EXSIM Method: A Stochastic Extended Finite-Fault Ground-Motion Simulation Algorithm

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Release Note

The input parameters are the same as the ones presented in Assatourians and Atkinson (2015) except for the amplification factors. The updated amplification factors are developed for a site with V_{S30} = 500 m/s (time-averaged shear-wave velocity in the top 30m) for Japan and California and are presented in Table 1. These factors are developed by scaling of the amplification factors used in Assatourians and Atkinson (2015) (V_{S30} = 760 m/s) according to the V_{S30} scaling model of Seyhan and Stewart (2014).

Table 1. Input Site amplification factors for Japan and California, for a reference site with V_{S30} = 500 m/s.

Frequency (Hz)	Amplification Japan	Frequency (Hz)	Amplification California
0.11	1.39	0.00	1.45
0.22	1.62	0.10	1.45
0.41	1.84	0.24	1.87
0.64	1.92	0.45	2.17
0.80	1.97	0.79	2.48
0.99	2.05	1.38	2.91
1.23	2.13	1.93	3.20
1.53	2.28	2.85	3.36
1.90	2.44	4.03	3.35
2.37	2.60	6.34	3.13
2.94	2.78	12.54	2.95
3.66	3.10	21.23	2.99
4.55	3.23	33.39	3.11
5.66	3.43	82.00	3.23
7.04	3.66		
8.75	3.71		
10.90	3.55		
13.50	3.03		

Method Overview

EXSIM is an open-source stochastic extended finite-source simulation algorithm, written in FORTRAN, that generates time series of ground motion for earthquakes (Motazedian and Atkinson, 2005; Boore, 2009; Assatourians and Atkinson, 2012). To consider the finite-fault effects (e.g. faulting geometry, distributed rupture, and rupture inhomogeneity) in ground-motion modeling, EXSIM subdivides the fault surface of an earthquake into a grid of subsources, each of which could be treated as a point source. Time series from the sub-sources are modelled using the point-source stochastic model developed by Boore (1983, 2003) and popularized by the Stochastic-Method SIMulation (SMSIM) computer code (Boore, 2003, 2005). The stochastic point-source model assumes that the source process is concentrated at a point and that the acceleration time series radiated to a site carry deterministic and random aspects of ground-motion shaking. The deterministic aspects are specified by the average Fourier spectrum, given as a function of magnitude and distance. The stochastic aspects are treated by modeling the motions as Gaussian noise with the specified underlying spectrum. The underlying deterministic spectrum is a multiplication of source term (Brune, 1970 & 1971) (Fourier spectrum of shear radiation at the source defined by seismic moment and stress parameter), path term (anelastic attenuation and geometrical spreading), and site term (crustal amplification and near-surface attenuation). EXSIM also uses the concept of dynamic corner frequency (Motazedian and Atkinson, 2005) in which the rupture begins with a high corner frequency and progresses to lower corner frequencies as the ruptured area grows. This makes the simulation results relatively insensitive to sub-source size. The duration of motion for each sub-source comes from the source duration plus the path duration. Finally, the time series from the sub-sources are summed in the time domain with a normalization factor, with appropriate time delays for propagation of the rupture front. The summation produces the shear wave train of the seismic signal at a site of interest.

Applicable Frequency Range

For Pseudo Spectral Acceleration (PSA) and Fourier Amplitude Spectrum (FAS) the recommended appliable frequency ranges are 0.2-100 Hz and 0.1-40 Hz respectively.

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