A Bayesian approach to estimate weights for GMPE models in a logic tree

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Seismic probabilistic risk assessment (SPRA) of nuclear facilities involves three elements: (i) probabilistic seismic hazard assessment (PSHA), (ii) performance based seismic fragility curves for components and subsystems, and (iii) system model (fault tree/event tree representation) of the facility to integrate the hazard with fragilities and calculate the risk for an earthquake ground motion. PSHA constitutes the basis of the seismic hazard at a site. PSHA is based on statistical models, whose parameters are estimated using observations from the earthquakes that have occurred in the past, from a few decades to several centuries. 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 and Eastern United States, due to the scarcity of recorded earthquake data. 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 PHSA practices, the estimate of branch weights for the GMPE models is based on expert judgement and there is no holistic approach for estimating the weights under uncertainty. In this research, we focus on the GMPE part of PSHA and we propose a new statistical methodology that is based on Bayesian inference, to evaluate the GMPE model weights from a list of GMPE models in the logic tree. It is shown that in certain cases the proposed methodology can calculate the weights without any approximations using analytical formulas and it is computationally inexpensive.