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A New Ground Motion Logic Tree and Site Response Model for Earthquake Hazard and Risk Assessment in Europe

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The assessment of earthquake risk requires careful characterization of the potential strength of ground shaking and the uncertainties inherent therein. A new pan-European probabilistic seismic hazard model is currently in advanced stages of development within the Horizon 2020 Seismology and Earthquake Engineering Research Infrastructure Alliance for Europe (SERA) project, to be released as the 2020 European Seismic Hazard Model (ESHM2020). The growth of ground motion data, new developments in earthquake hazard modelling and evolution of perspectives on the incorporation of epistemic uncertainty in regional seismic hazard have prompted a substantial shift in the construction of ground motion logic trees for seismic hazard analysis at a European scale. The proposed ground motion logic tree moves away from previous approaches of selecting multiple ground motion models to characterize epistemic uncertainty in seismic shaking, and instead adopts a "backbone" approach. This approach, widely established in site-specific hazard analysis, considers a single core model and attempts to quantify the model uncertainties in seismic attenuation, stress parameter scaling and statistical uncertainty. For shallow crustal seismicity, the "backbone" model itself is constructed from the recent European Strong Motion database (http://esm.mi.ingv.it) and integrates regional variation in seismic source scaling and attenuation properties. Similarly, for non-shallow seismicity new data from the Hellenic and Calabrian arcs, as well as the Vrancea deep seismic zone, are used to calibrate the model uncertainties in existing non-shallow ground models to allow them to be mapped into a similar backbone framework. The complete logic tree for application in the ESHM2020, including shallow and non-shallow seismicity is presented and compared against its predecessors in European seismic hazard models and to the traditional multi-model approach.

For the analysis of seismic risk on a European scale it is also necessary to account for local site amplification of strong shaking. When considered across a spatial scale as great as a country or continent, detailed site response information cannot be obtained in a homogeneous fashion, and instead it is often necessary to adopt alternative proxies such as 30 m average shearwave velocity inferred from topography. By adopting such approaches, however, important uncertainties may be unwittingly omitted from the seismic risk calculations. To attempt to redress this problem we explore the development of site amplification models directly from well-recorded strong motion sites by correlating the station-to-station variability from ground motion models with mappable geomorphological proxies within a mixed-effects regression analysis, using local geology as a random effect in the process. This approach ensures that the increased site amplification uncertainties are explicitly treated in the calculations of losses and can be scaled appropriately to the resolution of the exposure model required for the seismic risk analysis.