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Finite Source Modeling of a Large Earthquake Using the Ambient Seismic Field

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Large (M_w ≥7) earthquakes have the potential to generate long-period seismic waves that can be significantly amplified, even at large distances, by sedimentary basins. Prediction of these long-period ground motions (≥4 s) is essential to mitigate their impact on large-scale structures, such as high-rise buildings and oil storage tanks. We focus on the well-recorded Iwate-Miyagi Nairiku earthquake (M_w 6.9), which occurred on 14 June 2008 in the Tohoku region, Japan. This earthquake, which has a reverse-fault mechanism, caused several fatalities, collapse of houses and a bridge, and severe landslides. To simulate the long-period ground motions (4-10 s) generated by this event, we take advantage of the ambient seismic field continuously recorded by seismic stations of the Hi-net/NIED, Japan Meteorological Agency, and Tohoku University networks. Stations located in the vicinity of the mainshock fault plane are used as virtual sources and other stations as receivers. We use the deconvolution method to extract single force impulse response functions between each pair of stations. We first show that, after calibration of the amplitude, impulse response functions accurately simulate the long-period ground motions of a moderate M_w 5.0 aftershock that occurred close to the mainshock hypocenter. To simulate the mainshock, we construct a simple finite source model that is similar to the ones determined by source inversions. The fault plane is first discretized into subfaults of the size of the moderate M_w 5.0 earthquake. We show that it is possible to interpolate the impulse response functions extracted between every virtual source and each receiver to obtain one impulse response function for each subfault. We finally initiate and spread the rupture radially from the hypocenter with a constant velocity to simulate the long-period ground motions. We find that the simulated long-period ground motions are consistent with the earthquake records, which confirm the power of this technique to assess seismic hazard.

Keywords: Ground motion simulation, Ambient seismic field, Green's function, Finite source modeling

