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Spatio-temporal afterslip distribution of the 2011 Tohoku-Oki earthquake considering viscoelastic response

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1. Introduction

The 2011 off the Pacific coast of Tohoku Earthquake with a moment magnitude (Mw) of 9.0 occurred at 5:46 (UTC) on March 11, 2011 along the boundary between the subducting Pacific Plate and the overlying plate. Since large earthquake are likely to produce stress concentrations in neighboring region along the plate boundary, the mainshock might have been trigger afterslip. It is very important to determine the detail of spatio-temporal distribution of afterslip, in order to understand the characteristic of friction relationship on the plate boundary. In this study, we estimate spatio-temporal afterslip distribution using visco-elastic Green's function (GF).

2. Method

We make GF using 3D finite element method (FEM) with a grid model for the Hokkaido and Tohoku regions. The model space and assumed subsurface structure for the 3D-FEM have a dimension of 2600 km (in the ESE direction) x 1500 km (in the NNE direction) x 400 km (depth) and typical subsurface structure consist of four sub-regions, i.e., upper crust, lower crust, upper mantle, and Pacific plate. The numbers of node and cell of 3D-FEM mesh are 3,205,950 and 3,121,200, respectively. For the calculation, we use the Pylith version 1.9.0, which is designed for simulating lithospheric deformation. In order to estimate the distribution of afterslip, we assume subfaults on the plate interface in and around the co-seismic slip zone of the 2011 Tohoku-Oki event. In inversion, we impose the smoothness constraint on the slip distribution. We estimate co-seismic and spatio-temporal distributions at the same time, considering visco-elastic response, derived from GEONET and seafloor observations.

3. Results and discussion

We obtain the co- and post-seismic slip distributions. The maximum slip of the 2011 event is about 60 m close to the Japan Trench. Estimated afterslip distribution is complementary to co-seismic slip distribution and also historical source regions. Amount of afterslip is about 2m, and the cumulative seismic moment is 8.06, considering visco-elastic response during 2.5 years after event. In case of only considering elastic response, amount of after slip is about 4m. There is no slip off Fukushima prefecture only considering visco-elastic response. And, our result can explain seabottom observations. i.e., Miyagi-Oki1 site move to west about 38 cm during 2 years after event. The effect of visco-elastic response is too large. In inversion for afterslip distribution from geodetic data, it must be consider to visco-elastic response due to relaxation in upper mantle.

Keywords: Afterslip, Visco-elastic response, FEM