Temporal change of stress field in forearc region after the 2011 Tohoku-Oki earthquake

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The 2011 Tohoku-Oki earthquake changed the stress field around its source region. Significant coseismic rotation of the principal stress axes was observed and it was suggested that almost all the accumulated shear stress was released on the ruptured plate boundary (Hardebeck, 2012; Hasegawa et al. 2011). Hardebeck (2012) showed that the directions of the principal stress axes returned to those before the Tohoku-Oki earthquake in 0.1 years after the earthquake. She argued that slight strain re-accumulation within short time period can account for the rapid restoration of the stress orientation after the complete stress release.

In this study, we inverted focal mechanism solutions of earthquakes in the Tohoku forearc for temporal changes of the stress field after the Tohoku-Oki earthquake. We analyzed GCMT solutions selected by almost identical criteria used by Hardebeck (2012), but added the solutions from 2012 –2016. When we inverted all the earthquakes at once, the postseismic restration of the stress axes, similar to that reported by Hardebeck (2012), was identified.

Next, we divided the forearc region into two sub-regions to take into account possible spatial heterogeneities of the stress state and performed the stress tensor inversion. In the analysis, one sub-region was set inside the large co-2011 earthquake slip distribution (Yagi and Fukahata, 2011) and another was set outside of it. In the sub-region of the large coseismic slip, normal-faulting aftershocks were extremely active, whereas reverse-faulting earthquakes were dominant in the surrounding sub-region. The difference in dominant focal mechanisms suggests significant difference in stress state between the two sub-regions. The stress axes obtained by the inversion in the large coseismic slip sub-region rotated greatly at the occurrence of the Tohoku-Oki earthquake, and they changed towards the directions before 2011 gradually. However, the amount of postseismic rotation was not as large as that reported by Hardebeck (2012) and the stress regime has never been resumed to the pre-2011 state. On the other hand, in the surrounding sub-region, the coseismic rotation of the stress axes was smaller than that in the large coseismic slip sub-region, and the temporal change after the earthquake was also very small. As a result of the present reanalysis considering spatial variation of the stress field, we suggest that the result given by Hardebeck (2012) may contain apparent temporal stress changes due to spatio-temporal variations of the seismicity in the area, which she did not take into account.

