Application of Standard Deviation for Single-station Ground-motion Prediction Model in a Probabilistic Seismic-hazard Analysis

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The results of probabilistic seismic hazard analysis for empirical ground-motion prediction equations (GMPEs) are sensitive to the standard deviation, especially with long return periods. Recent studies have proven that variability decomposition cannot reduce the hazard level when moving the epistemic uncertainty into the logic tree unless we have a reasonable reason to remove it directly. In this study, we propose the use of single-station GMPEs to solve this problem. The single-station model is established from the observation records at a station, so the epistemic uncertainty of the site term can be ignored. We use 20,466 records for 506 crustal earthquakes with moment magnitudes greater than 4.0 obtained from the Taiwan Strong Motion Instrumentation Program (TSMIP) network to build the single-station GMPEs for 570 stations showing the peak ground acceleration (PGA) and spectral accelerations (SAs). The comparison is made of the total sigma of the regional GMPE (σ_T), the single-station sigma of the regional GMPE which is estimated by the variability decomposition method (σ_{SS}) and the single-station sigma of single-station GMPEs ($\sigma_{SS,S}$) for the different periods. Finally, we find that with the ideal for the path diagram approach as proposed by Sung and Lee (2016), we can separate the epistemic variance arising from single-station uncertainty, and through the decomposition of the variance components we can get the aleatory variability, which is indicative of the single-path sigma per station, $\sigma_{SP,S}$. Because the variability varies with geographical location, the analysis of the spatial correlation of these variances among sites can be plotted as $\sigma_{SS,S}$ and $\sigma_{SP,S}$ distribution maps. The results show that the $\sigma_{SS,S}$ for the PGA is 50% to 70% smaller than the σ_T and the $\sigma_{SP,S}$ for the PGA is 70% to 90% smaller than the σ_T in southern and northern Taiwan.

Keywords: strong motion, prediction model, single station, single path, variance decomposition, standard deviation