A self-consistent fault-slip model for the 2011 Tohoku earthquake and tsunami

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Introduction

The supporting information includes figures of the nested-grid configurations for high-resolution runup and inundation modeling at Noda, Aneyoshi, Ryori, and Onagawa as well as additional analyses of the starting model, the final fault-slip model (TP-MOD), and the preferred joint seismic and geodetic inversion model of Yue and Lay [2013].

Movie S1 provides an animation of the tsunami generation and propagation computed from T-MOD.

Datasets S1 and S2 provide the subfault parameters of T-MOD and TP-MOD, respectively. The reference point is the northeast corner of each subfault. Each column in the dataset includes the following parameters:

- **No**: Subfault number.
- **Tinit (sec)**: Rupture initiation time.
- **Trise (sec)**: Rise time.
- **D0 (m)**: Slip (dislocation).
- **lonR (°E)**: Longitude at the reference point.
- **latR (°N)**: Latitude at the reference point.
- **dR (km)**: Depth at the reference point.
- **L (km)**: Subfault’s length.
- **W (km)**: Subfault’s width.
- **strike (°)**: Strike angle.
- **dip (°)**: Dip angle.
- **rake (°)**: Rake angle.
Figure S1. Nested grids for runup and inundation modeling along the Pacific Tohoku coasts. (a) The level-2 grid with outlines of level-3 grids. (b) The level-3 North Tohoku grid with outlines of level-4 grids. (c) The level-3 South Tohoku grid with outlines of level-4 grids. Red circle denotes the epicenter and white circles indicate water-level stations.
Figure S2. Nested grids for high-resolution runup and inundation modeling at Noda Village and Aneyoshi. (a) The level-4 Iwate grid with outlines of level-5 grids. (b) The level-5 Noda Village grid. (c) The level-5 Aneyoshi grid. The level-5 Taro grid is shown in Figure 1e.
Figure S3. Nested grids for high-resolution runup and inundation modeling at Ryori and Onagawa. (a) The level-4 Miyagi grid with outlines of level-5 grids. (b) The level-5 Ryori grid. (c) The level-5 Onagawa grid.
Figure S4. Comparison of recorded near-field tsunami waveforms and spectra (black lines) with results from the starting model (red lines). Spectra are not shown for records of less than 6 hr duration.
Figure S5. Comparison of recorded runup with results from the starting model. (a) East Japan coasts with the red circle denoting the epicenter and the light and dark grey lines indicating the rupture zone and the trench. Black dash lines divide the recorded and computed data into west and north sectors for projection of the runup shown at the left and top panels. (b) Sanriku coasts with high-resolution modeling at five severely impacted sites. Black dots and red lines denote the recorded and computed runup.
Figure S6. Comparison of observed (black traces) and computed (red traces) teleseismic P wave ground displacements (causally filtered with a Butterworth passband of 0.005–0.9 s) from the final model TP-MOD (Figure 9b). The azimuth ($\phi$) and epicentral distance ($\Delta$) of each station are indicated. The peak-to-peak ground motion (microns) of each observation is shown in blue.
Figure S7. Moment rate functions for the finite-fault rupture models shown in Figure 9. (a) The initial model P-MOD2. (b) The final model TP-MOD. The seismic moment $M_0$ and corresponding $M_w$ are shown in each case. The subfault source time function parameterization involves seven 4.0-s rise-time triangles offset by 4-s each for P-MOD and eleven 4.0-s rise-time triangles offset by 4-s each for TP-MOD.
Figure S8. Stress variations across the final model TP-MOD (Figure 9b). The stress change in each subfault is color-coded with the vectors indicating the strength and direction of the shear stress at the center. The red star indicates the position of the hypocenter. Depths include a 3 km deep water layer. The results of two calculations of static stress drop are indicated. $\Delta\sigma_{0.15}$ is computed by removing all subfaults for which the inverted subfault seismic moment is less than 15% of the peak subfault seismic moment (to suppress weakly resolved slip in low slip areas), then computing the average slip and total area of the remaining subfaults. A circular fault stress drop calculation is then performed using the average rigidity for the retained subfaults [Ye et al., 2016a]. $\Delta\sigma_E$ is obtained using the variable slip distribution directly with weighting of the stress changes by the subfault slip following the method of Noda et al. [2013]. The latter value is the preferred estimate.
Figure S9. Comparison of recorded near-field tsunami waveforms and spectra (black lines) with results from the final model TP-MOD (red lines). Spectra are not shown for records of less than 6 hr duration.
Figure S10. Comparison of recorded near-field tsunami waveforms and spectra (black lines) with results from the preferred fault model of Yue and Lay [2013] based on joint seismic-geodetic inversion (red lines). Spectra are not shown for records of less than 6 hr duration.
**Movie S1.** Generation and propagation of the tsunami from the preferred model T-MOD. Time is in minute and second after the earthquake origin time. Grey rectangle denotes the rupture area and dark grey line indicates the 200-m depth contour showing the approximate extent of the continental shelf.

**Dataset S1.** Subfault parameters of the preferred tsunami-constrained model, T-MOD.

**Dataset S2.** Subfault parameters of the final model, TP-MOD.