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Identifying the origin of differences between 3D numerical simulations of ground motion in sedimentary basins: lessons from stringent canonical test models in the E2VP framework

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Numerical simulation is playing a role of increasing importance in the field of seismic hazard by providing quantitative estimates of earthquake ground motion, its variability, and its sensitivity to geometrical and mechanical properties of the medium. Continuous efforts to develop accurate and computationally efficient numerical methods, combined with increasing computational power have made it technically feasible to calculate seismograms in 3D realistic configurations and for frequencies of interest in seismic design applications. Now, in order to foster the use of numerical simulations in practical prediction of earthquake ground motion, it is important to evaluate the accuracy of current numerical methods when applied to realistic 3D sites. This process of verification is a necessary prerequisite to confrontation of numerical predictions and observations.
Through the ongoing Euroseistest Verification and Validation Project (E2VP), which focuses on the Mygdonian basin (northern Greece), we investigated the capability of numerical methods to predict earthquake ground motion for frequencies up to 4 Hz. Numerical predictions obtained by several teams using a wide variety of methods were compared using quantitative goodness-of-fit criteria.
In order to better understand the cause of misfits between different simulations, initially performed for the realistic geometry of the Mygdonian basin, we defined five stringent canonical configurations. The canonical models allow for identifying sources of misfits and quantify their importance. Detailed quantitative comparison of simulations in relation to dominant features of the models shows that even relatively simple heterogeneous models must be treated with maximum care in order to achieve sufficient level of accuracy.
One important conclusion is that the numerical representation of models with strong variations (e.g. discontinuities) may considerably vary from one method to the other, and may become a dominant source of inaccuracy, especially for seismic waves which are the most sensitive to those variations (e.g. guided or surface waves). A suggestion to temper this source of misfit is to resort to consistent homogenization (a.k.a. up-scaling) of the propagation model before to run and compare the simulations, and ideally during the construction of the model itself.