

The 2011 Tohoku-oki megathrust earthquake (Mw 9.0) and slip deficit of the past tsunami earthquakes in the region

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The 2011 Tohoku-oki megathrust earthquake of M_w 9.0 generated a devastating tsunami. Gusman et al. (2011) estimated the slip distribution of the earthquake, analyzing tsunami waveforms, GPS data, and ocean bottom deformation, and they indicated that the largest slip was located shallower part of the fault near the trench. That place is the same source areas of tsunamis by significant earthquakes of 869, 1611, 1793 and 1896 (Hatori,1975). This means a slip deficit existed in the region of the 2011 because there was little strain accumulation there if the region released the strain perfectly every time. We aware some of these earthquakes were tsunami earthquakes and there must have been the slip deficit. Seismic moment of an earthquake with some slip deficit is smaller than that of an earthquake without deficit, when the areal sizes of two earthquakes the same. Now the comparison is made to check the above hypothesis that the seismic moment of tsunami earthquakes is smaller than that of ordinary inter-plate earthquakes with a same size of rupture areas.

This is done by studying the scaling relation between seismic moment and rupture area of tsunami and ordinary earthquakes. Standard scaling law for ordinary earthquakes is adopted from Koyama (1977); $\log M_o = 1.5 \log S + 15.12$, where M_o is seismic moment [Nm] and S is rupture area [km²]. Compared to the relation, we obtained smaller seismic moment for some tsunami earthquakes such as 1992 Nicaragua, 2006 Java, and 2010 Sumatra. Some other tsunami earthquakes such as 1994 Java, 1996 Peru, and 1998 Papua New Guinea are almost the same as the relation. The former are those characterised by low rupture velocity, and the latter are by land-slides or slump of ocean bottoms and may be by a smooth faulting with weak fault heterogeneities.

The 1896 tsunami earthquake occurred in the region of horst and graben structure similar to the 1992 Nicaragua earthquake. This indicates tsunami earthquakes off the Pacific coast of Tohoku are also characterized by low rupture velocity, and there must have been slip deficits.

We conclude that before the 2011 earthquake, the trench side of the rupture zone had a large amount of slip deficit due to repeated ruptures by tsunami earthquakes. Since the 2011 megathrust occurred in Along-dip Double Segmentation, the trench-ward seismic segment has had the potential to generate large moment release due to the slip deficit and the large slip in the trench-ward segment had accompanied with the rupture in the land-ward segment.

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