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EGU21-4380
https://doi.org/10.5194/egusphere-egu21-4380
EGU General Assembly 2021

Combining recordings of earthquake ground-motion and ambient vibration analysis to estimate site response variability in the city of Lucerne, Switzerland

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Estimation of site effects is an essential part of local seismic hazard and risk assessment, especially in densely populated urban areas. The goal of this study is to assess the site response variability in the city of Lucerne (Central Switzerland), located in a basin filled with unconsolidated deposits. Even though it is a low-to-moderate seismicity area, the long-term seismic risk cannot be neglected, in particular, because the region was struck by strong earthquakes in the past (i.e. Mw 5.9 in 1601).

To determine the spatial distribution of the soil response in the test area, we combined earthquake and ambient noise recordings using the Hybrid Standard Spectral Ratio method (SSRh) introduced by Perron et al. (2018). In the first step, we installed a temporary seismic network to record ground-motion from low-magnitude or distant earthquakes. At selected urban sites inside the sedimentary basin, the dataset was used to estimate the amplification factors with respect to a rock site using the Standard Spectral Ratio approach (SSR - Borcherdt, 1970). Then, a survey including several dozens of densely distributed single-station ambient noise measurements was performed which enabled us to estimate the basin response variability relative to the seismic stations of the temporary seismic network. Finally, we corrected the noise-based evaluation using the SSR amplification functions. To verify the useability of the presented technique in the Lucerne area, we applied the SSRh method also to the temporary stations, the resulting amplification functions largely coincide with the SSR curves. However, the daily variability of the noise wavefield due to human activities can slightly affect the results. We will also discuss the influence of the station distribution and density of the temporary network deployment.

The amplification model for the Lucerne area estimated using the SSRh method shows consistency with geological data. The results indicate that seismic waves can be amplified up to 10 times in some parts of the basin compared to the rock site. The highest amplification factors are observed for frequencies between 0.8 and 2Hz. This means a local significant increase in seismic hazard.

The presented work is a part of a detailed site response analysis study for the Lucerne area,

considering 2D and 3D site effects and potential non-linear soil behaviour. This PhD project is performed in the framework of the Horizon 2020 ITN funded project URBASIS-EU, which focuses on seismic hazard and risk in urban areas.

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