Bulletin of the Seismological Society of America, Vol. 101, No. 5, pp. –, October 2011, doi: 10.1785/0120110117

Short Note

PGA and PGV Spatial Correlation Models Based on European Multievent Datasets

by Simona Esposito and Iunio Iervolino

Abstract Spatial modeling of ground-motion intensity measures (IMs) is required for risk assessment of spatially distributed engineering systems. For example, when a lifeline system is of concern, classical site-specific hazard tools, which treat IMs at different locations independently, may not be adequate to accurately assess the seismic risk. In fact, in this case, modeling of ground motion as a random field is required; it basically consists of assigning a correlation structure to the IM of interest. This work focuses on semiempirical estimation of the correlation coefficient, as a function of intersite separation distance, between residuals with respect to ground-motion prediction equations (GMPEs) of horizontal peak ground acceleration (PGA) and peak ground velocity (PGV). In particular, subsets of the European Strong-motion Database (ESD) and the Italian Accelerometric Archive (ITACA) were employed to evaluate the intraevent residual correlation based on multiple earthquakes, considering different GMPEs fitted to the same records. The analyses were carried out through geostatistical tools, which enabled results to be found that are generally consistent between the two datasets. Correlation for PGV appears to attenuate more gradually with respect to PGA. In order to better understand the dependency of the results on the adopted estimation approach and dataset, some aspects related to the working hypotheses are critically discussed. Finally, estimated correlation models are used to develop illustrative applications of regional probabilistic seismic-hazard analysis.

Introduction

Seismic-risk analysis of distributed systems and infrastructures requires a different approach with respect to the one commonly used for site-specific structures. In fact, systemic seismic performance may be conditional upon the behavior of many different components, each of which may respond differently to the input ground motion in the region where the system is deployed. In the seismic risk assessment of such systems, one of the key issues, at least on the demand side, is to account for the existence of a spatial statistical correlation between ground-motion intensity measures (IMs).

Traditionally, ground motion is modeled, for engineering purposes, via ground-motion prediction equations (GMPEs), which provide probabilistic distribution of the chosen IM, conditional on earthquake magnitude, source-to-site distance, and other parameters such as local geological conditions. GMPEs are obtained by regression of recorded data from historical events. The model's residual is usually expressed as the sum of two components: an interevent term, which is constant for each earthquake (common for all sites) and represents average source effects not explicitly appearing in the model covariates, and an intraevent term representing site-to-site variability of the IM (Strasser *et al.*, 2009). Boore *et al.* (2003) demonstrated that intraevent residuals, for example those referring to peak ground acceleration (PGA), are spatially correlated[1]. Therefore, IMs at different sites are correlated both because of inter- and intraevent residuals, and it is important to account for these dependencies in seismic-risk assessment when a region is of concern (Crowley and Bommer, 2006; Park *et al.*, 2007; Goda & Hong, 2008b, Crowley *et al.*, 2008).

Several correlation models are available in the literature, which depend uniquely on intersite separation distance. Most of the studies are based on dense observations of single events (e.g., Boore *et al.*, 2003; Wang and Takada, 2005; Jayaram and Baker, 2009) from different major earthquakes

[1]This kind of spatial correlation of ground motion consists of similarity between IMs (e.g., peak values of time history) observed at different sites within the same event. It is also worth mentioning here the coherency of ground-motion signals, which represents the similarity of ground motion in the frequency domain and describes the degree of positive or negative correlation between amplitudes and phase angles of two time histories at each of their component frequencies (e.g., Zerva and Zervas, 2002).