Broadband Strong Motion Simulation in Layered Half-Space Using Stochastic Green's Function Technique

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The stochastic Green's function method, which simulates one component of the far-field S-waves from an extended fault plane at high frequencies (Kamae et al., 1991), is extended to simulate the three components of the full waveform in layered half-spaces for broadband frequency range. The method firstly computes ground motions from small earthquakes, which correspond to the ruptures of sub-faults on a fault plane of a large earthquake, and secondly constructs the strong motions of the large earthquake by superposing the ground motions using the empirical Green's function technique (e.g., Irikura, 1986). The broadband stochastic omega-square model is proposed as the moment rate functions of the small earthquakes, in which random and zero phases are used at higher and lower frequencies, respectively. The zero phases are introduced to simulate a smooth ramp function of the moment function with the duration of 1/fc s (fc: the corner frequency), and to reproduce coherent strong motions at low frequencies (i.e. the directivity pulse). As for the radiation coefficients, the theoretical values of double couple sources for lower frequencies and the theoretical isotropic values for the P-, SV-, and SH-waves (Ohnishi and Horike, 2004) for high frequencies are used. The proposed method uses the theoretical Green's functions of layered half-spaces instead of the far-field S-waves, which reproduce the complete waves including the direct and reflected P- and S-waves, and surface waves at broadband frequencies. Finally, the proposed method is applied to the 1994 Northridge earthquake. Results show excellent agreement with the observation records at broadband frequencies. At the same time, it is found that the method still needs improvements especially because it underestimates the high-frequency vertical components in the near fault range. Nonetheless, the method will be useful as a high-frequency method of hybrid methods, which use stochastic and deterministic methods for high and low frequencies, respectively, (e.g, the stochastic Green's function method + finite difference methods; Kamae et al., 1998, Pitarka et al., 2000), because it reproduces the full waveforms including not only random characteristics at higher frequencies, but also theoretical and deterministic coherencies at lower frequencies.