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Embedding Spectral Decomposition Results in Broadband Simulation: Application to Rhine Graben Area

Hoby Razafindrakoto[1], Fabrice Cotton[1,2], Dino Bindi[1], Marco Pilz[1], and Robert Graves[3]
[1]GFZ German Research Centre for Geoscience, Potsdam, Germany (hoby@gfz-potsdam.de)
[2]Institute of Geosciences, University of Potsdam, Potsdam, Germany
[3]U.S. Geological Survey, Pasadena, California, USA

Over the past decade, there is growing consensus that physics-based simulations can be utilized in engineering applications. However, for the simulations to be accepted, they need to be calibrated and validated. This study presents the results of ground motion simulation calibration and validation using earthquakes that occurred in the Upper Rhine Graben with a modified version of the Graves-Pitarka (GP) hybrid ground-motion simulation methodology implemented on the Southern California Earthquake Center Broadband Platform, which uses an improved high-frequency computation. To calibrate the HF simulation, we take advantage of the growth of seismological data (including weak motions) in the region and the ability to evaluate critical seismic parameters such as anelastic attenuation, stress drop, and site effects through spectral decomposition methods (separate site-source-propagation from the datasets). Hence in the simulation, the adopted anelastic attenuation and stress parameter are defined based on the spectral decomposition results. The additional modification of the standard GP method is the incorporation of compressional wave in the HF motion.

Results are compared with observations and simulations from the unmodified GP approach; we also use a range of ground motion intensity measures as summary statistics. We found that in general, the modification in the HF part (e.g., incorporation of compressional waves) was necessary to improve the fit with observations. Our findings also validate the fact that parameters from the spectral decomposition are giving well-calibrated time-histories (in terms of frequency and amplitude) when used as input parameters of the broadband simulations. The findings in this study support the incorporation of scenario-based ground motion simulations for use in the characterization of seismic hazard and other engineering applications. For simulation of future earthquakes, instead of using event-specific stress-drops, we use the average stress-drops taken from the distribution of the stress drops derived from spectral decomposition.