Finite fault model of the 2012 intraslab earthquake doublet and its implication for coseismic stress change in the Pacific plate associated with the 2011 Tohoku-Oki earthquake

*Tatsuya Kubota[1], Ryota Hino[1], Yusaku Ohta[1], Daisuke Inazu[2], Syuichi Suzuki[1]

1. Graduate School of Science, Tohoku University, 2. Tokyo University of Marine Science and Technology

On December 7, 2012, an intraslab earthquake doublet, composed of a thrust deep earthquake (subevent 1, 57.8 km, Mw 7.2, Global CMT) and a normal shallow earthquake (subevent 2, 19.5 km, Mw 7.2) with time interval of 12 s, occurred near the Japan Trench, where the extremely large coseismic slip happened during the 2011 Tohoku-Oki earthquake (Mw 9.0). In the subducting Pacific slab in the area, the horizontal tensional and compressional stress fields associated with the slab bending had been developed in the shallow part and the deep part, respectively, prior to the 2011 earthquake (e.g., Gamage et al., 2009, JGR). Obana et al. (2012, GRL) found that the depth of the lower limit of the shallow normal faulting earthquake activity was deepened after the 2011 Tohoku-Oki earthquake, and suggested the stress state in the subducting slab changed.
Since it is expected that the vertical extents of the faults of the two subevents correspond to those of the tensional and compressional stress field in the subducting slab after the Tohoku-Oki earthquake, the vertical stress variation can be discussed by estimating fault models of the subevents in detail. But it is not easy to separate the source processes of the two subevents because two subevents occurred almost simultaneously. However, since the shallow subevent 2 is expected to excite tsunami much more efficiently than the deep subevent 1, it is expected that tsunami data will put strong constraint on the fault model of the subevent 2, which is especially difficult to constrain the source process from the seismic data. In this study, we analyzed the tsunami data associated with the 2012 doublet observed by the ocean bottom pressure gauges deployed around the focal area. Based on the results of tsunami data analyses, we discussed the depth variation of the stress field in the subducting slab after the Tohoku-Oki earthquake.
We first inverted the tsunami waveforms for the spatial distribution of seafloor vertical deformation (the tsunami source model). The obtained distribution has a zone of large subsidence and another with smaller uplift. The location and spatial extent of the subsided area are consistent with those of the seafloor displacement field expected from the Global CMT solution of the subevent 2. We estimated the fault model of the subevent 2 based on the spatial pattern of the seafloor subsidence and the aftershock distribution (Obana et al., 2014, EPS; 2015, AGU FM). The seafloor displacement field due to the subevent 1 was obtained by subtracting the seafloor deformation field, which is calculated from the fault model of the subevent 2, from the tsunami source model and we sought the optimum fault model of subevent 1 explaining the vertical displacement field. We reanalyzed teleseismic data to obtain CMT solution of the subevent giving additional constraint on the fault model. Based on the estimated fault model, the bottom of the shallow normal-faulting subevent 2 and the top of the deep thrust-faulting subevent 1 were located at 35 –40 km and 45 –50 km, respectively. These depths are obviously deeper than the lower limit of the normal-faulting earthquakes (~25 km) and the upper limit of the thrust-faulting earthquakes (40 –45 km) before the Tohoku-Oki earthquake by ~ 5 –10 km. The depth changes are probably caused by the static stress change associated with the Tohoku-Oki earthquake. However, considering the vertical stress gradient of the bending stress (~15 MPa/km) expected from the geometry and elastic property the Pacific plate, the static stress change associated with the Tohoku-Oki earthquake (~10 MPa) cannot change the depth profile of the intraslab field as large as seen in the change in

seismogenic depth we observed. This suggests that the depth change is caused not only by the static stress change of the Tohoku-Oki earthquake but also the increase of the normal-faulting seismicity at ~ 35–40 km depth associated with the decrease of the fault strength after the Tohoku-Oki earthquake.

Keywords: tsunami, The 2011 Tohoku-Oki earthquake, intraslab earthquake

