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Evaluation of the seismic noise conditions by statistical time series classification for site selection in densely-populated areas

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Several of the new techniques using the deep underground, such as geothermal power plants or CO2 sequestration, have to be installed in densely-populated areas to be economically successful. Geothermal power plants need access to the district heating network to efficiently use the low-temperature heat remaining after power production. Therefore, even weak and non-destructive induced earthquakes became a serious problem for operators as such events are felt by many residents. This provokes a loss of acceptance for the new technologies in the local population. The potential application of CO2 sequestration struggles with similar problems and even oil and gas production is coming closer to settlements. A transparent and comprehensive (seismological) monitoring of new geotechnologies is crucial to get and keep the public acceptance.

Seismological monitoring in cities and densely-populated areas is a challenging task due to the complexity of the man-made seismic noise wave field. Especially the important identification of the small events which are unnoticeable for humans is made difficult by numerous other man-made sources of seismic energy such as traffic and industry. Man-made seismic signals are the dominant source of seismic energy in the frequency range of interest above 1 Hz. A good knowledge and understanding of the seismic noise wave field in densely-populated areas is important for the successful planning and operation of seismological monitoring networks. Especially the identification of suitable measuring sites is important as the installation of entire networks in boreholes is hardly possible for economic or practical reasons. Furthermore, the reliable identification of small earthquakes requires a good knowledge of the local seismic noise besides other parameters (e.g. velocity structure, etc.).

We present a statistical classification in the time domain to quantify and characterize automatically the seismic noise. Not only the amplitude but also the character of seismic noise (e.g. Gaussian distributed or dominated by single transient signals) influences significantly the detection capabilities of a monitoring network. The statistical time series classification represents the character of the seismic noise by only six noise classes. This approach allows us to easily visualize the seismic noise properties (amplitude and statistical properties). Furthermore, it provides a reduced dataset from broadband seismic waveforms to analyze temporal and spatial changes of seismic noise conditions.

We use this classification scheme in combination with a spectral time-frequency analysis to present the most important properties of the urban seismic noise. The urban seismic noise exhibits a significant spatial and temporal variability especially in the frequency range important for seismological monitoring. We demonstrate the potential and importance of a careful site selection considering also the statistical properties and not only the amplitudes of seismic noise in densely-populated areas. We select representative measurements of a seismic network dedicated to the monitoring of geothermal power plants in south-western Germany for our discussion of the seismic noise in densely-populated areas.

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