Japan Geoscience Union Meeting 2010
(May 23-28 2010 at Makuhari, Chiba, Japan)

SSS016-P25 Room: Convention Hall Time: May 24 17:15-18:45

Fault geometry for the source inversion of the 2009 Suruga-bay earthquake

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We have examined the rupture process of an M6.5 intraslab earthquake that occurred within the subducting Philippine Sea plate on August 11, 2009, from waveform inversion analysis using strong-motion records obtained by NIED. One notable characteristic of this earthquake is a complex aftershock distribution. Hypocenter relocation using the double-difference method has revealed that the aftershock distribution indicates the south or southeast dipping plane in the southern source area including the mainshock hypocenter whereas it is dipping to the northeast or east directions in the northern area. The source mechanism determined from the P-wave polarity analysis is different from the moment tensor solution to some degrees. Moreover, the moment tensor solution contains 25% of non-double couple component. These observations suggest the complex fault geometry of the mainshock, which cannot be simply approximated by a single rectangular fault plane.
We have therefore constructed fault plane models that consist of the two rectangular fault planes dipping to the different directions in the northern and southern source areas. We have tested more than one hundred fault plane models, in which strike and dip angles of the two planes are varied in consideration of the source mechanisms determined by the P-wave polarity analysis and the moment tensor inversion as well as the aftershock distribution. Among the results derived using these different fault plane models, one consistent feature is that there is an area of large slip to the west of the mainshock hypocenter. Our preferred rupture model has been obtained using the fault plane model in which the southern plane follows the southeast dipping nodal plane of P-wave first motion solution (Segment I) and the northern plane follows the northeast dipping nodal plane of moment tensor solution (Segment II). This model has reproduced the synthetic waveforms for the stations located to the southwest of the source area better than the other rupture models. It seems that placing a segment with mechanism following moment tensor solution so as to include the large slip area (Segment II) is the key for reproduction of these waveforms. We will further estimate the rupture process using the curved fault model, which would approximate the aftershock distribution more flexibly. We will then examine the relationship between the fault geometry and the derived result to see to what degree the complex fault geometry indicated by the aftershock distribution should be considered in the source inversion analysis.

Keywords: 2009 Suruga-bay earthquake, Source process, Waveform inversion, Fault geometry