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Source modeling and strong motion simulation of the 2001 Geiyo (M_J5.4) earthquake, using the empirical Green's function method

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The 2001 Geiyo earthquake (M_J6.7) ruptured in the Philippine Sea slab beneath the Seto Inland Sea of Japan at a depth (51 km) on March 24, 2001. The source mechanism of the event was normal faulting. As the slab earthquakes tend to release high frequency energy, the study on the source modeling and the broadband strong motion simulation for the Geiyo earthquake is considered to be significant from both seismological and engineering points of views.

In this study, the source parameter estimation and strong motion simulation with use of the empirical Green's function method were carried out. 10 KiK-net stations (HRSH01, HRSH07, HRSH08, HRSH12, YMGH03, YMGH04, YMGH05, EHMH02, EHMH04, EHMH05) located at 19 to 66 km in epicentral distance are used. To focus on the source modeling without any consideration about nonlinear behavior of soft surface layers at many sites reported in previous studies [e.g. Kanno and Miura (2005)], borehole records were used.

First, the spectral amplitude of the S-wave main portion from mainshock and 12 aftershocks (M_J 3.5 to 5.1) are inverted to derive rough estimates of basic source parameters characterizing the omega-square source spectrum by Brune (1970). From preliminary analyses, the Qs-value along the path was estimated to be $Q(f)=81*f^{0.85}$. Horizontal spectra were inverted and decomposed into source effects and site effects. As a result, the seismic moment, the corner frequency, and the stress drop was estimated to be $3.2*10^{25}$ dyne*cm (Mw6.3), 0.52 Hz, and 377 bar for the mainshock and $7.9*10^{23}$ dyne*cm (Mw5.2), 0.77 Hz, and 32 bar for the largest aftershock.

Next, prior to the strong motion simulation, the seismic moment distribution on the fault plane was estimated by the waveform inversion. A simple fault plane of 30 km by 18 km with strike of 180 deg. and dip of 60 deg. was assumed with reference of previous studies [e.g. Kikuchi and Yamanaka (2001), Sekiguchi and Iwata (2001), Nozu (2001),and Kakehi (2004)]. The relative seismic moment release of the mainshock against the largest aftershock was estimated. It resolved at least two asperities: the largest asperity was at 15 km south and the second one was near the rupture starting point. From the waveform inversion, the seismic moment of the mainshock was about 80 times larger than that of the largest aftershock, corresponding to Mw6.5. Then, the simulation of the strong motion records from the mainshock in a range of 0.3 to 10 Hz was carried out. To combine the estimated seismic moment release distribution with the empirical Green's function, the method by Dan and Sato (1998) was applied. The maximum amplitudes of observed horizontal components from 10 stations were in a range of 24 to 123 cm/s^2 in acceleration and 1.6 to 8.5 cm/s in velocity. At most of the stations, the observed maximum amplitudes were simulated within a factor of 2.

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