Research Report for the ERI Visit from 8th May to 6th August 2023

1 People

- Chih-Hsuan Sung: the short visit scholar at the ERI and the assistant project scientist of the Civil and Environmental Engineering at UC Berkeley.
- Hiroe Miyake: the host and professor at the ERI of the University of Tokyo.
- Norman Abrahamson: the professor of the Civil and Environmental Engineering at UC Berkeley.
- N. Morikawa: the senior researcher of the NIED, who provides the crustal and subduction zone earthquakes in this research.

2 Research

At present, the ground-motion models (GMMs) for the subduction zones (interface and slab) and crustal earthquakes of Japan were developed in the National Research Institute for Earth Science and Disaster Resilience (NIED) (Morikawa and Fujiwara, 2013) and NGA-Sub project (e.g., Si *et al.*, 2022). These GMMs are ergodic models in that they apply to all of Japan. However, many studies have proven that the non-ergodic effects can capture the systematic source, path, and site effects from the ground motion scaling via the varying coefficient model and reduce the aleatory variability (e.g., Sung *et al.*, 2022a; Lavrentiadis *et al.*, 2021). In this study, we capture the non-ergodic behavior for the subduction zone and crustal earthquakes in Japan using the NIED dataset based on the different ergodic models (Morikawa and Fujiwara, 2013; Abrahamson *et al.*, 2014; Si *et al.*, 2022; Abrahamson and Gulerce, 2022; Abrahamson *et al.*, 2016). For the non-ergodic path effects, the cell-specific linear-distance scaling mimics the effects from a 2-D Q structure, ϕ_{P2P_Q}, (Dawood and Rodriguez-Marek, 2013; Kuehn *et al.*, 2019) and the path effect related to the 3-D velocity structure, ϕ_{P2P_V}, (Sung *et al.*, 2023) are all considered in our model. The model is a smooth spatially varying non-ergodic source, site, and path terms that can be applied to any source/site pair. For the region without the data, the adjustment terms would be close to zero and provide higher epistemic uncertainty of the non-ergodic term. The result shows that the full path variability (ϕ_{P2P}) of the non-ergodic path term is about 0.3-0.4 in natural logarithm units for all periods. Overall, with the non-ergodic terms, the fully non-ergodic models lead to an aleatory variance of residual values for the GMMs that is reduced by 65%, which can significantly affect seismic hazard calculations for the Japan region. In addition, our future work will focus on the ground motion model based on the 3D numerical simulation, which will improve the results for the shorter distance and great magnitude.

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