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2011 Tohoku earthquake: Unified source model and its rupture process

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The devastating 2011 Tohoku earthquake was observed by dense networks of strong motion, teleseismic, geodetic, and tsunami. We performed checkerboard resolution tests for assessing the resolving power of the datasets obtained by the networks. From the results, we found that the individual datasets had only limited resolutions. In order to overcome these limitations, Koketsu *et al.* (2011) constructed the first version of the unified source model through a triple joint inversion of the teleseismic, strong motion, and geodetic datasets. Yokota *et al.* (2011) next performed a quadruple joint inversion of all the four datasets to determine the 1.5th version of the unified source model.

Although the above inversions were performed using one-dimensional Green's functions, we constructed the second version of this unified source model inferred taking three-dimensional (3-D) velocity structures into consideration. To achieve this, we calculated the 3-D Green's functions using the finite element method. We first inverted each of the datasets separately, and then performed a triple joint inversion of the strong motion, geodetic, and tsunami datasets for the second version of the unified source model. The teleseismic dataset was excluded, because the checkerboard tests had shown its low resolving power.

The total seismic moment in the second version was calculated to be 4.2 x 10^{22} Nm, which yielded M_W 9.0. This model revealed that the first rupture expanded at a slow speed of 2.0 km/s to the Japan Trench after small rupture in the initial 40 s. The second rupture began 20 s later at the slowest speed of 1.7 km/s and became dominant with the largest slip of 36 m. The third rupture then played the leading role, propagating southward at a speed of 2.5 km/s. The slow rupture speed and first rupture to the Japan Trench can explain the features of the disaster by the earthquake.

Keywords: 2011 Tohoku earthquake, unified source model, rupture process