by means of outlier detection. To detect such events we use an outlier detection for skewed data that extends the inter-quartile range (IQR) method with a robust measure of skewness, the so-called medcouple. We evaluate this alternative detection approach using data recorded by a sensor array located in the Rosalia research forest of BOKU University, which is close to the seismically active Vienna Basin (Austria). The array consists of Geospace 4.5 Hz geophones and Shure VP64 microphones connected to a Geometrics Geode 24 bit seismic recorder. The detection results are validated against the earthquake catalogue published by the Seismological Service of the Austrian federal agency of meteorology and geodynamics (Zentralanstalt für Meteorologie und Geodynamik, ZAMG). With this robust approach, we reliably detect: (i) high amplitude seismic events occurring in the nearby Vienna Basin and (ii) low amplitude non-airborne events not related to seismic activity in the Vienna Basin. We believe that our method is a step forward in the development of automatable algorithms that permit a quasi-real time processing of large seismic datasets.