3-D strong motion simulation in the Sendai basin during the 1998 Miyagiken-Nanbu earthquake using a FDM with variable grid spacing

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We construct a 3-D velocity model for the Sendai basin based on the measurements of microtremors and simulate strong motions there during the 1998 Miyagiken-Nanbu earthquake (MJ5.0) by a 3-D finite difference (FD) method with variable grid spacing. The 3-D model used in the FD calculation is 30 km long, 33 km wide, and 19 km deep.The lowest S-wave velocity is set to be 500 m/sec in the topmost layer whose grid spacing is to be 50 m. As a result we succeed to simulate the observed displacement waveforms filtered from 0.2 to 1.67 Hz.

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We have already estimated S-wave velocity structures at five regions in and around the Sendai basin by array measurements of microtremors (Satoh et al., 1998). In addition we use microtremor data observed in 1997 at 24 stations. First we calculate horizontal-to-vertical spectral ratios (H/V) for the microtremors observed at 61 stations in total including large-array stations for the array measurements. Then we estimate the velocity structure to fit the first peak period of the theoretical H/V for the fundamental mode of Rayleigh wave with that of the observed H/V. Finally we construct a 3-D velocity model by compiling the velocity structures estimated from microtremors with the other previous information based on several geophysical explorations and geological surveys.

The 3-D model used in the FD calculation is 30 km long in the N130E direction, 33 km wide in the N40E direction, and 19 km deep. The Sendai sedimentary basin covers an area of about 25 km x 25 km and extends to a depth of about 1.3 km. The lowest S-wave velocity is set to be 500 m/sec in the topmost layer whose grid spacing is to be 50 m. The grid spacing is then increased to 150 m and 300 m depending on the S-wave velocity of the layers below. The maximum frequency to be considered is 1.67 Hz. This is derived from the accuracy condition of 6 grids per wavelength. The maximum grid node numbers in three directions are 545, 581, and 79, respectively. The time increment is 0.00363 s and the total number of time increments is 4133, resulting in 15 seconds of duration after the earthquake origin time. The total core memory is about 1.6 GBytes and the CPU time for a single calculation is about 6.5 days using a SUN UltraSPARC 2300 workstation.

The thrust fault along the Nagamachi-Rifu line with the length of 21 km and the strike of about N40E is running through the center of the Sendai basin. The 1998 Miyagiken-Nanbu earthquake (MJ5.0) occurred at the depth of about 13 km, probably on the same plane of this thrust fault, since the strike as well as the dip angle of the earthquake are consistent with the fault geometry. We use strong motion records observed at 14 stations including 10 stations deployed by the Building Research Institute and the Association for Promoting of Building Research (Kitagawa et al., 1994), three K-Net stations, and one station deployed jointly by Shimizu Corporation and Tohoku University. The peak acceleration and velocity of the radial component at the closest rock station (the Oridate elementary school) with the epicentral distance of 4.6 km are 270 cm/s2 and 14 cm/s, respectively.

First we estimate the duration of source time function to be 0.63 s from the observed displacement waveform in the transverse component at a rock site station (the Tamagawa junior high school). Then we estimate other source parameters by the grid-search technique (Sato et al., 1998) to fit three-component synthetics at five stations with the observed using a path-specific flat-layered model for each station. We fix only the hypocenter to be the one determined by Science and Technology Agency (http://www.sta.go.jp/jishin) in the grid search. Finally we simulate the strong motions for the 1998 Miyagiken-Nanbu earthquake by the variable-grid 3-D FDM with the source model and the basin model determined as mentioned above. After the first trial we tune up our 3-D model for the part not well constraint by the exploration data to better fit the synthetics with the observed through several trials of the FDM calculations. As a result we succeed to simulate the observed displacement waveforms filtered from 0.2 to 1.67 Hz.