Spatial characteristics of postseismic deformation following the 2011 Tohoku-oki earthquake inferred from repeated GPS/Acoustic observations

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On- and off-shore geodetic observation studies have revealed the postseismic deformation process of the 2011 Tohoku-oki earthquake (e.g., Ozawa et al., 2012, JGR; Watanabe et al., 2014, GRL). Using these observation data, Sun et al. (2014, Nature) and Sun and Wang (2015, JGR) modeled viscoelastic relaxation (VE) causing significant landward movement in the main coseismic ruptured area (MCRA) of the Tohoku-oki earthquake and afterslip causing trenchward movement in north and south of the MCRA. However, a broad spatial pattern of the postseismic deformation near the Japan trench has not been revealed because of shortage of the off-shore geodetic observation sites. Therefore, we have newly deployed twenty GPS/acoustic (GPS/A) observation sites near the Japan trench from Aomori-oki to Ibaraki-oki to spatially constrain the postseismic deformation pattern (Kido et al., 2015, IAGS).
We have conducted repeated GPS/A surveys at the new sites from September 2012 to November 2015; almost five times of surveys have been conducted at each site. Adopting the method of Kido et al. (2006, EPS), we estimated a horizontal seafloor transponders array positon for each survey. Moreover, a postseismic displacement rate at each site was calculated by M-estimation robust linear regression method. The estimation error of the rates is averagely ~3 cm/yr. Although we have reported the displacement rates in the new sites (e.g., Tomita et al., 2015, AGU), more reliable results are shown in this presentation using the latest survey data in November 2015.
The calculated displacement rates clearly show spatial variation of the postseismic deformation along the trench. In the south region of the MCRA (36-37°N), all of observation sites show high trenchward displacement rates (5-15 cm/yr), which is interpreted as the effect of afterslip. Moreover, we also found out that highest trenchward movement have been occurred in Fukushima-oki near the trench. In the MCRA, most of the observation sites show high landward displacement rates (~10 cm/yr), which are interpreted as the effect of VE. This landward movement is extended to 39.5°N. Meanwhile, some of the nearest observation sites to the trench which are located in the highest coseismic slip area show lower landward displacement rates (-7 cm/yr). In north of 39.5°N, the observation sites show low landward displacement rates (-5 cm/yr).
Although the spatial variation in the displacement rates can be roughly explained by the existing postseismic deformation models (Sun et al., 2014; Sun and Wang, 2015), there are two significant local misfits between the observation and the model. The first misfit can be seen in the northern MCRA (39-39.5°N) near the trench. In this region, the observed landward movements are significantly higher than the VE model. We expect that additional coseismic slip in this region to correct the VE model well reproduce further landward movement. The second misfit can be seen in the nearest MCRA region to the trench where the highest coseismic slip was occurred. Although the VE model predicts high landward displacement rates our results show clearly low landward displacement rates. This misfit requires aseismic fault slip and/or a new VE model which can produce moderate deformation in this region.
Thus, our GPS/A observation results revealed overall spatial characteristics of the postseismic deformation of the Tohoku-oki earthquake and suggest re-examination of the VE model. We expect that our results contribute to constructing a more reliable postseismic deformation model.

Keywords: postseimic deformation, the 2011 Tohoku-oki earthquake , GPS/Acoustic technique, seafloor geodetic observation

