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Tsunami source models of the 2011 Tohoku, 1896 Sanriku and 869 Jogan earthquakes

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The spatial and temporal slip distribution of the 2011 Tohoku tsunami source was inverted from 53 tsunami waveforms recorded at ocean bottom pressure gauges, GPS wave gauges, and coastal wave and tide gauges (Satake et al., 2013, BSSA). The result shows that fault slip started near the hypocenter and very large (> 25 m) slip occurred on the deep plate interface near the hypocenter within ∼2.5 min, then huge (up to 69 m) slip occurred at the shallow part near the trench axis and propagated to the north. The final slip distribution shows that the slip increases toward the trench axis. The average slip on a 550 km long and 200 km wide fault is 9.5 m, and the total seismic moment is 4.2 × 1022 Nm (Mw = 9.0). The slip distribution can be decomposed into a shallow slip near the trench axis (Mw = 8.8) and a deeper slip on the plate interface (Mw= 8.8).

The shallow slip near the trench axis is similar to the proposed model of the 1896 Sanriku "tsunami earthquake". The tide gauge records and the coastal tsunami heights of the 1896 Sanriku earthquake can be explained by halving the slip on the northern subfaults along the trench axis (200 km x 50 km). While the average slip, ∼7 m, is similar to the previous estimates (Tanioka and Satake, 1996, GRL), the slip increases toward south. This indicates that both the 1896 and 2011 earthquakes had similar slip distribution along the trench axis. Considering that the plate convergence rate is ∼ 8 m per century, some of the 2011 slip may be due to inelastic process.

The very large slip off Miyagi on the deep plate interface was similar to the previously proposed model of the 869 Jogan earthquake (Sawai et al., 2012, GRL). The tsunami inundation is computed on the 869 topography from several combinations of 2011 subfaults, and compared with the distribution of the 869 tsunami deposit. In order to reproduce the tsunami deposit distribution, the fault size must be at least 200 km long, 100 km wide, and the magnitude Mw = 8.5. However, considering the fact that the 2011 tsunami inundation distance was on the average 1.4 times the distance to the most inland tsunami deposit, the above values are minimum estimates, and the 869 Jogan earthquake could be larger in fault size and seismic moment.