A Bayesian Approach to Estimate Weights for GMPE Models in a Logic Tree

Saran Srikanth Bodda (✉ ssbodda@ncsu.edu)

North Carolina State University <https://orcid.org/0000-0001-5849-7468>

Merlin Keller

EDF Lab Saclay

Abhinav Gupta

North Carolina State University

Gloria Senfaute

EDF Lab Saclay

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Abstract

In current practice, the seismic hazard curves are generated by combining all possible choices for seismotectonic model (SM), earthquake magnitude recurrence models, and ground motion prediction equation (GMPE) models using logic trees. However, studies have shown that significant uncertainties exist in the evaluation of the seismic hazard, especially in low-to-moderate seismicity regions, such as Central \& Eastern United States and Europe, due to the scarcity of the recorded earthquake data and lack of precise knowledge concerning the earthquake generation and propagation mechanisms. Specifically, these uncertainties lead to conservatisms in the seismic hazard which poses a considerable risk for nuclear facilities. Designing or upgrading facilities with such conservative estimates of seismic hazard results in large capital costs. In standard probabilistic seismic hazard assessment (PSHA) practices, the estimate of branch weights for the GMPE models is based on expert judgment and there is no holistic approach for estimating the weights under uncertainty. In this research, we focus on the GMPE part of the PSHA and we propose a statistical methodology that is based on Bayesian inference, to evaluate the GMPE model weights from a list of GMPE models in the logic tree. In this study, Bayesian model averaging (BMA) approach with Bayesian linear models (BLM) is employed to combine GMPE models and the performance of the BMA model is tested against European Strong-Motion (ESM) database. It is shown that the proposed methodology can calculate the weights at different time periods without any approximations using analytical formulas and it is computationally inexpensive.

Full Text

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Figures

Figure 1

Sample logic tree used in PSHA

Figure 2

Simple Illustrative Example: Data set

Figure 3

Please see the Manuscript PDF file for the complete figure caption.

Figure 4

95% credible interval of GMPE models and BMA predictions

Figure 5

Please see the Manuscript PDF file for the complete figure caption.

Figure 6

Comparison of total sigma estimates before and after calibration (dotted – Org. GMPE, dashed – Org. GMPE + ESM, solid – Org. GMPE + added bias + ESM)

Figure 7

GMPE model probabilities or weights as a function of period

(a) Three GMPEs

(b) Eight GMPEs

Figure 8

Performance of GMPEs and BMA model against testing data set