Best-fit Source Model for Simulating Strong Ground Motions from the 2007 Niigata-ken Chuetsu-oki earthquake

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Summary

We attempt to make the best-fit source models for simulating strong ground motions from the 2007 Niigata-ken Chuetsu-oki earthquake (Mw 6.6). We collected the source models obtained by the waveform inversion analysis and by the forward modeling using the strong motion data from the 2007 Chuetsu-oki earthquake. Observed records near source have three distinct pulses. Source processes common in most of the source inversion results show that those three pulses are related to three asperities. The locations and starting points of the three asperities are determined taking into account the arrival times from the asperities to the observation points using the ray theory and the 3-D velocity structure model. We conclude that very large ground motions at the Kashizaki-Kariwa Nuclear Power Plant (hereafter KKNPP) are explained as seismic focusing effects including amplification due to geometrical spreading factors and ray concentration from extended area sources in the heterogeneous three-dimensional-geological-structure.

Introduction

The 2007 Niigata-ken Chuetsu-oki earthquake occurred on July 16, 2007, northwest off Kashiwazaki in Niigata Prefecture, Japan, causing severe damage such as ten people dead and major lifelines suspended to near-source region. In particular, strong ground motions from the earthquake struck KKNPP. Ground acceleration of 680 gals on the base mat of Unit No.1 reactor was recorded in spite of rock site. The active faults caused to the earthquake have not been specified in evaluating input ground motions for the aseismic design. The PGA attenuation-distance relationships generally follow the empirical relations in Japan obtained by Si and Midorikawa (1999) except the KKNPP.

Simulation Results

The source mechanism of this earthquake is supposed to be a reverse fault with the SW-NE strike and SE dip from the aftershock distribution re-determined using the OBS seismometers (ERI, Univ. of Tokyo 2008). Results of the rupture processes inverted by using strong motion data show the source fault with the SW-NE strike and SE dip gives slip distribution to match well observed data. Source processes common in most of the inversion results show three asperities which generate three distinct pulses clearly seen in the observed records. However, locations of those three asperities are different each other in the source processes inverted by many authors, although almost the same data of strong ground motions were used in the analysis. The main reason why the inverted results are different is that velocity structures are too complex to assume equivalent flat-layers-structure model in calculating the Green's functions for the inversion analysis. Then, we try to find one of the best-fit source models for simulating strong ground motions at the sites of the KKNPP, take into account the 3-D velocity structure model from source to site. First, we evaluated the 3-D velocity model which was modified the JNES model (2008) using the results of the seismic reflection profiling recently done around the KKNPP. Second, we estimated one of the best-fit source models for simulating strong ground motions there using Green's functions numerically calculated for flat-layers structure models. The flat-layers structures are equivalently given at the sites from the 3-D velocity structure. We adopted the source model estimated by the empirical Green's function method as the initial source model. Third, we simulate strong ground motions combining the empirical Green's function method with the ray theory. That is, in the empirical Green's function method, the propagation times and geometrical spreading factors from the source to site are calculated using the ray theory. Then, we search the best-fit source model for simulating strong ground motions from the earthquake changing the rupture starting times at the asperities and rupture velocities inside the asperities and in the background area.