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Estimation of the rupture process of the 2011 Fukushima-ken Hamadori earthquake using strong ground motion data

Miho Tanaka[1*], Kimiyuki Asano[1], Tomotaka Iwata[1]

[1]DPRI, Kyoto University

1. Introduction

On April 11, 2011 in southeast Fukushima prefecture, the 2011 Fukushima-ken Hamadori earthquake (Mw6.6) occurred and it is thought to be triggered by the 2011 off the Pacific coast of Tohoku earthquake. Tsutsumi and Toda (2012) surveyed this area and found two nearly parallel surface ruptures, the Itozawa and Yunodake faults. The hypocenter determined by JMA is located west of the Itozawa fault so it is thought the Yunodake fault ruptured after the Itozawa fault did. There are few cases that surface ruptures are appeared by a crustal normal-fault-type earthquake in Japan. In this study, the source rupture process was estimated by using strong motion data with two fault models (the Itozawa and Yunodake faults). In addition, we compared the obtained slip distributions with the surface displacement distributions by Tsutsumi and Toda (2012).

2. Data and Method

Three components of time series data from nineteen strong motion stations of the K-NET, KiK-net and JMA are used. These original acceleration data are integrated into velocity, band-pass filtered with 0.1~1.0Hz and resampled at 10Hz. The dataset in the source inversion comprises 35s of the time series from 1s before the S-wave arrival. The Green's functions are calculated with the discrete wave number method (Bouchon,1981) and the reflection and transmission coefficient matrix method (Kennett and Kerry,1979) assuming a one-dimensional velocity structure model for each station which is extracted from the Japan three-dimensional integrated velocity structure model (Koketsu et al.,2012).

Two planar fault models (the Itozawa and Yunodake faults) are assumed. Their strike and dip angles are 156 deg.,73 deg. and 130 deg.,62 deg., respectively, in reference to Fukushima et al.(2013), the size of models is 22km∗14km, 16km∗14km in accordance with the aftershock distributions in a day after the mainshock. The rupture starting point of the Itozawa fault is shifted about 1.8km from the hypocenter by JMA. That of the Yunodake fault is assumed at northern end, middle, or southern end at the depth of about 12.3km.

The inversion method is the multiple time window linear source inversion (Hartzell and Heaton,1983). The rake angle variations are limited within the dip angle plus and minus 45 deg. The temporal moment-release history at each subfault is expressed by six smoothed-ramp functions which have the duration of 1.0s and each function is separated by 0.5s. The rupture front propagation velocity is 2.04km/s, which is 60% of the S-wave velocity at the rupture starting point of the Itozawa fault. The time difference between the Itozawa's and Yunodake's rupture starting time has five variations, 4.5, 5.0, 5.5, 6.0, 6.5s.

3. Inversion Result

The difference between observed and synthetic waveform is the smallest when the rupture starting point of the Yunodake fault is located northern end of fault model and the delay time is 4.5s. The total seismic moment was estimated to be $1.0*10^{19}$Nm(Mw6.6). On the Itozawa fault the large slip is found in the north of the rupture starting point in the shallow portion. On the Yunodake fault it is found in the north area of the fault model and south in the slightly deep portion. The obtained maximum slip is 1.6m on the Itozawa fault and 2.2m on the Yunodake fault. The slip distributions in the shallow portion of both faults almost correspond to observed surface displacement distributions.

The observed and synthetic waveform fit well when the rupture front propagation velocity and the time difference between two faults is small. Then we will examine slip distributions with more wide range of parameters. Furthermore it is necessary to consider the depth of rupture starting point of the Yunodake fault.

4. Acknowledgments

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Keywords: the 2011 Fukushima-ken Hamadori earthquake, the Itozawa fault, the Yunodake fault, sorce process, strong motion data