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Stress change due to the great 2011 Tohoku earthquake (Mw 9.0) and induced earthquake activity in the inland areas of

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The 2011 Tohoku earthquake (Mw 9.0) triggered very high seismicity not only in the source region but also in the inland of eastern Japan (e.g. Hirose et al., 2011). Hasegawa et al. (2011, SSJ) and Yoshida et al. (2011, SSJ) estimated the stress field using these focal mechanisms, and suggested that the 2011 Tohoku earthquake changed the stress-field in the wide range from the source region to the inland area. This means that the stress magnitude (the important but unknown parameter) in Japan has been very small. In this study, to know the general value of the stress-magnitude in Japan, we examined in detail the boundary line between the two regions where the stress-fields have changed and unchanged due to the 2011 Tohoku earthquake. Thus, we analyzed the earthquakes near the Iwaki city and the northern part of the Ibaraki prefecture where the change in the stress-direction is reported by Yoshida et al. (2011).

We used the focal mechanism data estimated by 1) Asano et al. (2011) based on centroid moment tensor inversions of F-net and Hi-net data of NIED, 2) NIED applying moment tensor inversions to F-net data of with variance reductions better than 70% and 3) JMA based on P-wave polarity. Because there are few mechanism solutions at the shallow ($<$ 30 km in depth) portion in Iwaki and the northern part of the Ibaraki prefecture, 4) we presently picked the P-wave polarities for the earthquakes with the magnitude $>$ 1.0 and estimated the focal mechanisms of them. We only used the focal mechanisms which occurred in the hanging-wall. The classifying method is similar to Asano et al. (2011).

We performed the damped stress tensor inversion (Hardebeck and Michael, 2006). The region is gridded with 0.25 degree spacing, and each focal mechanism is assigned to the nearest grid node. These focal mechanisms are also divided with depth in two by the different way in the inland and offshore. In the inland part, the focal mechanisms in the shallower part have the depth 0 - 12.5 km, and the focal mechanisms in the deeper part have the depth 12.5 - 30km. This threshold is determined by considering the earthquake distribution. In the offshore part, we divided the focal mechanisms using the distance from the plate-boundary. The focal mechanisms in the deeper part occurred with the distance 0 - 25 km from the plate-boundary, and those in the shallower part with the distance 25 km- 50 km.

We compared the stress results in the region where stress-tensor is estimated both before and after the earthquake. In the shallower part of the inland, normal-faulting stress regime were estimated both before and after the earthquake. The directions of the maximum extension are NNW-SSE before the mainshock but E-W after the earthquake (E-W extension consists with the static stress change by the dislocation model). However, the confidence regions are overlapped. In the deeper part of the inland, different stress-regime are estimated. Before the earthquake, the reverse-faulting regime with the E-W maximum compression is estimated. But, after the earthquake the normal-faulting regime with the E-W minimum compression is estimated.

In the shallower part of the offshore, stress-fields are estimated near the coast both before and after the earthquake. Stress-field there changed from the E-W compressive strike-slip faulting regime to E-W extensional normal-faulting. In the deeper part of the offshore, stress-fields are estimated in wide range both before and after the earthquake. Generally, before the earthquake, E-W compressive reverse-faulting and strike-slip faulting regimes are estimated. But after the earthquake, E-W extensional normal faulting regimes are estimated.

These directions after the earthquake are consistent with the directions of the static stress-change by the 2011 Tohoku earthquake. The regions where the stress field changed before and after the earthquake are found in the area where the differential stress change is larger than about 1 MPa.

Keywords: 2011 Tohoku earthquake, focal mechanisms, stress tensor inversion, static stress change, stress magnitude