ESC2016-232, 2016
35th General Assembly of the European Seismological Commission
© Author(s) 2016. CC Attribution 3.0 License.

Estimation and Effects of Epistemic Uncertainty in Non-Ergodic Seismic Hazard Analysis

Nicolas Kuehn (1) and Norman Abrahamson (2)

(1) Pacific Earthquake Engineering Research Center, UC Berkeley, Berkeley, Ca, USA, (2) UC Berkeley, Berkeley, Ca, USA

Typically, the estimation of ground-motion models (GMMs) is based on the ergodic assumption, which means that the distribution of ground motions over time at a given site is the same as their spatial distribution over different sites. The ergodic assumption leads to a large value of the variance of aleatory variability, since it does not account for strong systematic, region and site-specific effects. Relaxing the ergodic assumption means trading (apparent) aleatory variability and epistemic uncertainty, because the systematic effects can in principle be modeled, if enough strong-motion data is available. In recent years, steps have been undertaken to remove some of the systematic effects from ergodic GMMs, such as the estimation of systematic site effects and the use of single-station sigma in probabilistic seismic hazard analysis (PSHA). In addition, some GMMs include regional adjustments for some aspects, such as a regional attenuation term. For a truly non-ergodic PSHA, one needs to account for region-specific source effects as well as source-site specific path effects. This reduces the variance of the aleatory variability significantly – however, in the absence of information about the systematic effects, the epistemic uncertainty is greatly enhanced. It is very important to account for these uncertainties, because otherwise the mean hazard values are underestimated. Without observations or 3-D simulations, this leads to a large increase in the width of the hazard curve distribution.
It has been recognized that systematic source, site and path effects are spatially correlated. This allows one to both constrain their variances, but also to estimate their expected value and uncertainty for locations with no observations.
We show how different effects can be modeled using different correlation functions, both stationary and non-stationary. The spatial correlations are estimated based on data from Taiwan and the ANZA, CA array. The estimated correlations from the two data sets are different, but become similar if a magnitude dependence to the correlation is included.
We show how observed between-event and within-event residuals, together with their spatial correlations, can be used to estimate the systematic source and path effects and the associated uncertainty for new locations. This provides a framework to incorporate the systematic effects into a non-ergodic PSHA. We show a few examples how going from a non-ergodic to an ergodic PSHA affects the hazard curve distribution, as well as how even just a small number of observations can significantly reduce the epistemic uncertainty due to systematic source and path effects.