Source Process of the 2004 Mid Niigata Prefecture Earthquake Estimated from the Waveform Inversion of Strong Motion Records (2)

Kimiyuki Asano[1]; Tomotaka Iwata[1]

[1] DPRI, Kyoto Univ.

1. Introduction

The source modeling of the 2004 Mid Niigata Prefecture (Chuetsu) earthquake has been extensively studied using strong motion records (e.g., Asano and Iwata, 2005; Hikima and Koketsu, 2005; Honda et al., 2005). The strong motions densely observed around the source region give sufficient information to retrieve spatial and temporal rupture process of the event in detail. However, strong ground motions would be influenced by the complicated underground structure from the source to the site. Especially, in Chuetsu region the thick sediment layers are widely recognized and their thicknesses are spatially varied in and around the source region. Because of the lack of information for these thick sediment layers, it is difficult to calculate appropriately theoretical Green's functions. In this study, we improved the velocity structure models for 22 sites within 50 km from the hypocenter by the following method described in Section 2.

The precise relocation of the aftershocks using the urgent aftershock observations by several research groups (e.g., Kato et al., 2005; Okada et al., 2005; Shibutani et al., 2005) indicates that the source fault plane of the mainshock should be moved to approximately 4 km northeast from the hypocenter routinely determined by JMA. It is important to check how the kinematic source inversion result might be influenced by the difference in the location of the source fault plane. Also, we will evaluate the effect of the different combination on sets of station data for estimating the robustness on the obtained source model.

2. Modeling of velocity structure for each strong motion station

We tried to improve the velocity structure model to calculate the theoretical Green's functions for each strong motion station by the forward modeling of aftershock records. The reference velocity model is assumed from the refraction survey result (Ikami et al., 1986), S-wave velocity structure model recently constructed by Yamanaka et al. (2005), and PS logging information released from K-NET and KiK-net. The objecting function used here is the one using the cross-correlation function proposed by Ji et al. (2000), and the optimization of the thickness of each sediment layer is conducted using the GA technique. The theoretical waveforms are calculated by the discrete wavenumber integration method (Bouchon, 1981) with the reflection and transmission matrix (Kennett and Kerry, 1979). Finally, we obtained the velocity models for 22 stations which reproduce the waveforms of aftershocks fairly well.

3. Estimation of the source process by the waveform inversion method

The source process is estimated by the multiple time-window linear waveform inversion method (Sekiguchi et al., 2000). The fault plane of 28 km x 18 km is assumed based on the extent of aftershock distribution. The fault plane is divided into 126 subfaults, and the moment release from each subfault is expressed by a series of six smoothed ramp functions. The spatial and temporal smoothing is introduced following Sekiguchi et al. (2000), and the appropriate smoothing strength is evaluated by ABIC approach.

At first, we estimated the source model by the waveform inversion using all 22 stations. The maximum slip is observed in the vicinity of the hypocenter, and large slip area extends to the shallow part of the fault plane. The rupture process seems to be rather complicated. We assume this model to be the reference solution during the later analysis, and we will discuss about the robustness of the kinematic waveform inversion with strong motion data.

Acknowledgments: The strong motion data released by K-NET, KiK-net, JMA, and Niigata Prefecture Government are used in this study. We would like to thank Drs. Aitaro Kato, Tomomi Okada, and Takuo Shibutani for allowing us to use their relocated hypocenter information.