Song Method: A Pseudo-dynamic Rupture Model Generator (RMG), Based on 1-Point and 2-Point Statistics of Earthquake Source Parameters

Seok Goo Song (sgsong@kigam.re.kr)

Earthquake Research Center, KIGAM, Daejeon, Korea

Release Notes (V. 19.4)

In this version, the code is improved by implementing a multi-segment module, with which we can simulate multi-segment earthquake rupture models with complex fault geometry (i.e., multiple strikes and dips). The output rupture models are stored in the standard rupture format (SRF, Version 2 released in 2015).

Method Overview

This pseudo-dynamic rupture model generator (RMG) produces a number of rupture scenarios with a full description of spatio-temporal evolution of slip velocity function at each grid on the finite fault. The generated finite source models are to be used to simulate ground motions and to investigate the effect of earthquake source on near-source ground motion characteristics. Song et al. (2009) and Song and Sommerville (2010) originally introduced the main idea and mathematical framework in the rupture model generator, and they were expanded and improved by following studies (Song and Dalguer 2013; Song et al. 2014). Song (2016) developed a generalized version of input pseudo-dynamic source models for Mw 6.5-7.0 by analysing a number of spontaneous dynamic rupture models. Song (2015) investigated the effect of fracture energy on the source correlation statistics. Finally, Lee and Song (2017) improved the stochastic source modelling algorithm by adopting the non-parametric co-regionalization.

A set of spatial random fields model the spatial distribution of several key kinematic source parameters, such as slip, rupture velocity, and peak slip velocity. The random field model is constrained by rupture dynamics and past events in the framework of 1-point and 2-point statistics. One-point statistics is a marginal probability density function at a given point on the fault. If we assume the Gaussian distribution, mean and standard deviation are two main representative parameters. They control the possible range of values for each source parameter. Two-point statistics is composed of both auto and cross-correlation. Autocorrelation controls the heterogeneity of each source parameters while cross-correlation controls coupling between source parameters. Once we have target 1-point and 2-point statistics, we can generate a number of rupture scenarios by Monte Carlo sampling, assuming the multi-variate Gaussian distribution. We first construct a covariance matrix, given the target auto- and cross-correlation structures, and simulate the spatial distribution of source parameters that satisfy the target covariance matrix using the Cholesky factorization. Mean, standard deviation, and even the shape of marginal probability density function can be adjusted afterwards. Finally we combine the simulated spatial distribution of source parameters with a prescribed shape of slip velocity function, and produce a full description of finite source model in the standard rupture format (SRF), which can be directly implemented at the SCEC Broadband Platform (BBP).

As illustrated in Figure 1, we found this approach very efficient in understanding the effect of earthquake source on ground motions in the same framework of 1-point and 2-point statistics, and consequently quantifying the 1-point and 2-point statistics of ground motion intensity measures in simulation-based ground motion prediction studies.

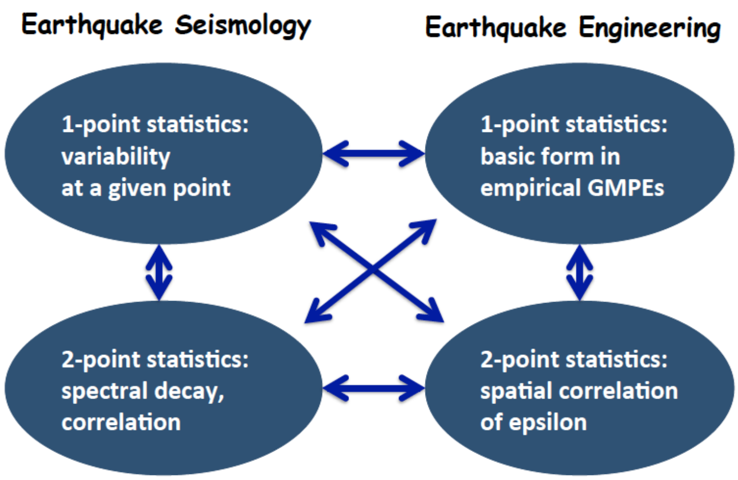

Figure 1. Consistency between earthquake source and ground motion modeling

References

Lee, K., and Song, S. G. (2017), Stochastic Earthquake Rupture Modelling Using Nonparametric Co-regionalization, Pure and Applied Geophysics, 174, 3569-3587.

Song, S. G. (2016), Developing a Generalized Pseudo-Dynamic Source Model of Mw 6.5-7.0 to Simulate Strong Ground Motions, Geophys. J. Int. 204, 1,254–1,265. doi:10.1093/gji/ggv521.

Song, S. G. (2015), The Effect of Fracture Energy on Earthquake Source Correlation Statistics, Bull. Seismol. Soc. Am. 105, 1042-1048.

Song, S. G., Dalguer, L. A., and Mai, P. M. (2014), Pseudo-Dynamic Source Modelling with 1-Point and 2-Point Statistics of Earthquake Source Parameters, Geophys. J. Int. 196, 1,770–1,786. doi:10.1093/gji/ggt479.

Song, S. G., and Dalguer, L. A. (2013), Importance of 1-Point Statistics in Earthquake Source Modelling for Ground Motion Simulation, Geophys. J. Int. 192, 1,255–1,270, doi:10.1093/gji/ggs089.

Song, S. G., and Somerville, P. (2010), Physics-Based Earthquake Source Characterization and Modeling with Geostatistics, Bull. Seismol. Soc. Am. 100, 482–496. doi:10.1785/0120090134.

Song, S. G., Pitarka, A., and Somerville, P. (2009), Exploring Spatial Coherence between Earthquake Source Parameters, Bull. Seismol. Soc. Am. 99, 2,564-2,571.