Spatial and temporal variations of seismic moment release before and after the 2011 Tohoku-Oki earthquake

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Seismicity is often changed significantly before and after a large earthquake, probably due to the change of stress distribution in and around its fault area. We examined seismic moment release for coseismic and adjacent areas before and after the 2011 Tohoku-Oki earthquake. We adopted not the number of events but the amount of seismic moments because we like to focus on large events that represents the stress states in the studied area. With the JMA catalog of event locations and magnitudes (m) from 1967 to 2016, we converted the seismic moment (M_0) in Nm by $\log M_0 = 1.5m + 9.1$. The area is divided into the segments based on the pre-2011 version of the evaluation of its major subduction earthquakes by the headquarters for earthquake research promotion. The area off the trench axis of the Pacific plate where outer-rise earthquakes occur is included. We further divided each segment into three depth levels based on its depth of the plate boundary: the shallow zone (i.e., in-land intra-plate events), the plate boundary zone defined by the depth range between 10 km and 20 km in shallow and deep sides, respectively, and the deep zone (slab intra-plate events).

The most outstanding contrast in terms of temporal change before and after the 2011 mega-event (hereafter called the main shock) is a decline of moment release in the off Miyagi segment versus a significant increase in the off Fukushima segment. In the former segment, there were many earthquakes even before the main shock, compared with other adjacent ones. Although there were intensive aftershock activities, the amount of moment release was not significantly amplified. In contrast, there were a few events in the off Fukushima segment prior to the main shock, particularly with the small amount of moment release, that is, only small events had occurred. After the main shock, not only the number but also the mount release rate was clearly increased, getting comparable to the active off Miyagi segment. The amount of slips in this segment was not large for the main shock. We may conclude that there were no stress or strain accumulated before the main shock and the coseismic slip in this segment might not have been spontaneous but rather associated with large slips in the off Miyagi segment, resulting in newly built-up stress that started inducing active seismicity there. A similar increased seismicity was found in the Kodiak segment after the 1964 Alaska earthquake (Doser et al., 2006).

In all the outer-rise areas, there were a few events before the main shock while seismic activities or moment releases were clearly enhanced after it, particularly in the off Miyagi and off Fukushima segments. This change seems to have been caused by the large coseismic slips on its adjacent plate boundary although the original stress was small.

Keywords: seismic moment release, the 2011 Tohoku-Oki earthquake, spatial and temporal variations of seismicity

