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Using Large Strong Motion Datasets to Model Regional Site Response in Seismic Risk Assessment: Examples from Japan and Europe

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Characterisation of seismic risk within a probabilistic framework is dependent upon well-constrained models of the seismic source, the ground motion scaling and the local site response, in addition to both their aleatory variability and epistemic uncertainty. When assessing risk as a large geographical scale such as that of a country or continent, however, complex models of site response that require detailed parameterization of the site conditions are seldom feasible to constrain. Instead, the use of simpler proxies, such as the well-known topographically inferred 30 m averaged shear-wave velocity (V_{S30}), have become widely adopted for this purpose. In practice, the inference of V_{S30} from topographic and/or geological proxies have substantial limitations in terms of both the geological environments for which they are appropriate and the increased uncertainty in the prediction of site response; limitations that are not always accounted for in existing seismic risk models.

The volume of data reported by both new and well-established stations is increasing at an exponential rate, with hundreds of thousands of strong motion records now available from thousands of stations. Through this enormous and ever-expanding data set it is possible to constrain thousands of station-specific amplifications and utilize this dataset to calibrate the site amplification directly upon regionally mappable parameters, which can be applied across large spatial scales needed for regional seismic risk analysis. In doing so, it is possible not only to adapt the model of site amplification to different geological environments, but also to adjust the uncertainty in the ground motion characterization to ensure that this is captured appropriately in the seismic risk analysis when using the mappable site proxies. Applications of this approach have been made for two case study regions: i) Japan, where detailed station metadata are available and the relative increase in uncertainty from using regionally-mappable parameters instead of well-constrained site properties can be constrained, and ii) Europe, where station metadata more limited but a large number of stations with repeated observations are available. The implications for the estimates of seismic losses when adopting this new approach in place of the existing methodology are illustrated using examples from the 2020 European Seismic Risk model.