Source model composed of asperities for the 2003 Tokachi-oki, Japan, earthquake ($M_{JMA} = 8.0$) estimated by the empirical Green's function method

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A preliminary source model composed of asperities for the 2003 Tokachi-oki, Japan, earthquake ($M_{JMA} = 8.0$) was estimated by the empirical Green's function method. The source parameters for three asperities located on the fault plane were determined from the comparisons of the synthesized broad-band ground motions with the observed ones. We found that the pulsive waveforms observed in north direction of the hypocenter were generated by the forward rupture directivity effect. Furthermore, the estimates of the stress parameter for asperities are higher than the averaged ones for past inland and subduction earthquakes.

Key words: Source model, asperity, broad-band strong ground motion, forward modeling, empirical Green's function method.

1. Introduction

The September 26, 2003 Tokachi-oki, Japan, earthquake ($M_J M A = 8.0$) occurred on the plate interface between the North American plate and the subducting Pacific plate. In this earthquake, many strong ground motions from the mainshock as well as aftershocks have been recorded by the strong motion observation networks of the K-NET, KiK-net, and so on. The understanding of the source characteristics for explaining broad-band strong ground motion recordings is very important in verification of the recipe by Irikura *et al*. (2003) for strong ground motion prediction for future subduction earthquakes. This paper provides a preliminary source model for the 2003 Tokachi-oki earthquake estimated by the empirical Green's function method (Irikura, 1986). In our simulation, we determine a source model composed of asperities which is capable of reproducing broad-band strong ground motions using a forward modeling approach. We assume that ground motions are generated from several asperities, each of which has a uniform stress drop with a finite extent on the mainshock fault plane and obeys an ω^{-2} spectral scaling. Their locations are determined based on an inverted slip model. This procedure is the same as Kamae and Irikura (1998).

2. Strong Ground Motion Data

We used borehole data at eight stations obtained by KiK-net of the National Research Institute for Earth Science and Disaster Prevention. The locations of these stations are shown in Fig. 1 together with the epicenters of the mainshock and the aftershock used here as the empirical Green's function. Table 1 shows the information of the aftershock and its source parameters estimated roughly from the borehole data of KiK-net which is not affected strongly by the reflected wave from the surface. We used the aftershock data bandpass-filtered between 0.1 and 10 Hz.

3. Source Model and Synthetics

Several inverted source models have already been estimated from teleseismic data or/and strong ground motion data. In this study, we referred to the slip model by Yamanaka and Kikuchi (2003) to determine the locations of each asperity. Figure 2 shows the slip model by Yamanaka and Kikuchi (2003). This inverted source model has three separate regions with relatively large slip, hereafter referred to as asperities. The first asperity (Asp-1) is located near the rupture nucleation point (hypocenter); the second (Asp-2) in the deeper part of north-west direction of the hypocenter; and the third (Asp-3) in the deepest part of north direction of the hypocenter. Our objective is to determine a source model capable of explaining broad-band motions containing low- and high-frequency components. To accomplish this, we assumed a simplified source model composed of asperities located on three regions shown in Fig. 2. We assumed that the ground motions should be generated only from the three subevents that correspond to Asp-1, Asp-2, and Asp-3. We adjusted the locations, sizes, and stress parameters of those three subevents to fit the simulated motions to the observed ones using a forward modeling approach. We assumed an S-wave velocity of 3.8 km/s along the wave propagation path and a rupture velocity of 2.8 km/s on the fault plane. Furthermore, we assumed that the rupture should start from the inside subevent (Asp-1) near the hypocenter and propagated radially.

After several trials, we obtained the best source model shown in Fig. 2. The source parameters for each subevent are summarized in Table 2. Here, the size and stress param-