Source process of the 2008 Iwate-Miyagi Nairiku Earthquake considering the conjugate faults and its relation to strong motion

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INTRODUCTION
Since K-NET was constructed, multiple strong motion records are often observed in the source region of large crustal earthquakes. Those data have revealed not only detailed rupture process on a fault, but also complex fault system in itself. The 2008 Iwate-Miyagi Nairiku Earthquake is an example of such faults. Hikima and Koketsu (2013) revealed that fault displacements occurred on the complex source composed by conjugate faults, namely west-dipping faults and east-dipping fault. In this study, we revalidate the source model and discuss the strong ground motions caused by those complex faults.
OUTLINE of ANALYSES
We get the idea of the conjugate faults by referring the results of Abe et al. (2013), which were determined using InSAR deformation data. The total length of the west-dipping fault is 42 km, and the fault is composed in two planes. Abe et al.'s curved east-dipping fault is modified to one plane of 20 km length. We determined those planes by considering aftershock distribution those were relocated using DD method (Hikima et al., 2008).
The source process was inverted by the multi time window analysis (Yoshida et al., 1996, Hikima, 2012). The velocity waveforms obtained by K-NET and KiK-net, filtered between 0.03 and 0.5Hz, were used. The Green's functions were calculated using 1-D velocity models, which were estimated by the waveform inversion method (Hikima and Koketsu, 2005). We used the geodetic data by the GPS stations simultaneously.
RESULT and DISCUSSION
A large slip area (asperity) is recovered on the east-dipping fault as same as the result of Hikima and Koketsu (2013). To examine the reality of the conjugate faults, we performed inversion analysis assuming only the west-dipping fault, additionally.
/ Reproducibility of waveforms
The agreement between the synthetic and observed waveforms is better for the conjugate fault model, in general. The synthetic waveforms of IWTH25, which is located just above the conjugate faults, are significantly better than the west-dipping fault model.
/ Crustal deformation
At Kurikoma-2 of GPS station, which was used in inversion analyses, its large deformation is reproduced better by the conjugate faults. In addition, the acceleration waveforms were integrated to produce displacements, and those were compared to calculated waveforms. Although it can't deny the possibility that the displacements contain a few errors, the uplift at IWTH25, which is over 1.5 m, was reproduced by the conjugate faults sufficiently.
/ Aftershock distribution
Our fault models were determined as following the relocated aftershocks, so the fault planes are generally shallower than the other analyses. Moreover, the relocated aftershocks by Yoshida et al. (2014) are roughly consistent with the conjugate faults.
/ Stress drop on the faults
The maximum slip of the west-dipping fault is larger than that of the conjugate faults, and the average stress drop at the asperity is about 25 MPa. On the one hand, the stress drop of the conjugate faults is about 15 MPa, which is typical value for asperities of crustal earthquakes.

As shown above, the conjugate fault model is more consistent with a number of observed data. It is, therefore, highly likely that the east-dipping fault exists.

STRONG MOTION

Although it is an easy-to-use calculation, we computed equivalent fault distances (Ohno et al., 1993) for the conjugate faults and the west-dipping fault, respectively. Those distances are almost same at distant points from the fault area, and even in near fault area the differences are 1 to 2 km at the most. Therefore, it is thought that the difference of the expected strong motions from these two fault models is not so large. Of course, more quantitative analyses, e.g. strong motion simulation, are needed for detailed discussion. However, those are future studies.

Keywords: 2008 Iwate-Miyagi nairiku earthquake, Source process, Crustal earthquake, Near fault, Strong motion