High-frequency envelope inversion analysis of the 2003 Tokachi-Oki earthquake (Mw 8.0)

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The 2003 Tokachi-Oki earthquake (M 8.0) took place on September 26, 2003 along a plate boundary between the subducting Pacific plate and the landward one in the northeastern Japan. The focal mechanism is a thrust type on a fault plane dipping to the northwest. Waveform inversion analyses for this earthquake were already done by a few groups. In this study, we execute an envelope inversion analysis based on the method by Nakahara et al. (1998) and clarify the spatial distribution of high-frequency (higher than 1Hz) seismic energy radiation on the fault plane of this earthquake.

We use three-component sum of mean squared velocity seismograms multiplied by a density of earth medium, which is called envelopes here, for the envelope inversion analysis. Three frequency bands of 1-2, 2-4, and 4-8 Hz are adopted. We use envelopes in the time window from the onset of S waves to the lapse time of 128 sec. Green functions of envelopes representing the energy propagation process through a scattering medium are calculated based on the radiative transfer theory, which are characterized by parameters of scattering attenuation and intrinsic absorption. We use the values obtained for Hiroo, eastern Hokkaido (Hoshiba, 1993).

We assume the fault plane as follows: strike=249deg., dip=15deg., rake=130deg., length=160km, width=180km with reference to a waveform inversion analysis in low-frequencies (Yagi, 2003). We divide this fault plane into 72 subfaults, each of which is a 20km x 20km square. Rupture velocity is assumed to be constant. Seismic energy is radiated from a point source as soon as the rupture front passes the center of each subfault. Time function of energy radiation is assumed as a box-car function. The amount of seismic energy from all the subfaults and site amplification factors for all the stations are estimated by the envelope inversion method. Rupture velocity and the duration time of a box-car function should be estimated by a grid search.

Theoretical envelopes calculated with best-fit parameters generally fit to observed ones. The rupture velocity and duration time were estimated as 3.4 km/s and 10 sec, respectively. The high-frequency seismic energy was found to be radiated mainly from three spots on the fault plane: the northeast shallowest part, 40km deep from the initial rupture point, southwest shallower part.

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