Ground Motion Simulation for Finite Faults using the Ambient Seismic Field

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After the 2011 Tohoku earthquake, the Japanese government re-evaluated the source regions of potential megathrust earthquakes, leading to new seismic and tsunami hazards that need to be assessed. The long-period ground motions, which may affect tall-buildings and critical structures, need to be carefully simulated. Deterministic numerical simulation of long-period ground motions are currently widely applied for both crustal and subduction earthquakes. However, the period-range is limited between 1 to 20 s and 2 to 20 s for crustal and subduction earthquakes, respectively, due to the accuracy of the velocity structure models. As an alternative approach, ground motion simulation using the ambient seismic field (i.e., seismic interferometry) has been proposed.

Finite fault application is necessary for ground motion simulations of large magnitude earthquakes. Denolle et al. (2014) demonstrated the finite fault application of the ambient seismic field by simulating the ground motions of earthquake scenarios along the San Andreas fault. Simulated ground motions tend to over predict the ground motion obtained with physics-based simulations, indicating a possibility of large ground motion variations. Viens et al. (2016) showed a good agreement between observed and simulated ground motions for the 2008 Iwate-Miyagi earthquake. Surprisingly, the point source assumption shows a similar performance to the finite fault assumption as long as the period range is longer than 4 s. Another alternative is to convolve the source time function of the large earthquake with the Green's functions retrieved with a station located close to the earthquake source. We validate this approach by simulating the long-period ground motions ($T > 4$ s) of the 2007 Chuetsu-oki earthquake. Up to now, these techniques have only been applied to crustal earthquakes. With the recent increase of offshore continuous observation systems, such as the S-net, DONET, and JMA networks, the application can be extended to subduction earthquakes with finite source modeling using offshore-onshore Green's functions. The ambient seismic field has a potential to overcome the current limitation of velocity structure modeling, especially for shallow oceanic soft layers. However, some issues still need to be solved, such as the Green's function amplitude calibration, the earthquake depth limitation, the period range limitation, potential azimuthal variations, and seasonal variation.

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