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A Non-ergodic GMPE for Europe and the Middle East with Spatially Varying Coefficients

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We estimate a fully non-ergodic ground-motion model using strong-motion data from Europe and the Middle East. The model is cast as a varying coefficient model (VCM), where the coefficients are allowed to vary by geographical location. This makes it possible to incorporate the spatially varying source, path and site effects. Different effects are modeled by different coefficients in the model, which depend on source and/or site coordinates. The model places a Gaussian process prior on the coefficients, which automatically constrains the repeatable effects to be similar for locations that are spatially close. The amount of correlation (the correlation length scale) is determined by the data. The VCM outperforms a classical, ergodic ground-motion prediction equation (GMPE) in terms of generalization error, estimated by cross-validation. Compared to the ergodic GMPE, the value of the aleatory standard deviation is reduced, which has important consequences for seismic hazard calculations. The reduction in aleatory variability trades off with changes in the median predictions for different locations.
The spatial correlation structure of the model makes to possible to extrapolate the model to new source/site locations, and trace the corresponding uncertainties. Predictions for source/site coordinates that are close to observed data are associated with small predictive uncertainty, while the uncertainty for locations lacking observations in the vicinity is large.
The results show strong differences in eh systematic effects between Italy, Greece, and Turkey, as well as within those regions. The correlation length scales are similar to those observed for a similar model in California.