Spatial distribution of ground-motion variability in broadband ground-motion simulations

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Ground-motion prediction for a scenario earthquake requires evaluation of both the average ground-motion level and ground-motion variability due to model uncertainties.
This study aims to evaluate the ground-motion variability due to aleatory variability of the source parameters by modeling ground motion of the 2000 Tottori earthquake (strike-slip type) and the 2004 Chuetsu earthquake (reverse-fault type).
The source models are based on the characterized source model by the “recipe” (HERP, 2016) with fault location, size, and geometry as given parameters. Aleatory variability for the three source parameters is considered: (1) asperity location, (2) rupture initiation point, and (3) seismic moment. Two asperities are randomly located on the fault with no overlapping. A rupture initiation point is chosen randomly from the 2 km grids on the fault. Seismic moment M_0 is sampled from a normal distribution in which the mean value is given by the M_0-S relation (S being the fault area) by Irikura and Miyake (2001) and mean+2 σ equals to $2M_0$. Short-period level A, another important parameter in the characterized source model, is derived from A-M_0 relation by Dan et al. (2001).
Ground motion for each earthquake is simulated by a hybrid approach; 3D FDM (Aoi and Fujiwara, 1999) for long periods (> 1 s) and the stochastic Green’s function method (Dan and Sato, 1998) for short periods (< 1 s), using a set of 50 source models and a 3D velocity model of J-SHIS v2 (Fujiwara et al., 2012). For the 2004 Chuetsu earthquake, simulations using a simple 1D stratified velocity model are also conducted in order to exclude the effects of the complicated subsurface structure around the source area.
From the ground-motion simulation results with 50 source models for each earthquake, standard deviation (SD) of ground-motion indexes, ln of 5% damped acceleration response (Sa), PGA, and PGV, are analyzed at 10 km interval mesh. Distance and azimuthal dependence of SD are observed; the characteristics of the spatial distribution of SD differ from short periods to long periods. It is also found that the spatial distribution of SD is largely distorted by the complicated subsurface velocity structure for the Chuetsu earthquake.
As a step toward constructing a model of ground-motion variability in ground-motion prediction for a scenario earthquake, we attempt to fit the SD, each for strike-slip type and reverse-fault type, with a simple regression model using the fault distance and directivity parameters.
Effects of variability in other source parameters, such as rupture velocity and source time function, should be studied in our future works. Modeling variabilities in such source parameters requires investigation in physics- or empirical-based criteria.

Keywords: ground-motion prediction, ground-motion variability, source parameter, uncertainty

