Source rupture process during the 1987 east off Chiba earthquake (M6.7) inferred from broadband strong-motion data

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The 1987 east off Chiba earthquake was one of the early important events occurring beneath the Tokyo Metropolitan area after modern strong-motion seismographs had been widely installed in Japan. Due to rather deep hypocenter of about 60 km, the damaged area from the event was extended over the Southern Kanto district. It is important for disaster mitigation on the Metropolitan area which is the center of politics and economy to reveal the source rupture process of this event. I this article we apply the source inversion scheme composed of the empirical Green's function method and simulated annealing to broadband strong-motion data from the 1987 event and separately estimate the distributions of the seismic moment and effective stress on the fault.

The source inversion algorithm proposed by Shiba and Irikura (2005) is modified by introducing smoothing constraints for spatial distributions of search parameters. In this procedure the empirical Green's function method is used as forward process and very fast simulated annealing is employed for search algorithm of an optimal solution. Consequently our proposed method is possible to evaluate strong motions in the higher frequency range compared with other conventional methods. Although Shiba and Irikura (2005) inverted the displacement waveforms and velocities independently to estimate several source parameters such as seismic moment, rise time, rupture time and effective stress at each sub-fault, we in this study assume constant rise time over the whole fault plane and estimate other three parameters through only the velocity waveform inversion. Smoothing constraints for the seismic moment and effective stress are added to the inversion algorithm and weighting factors for these constraints are determined by calculating ABIC. Only the causality law is taken into consideration for estimation of the rupture times.

Strong-motion records of two horizontal components from nine stations are used for the inversion. A moderate event of Mj5.3 occurring on September 20, 2003 is chosen as the empirical Green's function. For an initial fault model we assume the rectangular fault of 21km long and 24km wide following Fukuyama and Kinoshita (1989), and it is divided into $7*8$ sub-faults. Rupture starts from the southern deepest sub-fault and the search area of rupture velocity is restricted as the range from 0.7 to 0.9 times the S-wave velocity based on several test runs. The strong-motion accelerograms used for the inversion are band-pass filtered between 0.1 to 5 Hz, and numerically integrated into velocity motions.

Ten inversion analyses are carried out with different initial values for random number generation, and convergence of solutions is confirmed. As a result all optimal solutions show similar distributions of the seismic moment and effective stress except for one local minimum solution. The peak of the effective stress expands from the rupture initiation point to the upper bound of the assumed fault plane, suggesting the stress change at the upper boundary of the Philippine Sea plate. On the other hand the seismic moment is released mainly from deeper area near the hypocenter. The rupture propagation seems to be decelerated near the peak of effective stress.

For the waveform fitting we see underestimation of amplitude for the EW component at some stations. It might be due to the inappropriate correction of radiation patterns between the target and element events. We will further verify the reliability of estimated source model for the prediction of strong ground motions.