A methodological approach to update Ground Motion Prediction Models using Bayesian Inference

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The expected ground motion at a site is represented by an attenuation relationship or a ground motion prediction equation (GMPE). GMPEs estimate the intensity of ground shaking and their underlying uncertainty based on ground motion characteristics such as earthquake magnitude, propagation path and soil conditions, style-of-faulting, and other seismological parameters. Historically, several GMPEs with different functional forms have been published using strong ground motion records available from NGA-West and European databases. However, low-to-moderate seismicity regions, such as Central & Eastern United States are characterized by limited strong-motion records in the magnitude-distance range of interest for PSHA. In these regions, the available data for the development of empirical GMPEs is very scarce and limited to small magnitude events. For these regions, the general practice in PSHA is to consider a set of GMPEs developed from data sets collected in other regions with high seismicity. This practice generates an overestimation of the seismic hazard for the low seismicity regions. There are two potential solutions to overcome this problem: (i) a new GMPE model can be developed; however, development of such a model can require significant amount of data which is not usually available, and (ii) the existing GMPE models can be recalibrated based on the data sets collected in the new region rather than developing a new GMPE model.

In recent years, many methodologies (Bertin et al., 2020; Kowsari et al., 2019, 2020; Wang and Takada, 2009) based on Bayesian inference have been used to update the model parameters by accounting for various sources of uncertainty. In the aforementioned studies, the original GMPEs are calibrated for new data set either by (i) fixing the GMPE functional form and estimating additional terms to account for bias correction, or (ii) estimating all the regression parameters in the GMPE model. In this study, we propose a methodological approach to recalibrate the coefficients in a GMPE model using different algorithms to perform Bayesian inference. The coefficients are recalibrated for a subset of European Strong-Motion (ESM) database that corresponds to low-to-moderate seismicity records. In this study, different statistical models are compared based on the functional form given by the chosen GMPE, and the best models and algorithms are recommended using the concept of information criteria.

References

Bertin, M., Marin, S., Millet, C. and Berge-Thierry, C. (2020). "Using Bayesian model averaging to improve ground motion predictions." *Geophysical Journal International*, 220(2), pp. 1368–1378.

Kowsari, M., Halldorsson, B., Hrafnkelsson, B., Snæbjörnsson, J. Þ. and Jónsson, S. (2019). "Calibration of ground motion models to Icelandic peak ground acceleration data using Bayesian Markov Chain Monte Carlo simulation." *Bulletin of Earthquake Engineering*, 17(6), pp. 2841–2870.

Kowsari, M., Sonnemann, T., Halldorsson, B., Hrafnkelsson, B., Snæbjörnsson, J. Þ. and Jónsson, S. (2020). "Bayesian inference of empirical ground motion models to pseudo-spectral accelerations of south Iceland seismic zone earthquakes based on informative priors." *Soil Dynamics and Earthquake Engineering*, 132, p. 106075.

Wang, M. and Takada, T. (2009). "A Bayesian framework for prediction of seismic ground motion." *Bulletin of the Seismological Society of America*, 99(4), pp. 2348–2364.