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距離減衰式評価手法に関する数値実験
A study on model selection methods for ground-motion prediction equations using synthetic data

野田 朱美 [1*] ; 呉 長江 [2] ; 司 宏俊 [3] ; 西條 裕介 [1] ; 焦 凝 [1]
NODA, Akemi[1*] ; WU, Changjiang[2] ; SI, Hongjun[3] ; SAIJO, Yusuke[1] ; JIAO, Ning[1]

[1] 構造計画研究所, [2] 原子力安全基盤機構, [3] 東京大学地震研究所
[1]Kozo Keikaku Engineering Inc., [2]Japan Nuclear Energy Safety Organization, [3]Earthquake Research Institute, University of Tokyo

Numerous ground motion prediction equations (GMPEs) have been proposed for the purpose of assessing seismic hazard. However, a critical problem is that how to select appropriate GMPEs for the application of GMPEs to practical engineering problems.

Recently some model selection methods for GMPEs that evaluate the agreement between observed and predicted data have been proposed. In present study, in order to check the properties of model selection methods, we compare the model selection methods by using artificial dataset generated by a known GMPE. As candidate model selection methods, we have chosen three methods, that is, analysis of root mean square residual (RMR), the log-likelihood method (LLH method, Scherbaum et al., 2009, BSSA) and the Euclidean distance-based ranking method (EDR method, Kale and Akkar, 2013, BSSA). The analysis of RMR is one of the simplest methods to evaluate the difference between observed data and medians of GMPE model. On the other hand, the LLH method quantifies the distance between observed data and GMPEs defined as probability density function (both of median and standard deviation), based on information-theoretic perspective. However, Kale and Akkar (2013) points out the problem that the LLH method may favor GMPEs with larger standard deviations. The EDR method considers not only ground-motion uncertainty of model through standard deviation, but also agreement between the median estimations of models and observed data trend (model bias).

First, we assumed a vertical strike-slip fault with moment magnitude 7.0. We randomly chose 200 sites, whose fault distances are up to 200km. Next, we calculated theoretical PGA and response spectral acceleration for 16 periods using ground motion prediction model of Chiou and Youngs (2008, Earthq. Spectra), which is referred to as CY08 hereafter. And, we generated three kinds of synthetic dataset by adding three types of random noise with (1) zero standard deviation, (2) standard deviation of CY08, and (3) twice the standard deviation of CY08, respectively.

We selected five candidate GMPEs, that is, CY08, Abrahamson and Silva (2008, Earthq. Spectra), Campbell and Bozorgnia (2008, Earthq. Spectra), Zhao et al. (2006, BSSA) and Kanno et al. (2006, BSSA), and ranked the performance of candidate GMPEs for each synthetic dataset. In analysis of RMR that does not account for standard deviations of the prediction models, CY08 is stably ranked the best performing model for all kinds of synthetic dataset. The LLH method basically ranked CY08 as the best performing model for synthetic dataset (1) and (2), but it favored GMPEs with larger standard deviations for synthetic dataset (3). It suggests that the standard deviation of model is emphasized more than the median when we apply the LLH method to poor quality data. In the EDR method, in principle, the parameter to measure the level of model bias of CY08 is not able to be calculated for synthetic dataset (1) that does not have random noise. For synthetic dataset (2) and (3), however, the EDR method ranked CY08 as the best performing model both in the point of view of model uncertainty and model bias.

キーワード: 距離減衰式, 強震動予測モデル, 残差の二乗平均平方根, 対数尤度法, ユークリッド距離ランキング法
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