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Low frequency amplification in deep alluvial basins: an example in the Po Plain (Northern Italy) and consequences for site specific SHA

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This work deals with the problem of long period seismic site amplification that potentially might involve large and deep alluvial basins in case of strong earthquakes. In particular, it is here presented a case study in the Po Plain (Northern Italy), one of the most extended and deep sedimentary basin worldwide. Even if the studied area shows a low annul seismicity rate with rare strong events (Mw>6.0) and it is characterized by low to medium seismic hazard conditions, the seismic risk is significant for the high density of civil and strategic infrastructures (i.e. high degree of exposition) and the unfavourable geological conditions. The aim of this work is to provide general considerations about the seismic site response of the Po Plain, with particular attention on deep discontinuities (i.e. geological bedrock), in terms of potential low frequency amplification and their incidence on the PSHA.
The current results were obtained through active and passive geophysical investigations performed near Castelleone, a site where a seismic station, which is part of the INGV (National Institute for Geophysics and Volcanology) Seismic National Network, is installed from 2009. In particular, the active analyses consisted in a MASW and a refraction survey, whereas the passive ones consisted in seismic ambient noise acquisitions with single stations and arrays of increasing aperture. The results in terms of noise HVSR indicate two main peaks, the first around 0.17 Hz and the second, as already stated in the recent literature, around 0.7 Hz. In order to correlate the amplified frequencies with the geological discontinuities, the array acquisitions were processed to obtain a shear waves velocity profile, computed with a joint inversion, considering the experimental dispersion curves and the HVSR results. The obtained velocity profile shows two main discontinuities: the shallower at ∼165 m of depth, which can be correlated to the seismic bedrock (i.e. Vs > 800 m/) and the deeper at ∼1350 m of depth, properly associable to the geological bedrock, considering the transition between the pliocenic loose sediments and the miocenic marls observable from the available stratigraphy. Numerical 1D analyses, computed to obtain the theoretical Transfer Function at the site, support the correlation between the experimental amplification peak around 0.17 Hz and the hypothesized geological bedrock.
In terms of site specific SHA, the UHS expressed in displacement (MRP: 475 years) shows a significant increase if the seismic input is located at the geological bedrock (∼1350 m) instead of the seismic bedrock (∼165 m). Even if this increase is not relevant for the studied site, since the seismic hazard is low, it could be significant in other part of the Po Plain, where the seismic hazard is medium-high. According to the HVSR results, obtained for other available Po Plain broadband stations, the considerations of this work could represent a warning for future seismic hazard investigations in other areas of the basin.