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Variability of site response in the Mygdonian basin (Greece) from accelerometric recordings and 3D numerical simulations

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We present a numerical study which aims at better understanding the observed and modeled variability of the site response in the Mygdonian basin, near Thessaloniki (Greece). The 3D visco-elastic simulations include an extended and realistic model of the basin (69 km x 69 km x 30 km), and are performed with the Spectral Element Method (specfem3D) allowing numerical accuracy up to 4 Hz for a lowest S-velocity of 130 m/s. Using reciprocity-based calculations, we built a bank of Green's functions between 15 receivers and a circular setting of 1260 point-sources regularly distributed in distance [2.5-30 km], depth [2.5-15 km] and back azimuth [0-350°] from the center of the basin. For the purpose of this study, the focal mechanisms are randomly generated to match the typical normal-faulting mechanisms encountered in the area.
The level of variability reached for that large amount of sources is quantified for relative measures of amplification (SSR, H/V) and duration lengthening. The same analysis is performed on recorded ground accelerations that are available from the EUROSEISTEST permanent array. Our results show that the variability of the site response is related to 3D source-site interactions that cause a variable generation of surface waves at the edges of the basin. The North-South asymmetry in the edge slopes plays a strong role in that effect; depending on which edge the incident waves are coming from, different responses are induced. Thus, the resulting 3D site amplification differs significantly from the 1D site amplification caused by vertical propagation only. The location of the sources relative to the basin (expressed in back azimuth, depth and epicentral distance) is the key parameter to map the frequency-dependent variability of the basin response, both for observed and modeled data. The highest variability in the basin amplification and duration lengthening is reached for deep close events (quasi-vertical incidence) and shallow, distant events (grazing incidence). Duration lengthening is associated to surface-waves generation and affects a broad frequency range from the site fundamental frequency. As for the H/V measurements, they are more variable than SSR, while the amplified frequencies match between the two methods. The H/V variability cannot be easily related to the source location as horizontal and vertical components are both affected by the surface waves generated at the basin edges.
Finally, the robustness of the SSR and duration-lengthening measures is shown to be strongly dependent on the choice of the reference station. When the reference is chosen outside the basin but close to its edges, the apparent variability is strongly increased. This variability is due to the feedback effect of the basin edges which contaminates the ground motion at the reference site. It is reduced when considering the reference motion in the bedrock below the basin and the site of interest (such as a downhole sensor).