SDSU Module: A Hybrid Broadband Synthetics Generator Using High-Frequency Scattering Functions.

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Method Overview

For computing broadband hybrid seismograms using the SDSU broadband synthetics rupture generator on the SCEC BBP, we adopt a three-stage approach. First, we calculate low-frequency (LF) synthetics for a finite-fault earthquake rupture embedded in a 1D Earth model using the Graves and Pitarka (GP) rupture generator. Second, we generate high-frequency (HF) scattering contributions for each observer location, considering path-averaged scattering properties and local site conditions based on site kappa (κ). The HF scatterograms are generated for each component of motion based on the theory for multiple S-to-S, S-to-P and P-to-S scattering by Zeng et al. (1991, 1993). The scatterograms are based on user-specified site-scattering parameters and are partly based on the site-specific velocity structure. The seismic-scattering wave energy is realized to appear after the direct P-wave arrival time, which is found from 3D ray tracing (Hole, 1992). Finally, the scatterograms are convolved with an appropriate source time function. It is assumed that the scattering operators and moment release originate throughout the fault but start at the hypocenter. If desired, the method incorporates inter-frequency and spatial correlation, by applying an empirical correlation matrix to the Fourier amplitudes of the synthetic ground motion time series (Wang et al., 2019, 2021). Finally, the two sets of seismograms are reconciled to form hybrid broadband seismograms using matched filtering in the time domain, with the option of scaling the HFs 1) to the amplitude level of the LFs at the merging frequency, or 2) using a theoretical value calculated from the source and model parameters. Additional frequency-dependent site-effect corrections can be applied to the broadband synthetics. The SDSU BBP module participated in and passed the SCEC BBP validation exercise (Goulet et al., 2015).

Release Notes (V 22.3)

This release of the SCEC BBP SDSU Module includes a series of changes. We have incorporated spatial correlation along with inter-frequency correlation in the SDSU Module, essentially as a post-processing method, by applying an empirical correlation matrix to the Fourier amplitudes of the synthetic ground motion time series (Wang et al., 2021). Figure 1 shows a comparison of the inter-frequency correlation structure for the Loma Prieta event before and after applying our method.

We have changed the recommendation for parameters including the high-frequency exponent f_{dec} and Q_0 factor in $Q(f) = Q_0 f^{f_{dec}}$, and the κ spectral decay parameter in $P(f) = \exp(-\pi\kappa f)$ (Graves and Pitarka, 2010) for all regions as shown in Table 1. All regions are now using $a = 57.0, b = 34.0$ determining the velocity dependent Q in $q_k = a + b\beta_k$ to be consistent with the GP method. (Seyhan et al., 2013)

Table 1. Parameter suggestions changed since last release for California and Japan regions.

Regions	*N. CA*	*C. CA*	*LA Basin*	*Mojave*	*S. Sierra NV*	*C. Japan*	*W. Japan*
Q_0	100.0	200.0	120.0	100.0	300.0	100.0	150.0
f_{dec}	0.4	0.2	0.4	0.7	0.6	1.0	0.9
κ	0.04	0.036	0.04	0.04	0.037	0.04	0.018

Known Issues

An error will occur from the spatial correlation if two or more identical station locations are used. This error can be avoided if a small perturbation in location coordinates is applied to those stations.

Bandwidth of Results

We have validated the BBP results for the SDSU module for PSA using periods longer than 0.02 s and for FAS using frequencies less than 10 Hz. Validation of BBP results outside these ranges is ongoing.

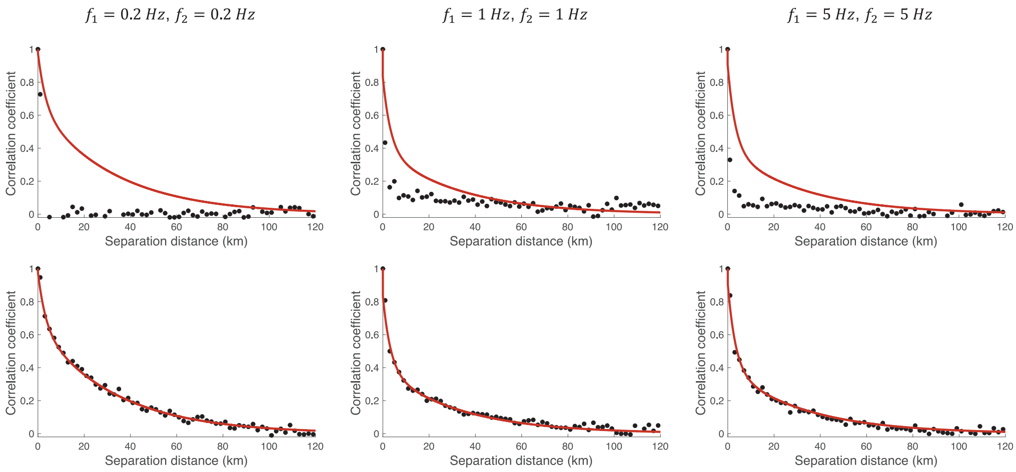

Figure 1. Comparison of the spatial correlation coefficient of epsilon for EAS at the reference frequency pairs $f_1=f_2=0.2$ Hz (left), $f_1=f_2=1$ Hz (middle), and $f_1=f_2=5$ Hz (right) from the model (red lines) and the SDSU Module before (top) and after (bottom) applying our method (dots) for the Loma Prieta earthquake with 50 source realizations. From Wang et al. (2021).

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