Broadband ground motion prediction considering variabilities of source parameters and comparison with observed records

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The strong motion prediction “recipe” (Earthquake Research Committee, 2009) has proposed the characterized source model whose source parameters are determined by the scaling laws that extract average characteristics of the source parameters of past earthquakes. Consequently, the predicted ground motion of the National Seismic Hazard Maps using the characterized source models with a limited number of locations of the asperities and hypocenters may be at average level, which is insufficient for prediction of unknown earthquake ground motion. In order to overcome this problem, two approaches may be important. One is to comprehend the variabilities of the source parameters by analyzing the ground motion records of past earthquakes. The other is to introduce probabilistic source models and perform large amount of ground motion computation.
In this study, we attempt to perform “ground motion prediction” of past earthquakes by using source models that take into account the variabilities of source parameters. The 2000 western Tottori earthquake is chosen as our first target earthquake. Aleatory variabilities of selected source parameters are assumed to have normal distributions whose means and standard deviations are estimated from the recipe, and the source models are constructed by sampling the source parameters by the Latin Hypercube Sampling (LHS), following the method by Yamada et al. (2007, 2011). Variabilities of five parameters are considered; the (1) short-period level (ratio to $M_0^{1/3}$), (2) slip within the asperities (ratio to the average slip), (3) rupture velocity (ratio to the shear-wave velocity of the source region), (4) asperity locations, and (5) hypocenter location.
As a preliminary analysis, we constructed source models in which the short-period level, asperity slip, and rupture velocity have either the mean or mean+SD values with fixed locations of asperities and hypocenter. Broadband ground motion was computed by a hybrid method of 3D FDM and the stochastic Green’s function method. By comparing the simulation results with each other and with observation via an evaluation method using the 5% damped pseudo acceleration response spectra (PSA) at 40 stations with hypocentral distance of 1 –180 km (Goulet et al. 2015), we found that The basic case (all parameters have the mean values) over- and underestimated the PSA at long- (> 1 s) and short- (< 1 s) periods, respectively. The mean+SD short-period level amplified the PSAs at all stations at periods 1 s and shorter. The influence of the mean+SD rupture velocity model largely varied among the stations.
We will conduct ground motion simulations for ~100 source models in which all the five parameters are sampled by LHS. We will evaluate the variability of the predicted ground motions and compare them with the observed records. It is important to perform these analyses for various other past earthquakes in order to compare the variabilities of the predicted ground motions with those of the observed ground motions.

Keywords: ground motion prediction, source model, variability

