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Ground-motion intensity measure correlations observed in Italian data

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Ground-motion models (GMMs) are commonly used in probabilistic seismic hazard analysis (PSHA) to estimate the probability distribution of earthquake-induced ground-motion intensity measures (IMs). Accounting for spatial correlation and cross-IM correlation in ground-motion data has important implications on probabilistic seismic hazard and risk assessment. The current state-of-practice estimates ground-motion spatial correlation separately from the GMM estimation process, which may result in statistically inconsistent and inefficient estimators of parameters in the spatial correlation models and GMMs. Also, several correlation models between different IMs have been calibrated and validated based on the NGA-West and NGA-West2 databases and advanced GMMs. However, modelling the correlation between different IM types has not been adequately addressed by current, state-of-the-art GMMs for Italy. Such correlation models are often required for the performance-based seismic design and assessment of structures, for instance, in the definition of target IMs to be used for ground motion simulation, selection, and modification (e.g., the generalized conditional intensity measure or the conditional spectrum approaches).

This study first develops a series of new Italian GMMs with spatial correlation for 31 amplitude-related IMs, including Peak Ground Acceleration (PGA) and Peak Ground Velocity (PGV) and 5% damped spectral accelerations with periods from 0.01 s to 4 s (29 periods). The model estimation is performed through a recently-developed one-stage non-linear regression algorithm proposed by the authors, known as the Scoring estimation approach. The proposed algorithm is flexible in considering advanced (e.g., non-stationary) spatial correlation models.

Based on the newly-developed GMMs, this study also proposes a set of empirical correlation models between the selected IMs for the considered Italian dataset. Results are shown for correlations of both maximum direction and geometric mean spectral acceleration values. Additionally, the potential magnitude-, distance- and site-condition-dependence of IM correlations are evaluated.

Results from this study show that newly-developed GMMs with spatial correlation are generally consistent (in terms of median predictions and dispersion) with the existing GMMs for Italy and Europe. The spatial correlation model estimated in this study shows a similar trend as existing models in the literature; however, the obtained model parameters are smaller than those in existing studies. This may be due to the use of the classical geostatistical tools, which generally tends to overestimate the parameters in the spatial correlation models. Finally, results from this study seem to consolidate the general understanding that IM correlations are stable across a range of source and site conditions.

The proposed GMMs can help improving seismic risk assessment exercise, especially for spatially distributed systems.