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Rupture process analysis of the 2011 Tohoku-Oki earthquake using 2.5D finite-difference Green's functions

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The March 11, 2011 Tohoku-Oki earthquake (GCMT Mw9.1) generated strong shaking reaching the maximum intensity (seven) on the JMA's scale and caused devastating tsunamis with run-up heights exceeding 30 m. Such ultra-large-sized earthquake of magnitude 9 was not expected to occur along the plate interface off the northeastern Japan. Thus it is very important to infer the rupture process of this event for understanding the geophysical condition of the generation of magnitude-9-class earthquake and the mechanism of the excitation of the large tsunamis.

We present the rupture process analysis of the 2011 Tohoku-Oki earthquake by using a non-linear teleseismic body waveform inversion method [1]. We incorporate the effect of the near-source laterally heterogeneous structure (including the ocean layer and sediments) on the waveforms by using a 2.5-dimensional finite difference method [2]. This is because the structural effect can leads to improper solutions if the effect is not considered (e.g., a flat layered structure is used) in generating the synthetic waveforms [1]. We use thirty one P-waveforms (vertical component of displacement) within the epicentral distance range from 30 degree to 90 degree. We remove the instrumental response from the raw-data and apply a bandpass-filter with corner frequencies of 0.2 Hz and 0.004 Hz (5 s to 250 s). The final sampling rate is 2 s.

The preliminary analysis by using the finite-difference Green's functions results in a heterogeneous rupture process with large slips off Miyagi prefecture, near and around the JMA epicenter. The maximum slip is about 45 m, and the moment magnitude is about 4.1e22 Nm (Mw 9.0). The results (large slips near the epicenter) is similar to that obtained by a joint inversion [3]. We will further discuss the differences in the solutions for different Green's functions: we will compare the results obtained by using the finite-difference Green's functions and those by using Green's functions computed for flat-layered near source structure model.

[1] Okamoto and Takenaka, Earth Planets Space, 61, e17-e20, 2009.
[2] Takenaka and Okamoto, in Seismic Waves, Research and Analysis, ed. Kanao Masaki, 305-326, Intech, 2012. (http://www.intechopen.com/books/show/title/seismic-waves-research-and-analysis)
[3] Koketsu et al., Earth Planet. Sci. Lett., 310, 480-487, 2011.

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