EGU2020-5187
https://doi.org/10.5194/egusphere-egu2020-5187
EGU General Assembly 2020

Spatial Variability of Source and Attenuation Characteristics in Large Ground-Motion Datasets

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Ground-Motion Models (GMMs) characterize the random distributions of ground-motions for a combination of earthquake source, wave travel-path, and the effected site's geological properties. Typically, GMMs are regressed over a compendium of strong ground-motion recordings collected from several earthquakes recorded at multiple sites scattered across a variety of geographical regions. The necessity of compiling such large datasets is to expand the range of magnitude, distance, and site-types; in order to regress a GMM capable of predicting realistic ground-motions for rare earthquake scenarios, e.g. large magnitudes at short distances from a reference rock site. The European Strong-Motion (ESM) dataset is one such compendium of observations from a few hundred shallow crustal earthquakes recorded at a several hundred seismic stations in Europe and Middle-East.

We developed new GMMs from the ESM dataset, capable of predicting both the response spectra and Fourier spectra in a broadband of periods and frequencies, respectively. However, given the clear tectonic and geological diversity of the data, possible regional and site-specific differences in observed ground-motions needed to be quantified; whilst also considering the possible contamination of data from outliers. Quantified regional differences indicate that high-frequency ground-motions attenuate faster with distance in Italy compared to the rest of Europe, as well as systematically weaker ground-motions from central Italian earthquakes. In addition, residual analyses evidence anisotropic attenuation of low frequency ground-motions, imitating the pattern of shear-wave energy radiation. With increasing spatial variability of ground-motion data, the GMM prediction variability apparently increases. Hence, robust mixed-effects regressions and residual analyses are employed to relax the ergodic assumption.

Large datasets, such as the ESM, NGA-West2, and from KiK-Net, provide ample opportunity to identify and evaluate the previously hypothesized event-to-event, region-to-region, and site-to-site differences in ground-motions. With the appropriate statistical methods, these variabilities can be quantified and applied in seismic hazard and risk predictions. We intend to present the new GMMs: their development, performance and applicability, prospective improvements and research needs.