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Evaluation of the variability of soil response in urban environment using reference-site methods: the case of Lucerne, Switzerland

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The long-term seismic risk cannot be neglected even in low-to-moderate seismicity countries like Switzerland, especially in densely populated urban areas. Site effects evaluation is a crucial part of local seismic hazard and risk assessment. The focus of this study is the city of Lucerne, located in a basin filled with unconsolidated deposits and struck by strong earthquakes in the past (i.e. Mw 5.9 in 1601). Our aim is the estimation of the site response in different parts of the city and a better characterization of the influence and variability of the local geological structure. This work is in the framework of the European URBASIS project concentrated on seismic hazard and risk in urban areas.
In the presented analysis, we used the weak motion observations from low-magnitude or distant earthquakes recorded by a temporary seismic network installed for half a year at selected urban sites. The dataset was supplemented by earthquake recordings at 3 permanent accelerometric stations belonging to the Swiss Strong Motion Network (SSMNet). We show the comparison of relative amplification factors evaluated using standard spectral ratio method applied to earthquakes (SSR - Borcherdt, 1970) and ambient noise (SSRn – Kagami, 1982) recordings, as well as a hybrid approach (SSRh) combining these two techniques (Perron et al., 2018). While amplification estimated with SSRn is usually overestimated in comparison to the SSR, matching results were obtained using the SSRh method. Another presented approach based on regional earthquake recordings is Empirical Spectral Modelling (ESM - Edwards et al., 2013). ESM shows consistent results with the SSR method due to similarities between the outcropping rock in Lucerne with the Swiss reference rock used in ESM.
In the next step, we applied the SSRh technique to estimate the spatial variability of basin response in a test area. A survey including several dozens densely distributed single-station noise measurements was performed in June 2020. Moreover, we combined our dataset and recordings from the past 20 years in the Lucerne city center to map the fundamental resonance frequency (f0) across the area.
This work represents the first step in a detailed site response analysis study for the Lucerne area, considering 2D and 3D effects and potential non-linear soil behaviour as well. We present the current status of the ongoing site effects assessment, highlighting the limitations and specifics of the site characterization in urban areas.

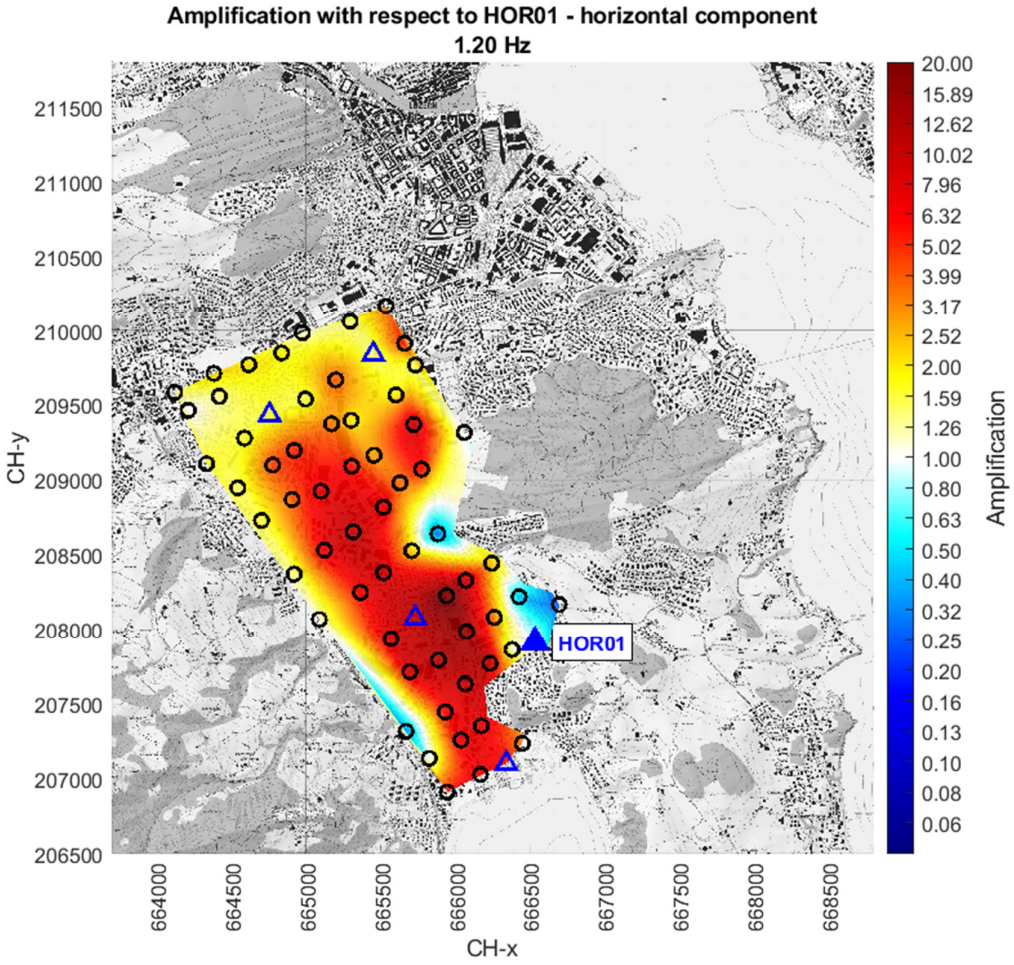

Figure 1. Amplification factors with respect to the rock station HOR01 estimated using the SSRh method. Blue triangles represent sites where earthquake recordings are available, black circles are ambient noise measurements.

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