Source process of the 2001 Geiyo earthquake from the inversion of strong motion waveforms and its effect on strong ground motions

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Earthquakes occurring within subducting slabs (slab earthquakes) can give large damage to the cities located above. The source characteristics of slab earthquakes, however, have not been investigated in detail. This study investigates the source processes of the 2001 Geiyo earthquake (Mw = 6.8) by the waveform inversion of strong ground motion records. Relation between the source process and the strong ground motions is also examined.

1. Data and method

We use 19 NIED KiK-net stations with epicentral distances between 50 km and 100 km for the waveform inversion. We use the records of the Mw = 5.1 aftershock (Mar. 26, depth = 49.3 km) as the empirical Green's functions.

The mainshock and EGF acceleration waveforms are integrated into velocity waveforms and filtered between 0.1 and 1.0 Hz. The waveform data with total lenth of 16 s and starting time 1 s before S-wave arrival are used. The assumed fault plane is 30 km x 21 km, with strike 180 deg. and dip 60 deg. The number of meshes are 10 x 7. We put 8 time windows with 1.0 s durations and 0.5 s time lags for each mesh. The propagation velocity for the 1st time window is 3.6 km/s (= 0.8 Vs, Vs = 4.5 km/s). We give spatial and temporal smoothing constraint and non-negative constraint to stabilize the inversion.

2. Source process estimated from waveform inversion

We find two large distinct large-slip areas (asperities), one is located at the rupture starting point, and the other is located 16km southward and at the deepest part of the assumed fault plane. Another asperity is seen at the shalower part, though it is not so clear as the other two. In this way, the obtained slip distribution is very heterogeneous. Source heterogeneity is also suggested by the complex shapes of the source time functions at the meshes on the fault plane. The estimated total seismic moment is 1.9 x 10**19 N*m. The source duration is about 10 s.

3. Source process and strong ground motions

Globaly looking, rupture started at the northern edge and prpagated southward. The waveforms at the southern stations, which are located at the forward-directivity side of the source, have shorter duration generally. At the northern stations, which are located at the backward-directivity side, we can see complex and long-duration waveforms. This is the effect of backward directivity, namely, the waves coming from different parts on the fault plane arrive separately.

To see the effect of rupture directivity on strong ground motions, we perform experimental simulations assuming various locations of rupture starting point. In these simulations, the source model obtained in the inversion above is used except for the rupture times of the meshes. Considering the source process will be naturally different depending on the location of rupture starting point in actual situation, this is of course physically nonsense. This is not for the sutdy of source physics but just for the check of the effect of rupture propagation on the waveforms. Drastic difference is seen in the maximum amplitudes and waveform lookings depending on the locations of rupture starting point. This suggests the importance of trying plural scenarios of rupture propagation in the actual strong ground motion predictions for scenario earthquakes.

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