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Seismic activity in eastern Japan and the source region after the 2011 off the Pacific coast of Tohoku earthquake

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Changes of seismic activity in eastern Japan and the source region were shortly reported after the 2011 off the Pacific coast of Tohoku earthquake (Toda et al., 2011; Kato and Igarashi, 2012). To clarify subsequent changes, we investigated seismic activity in the wide region for two and a half years since the 2011 Tohoku earthquake.

We examined a region in a range of 33.4-42N and 136-145E. The region was divided into small squares with a size of 0.2 degree, and in each square, we computed seismicity rates. First, as the background seismicity, we computed the average number of earthquakes per a year, based on seismic activity for nine years before the 2011 earthquake. Then, to obtain seismicity rates after the 2011 earthquake, we counted the number of earthquake during two periods, respectively, and computed the ratios against the background seismicity. The two periods are 0-1 and 1.5-2.5 years after the 2011 earthquake. We used hypocenters determined by JMA. In regions where large inland earthquakes occurred before 2011, the background seismicity was computed from a period excluding aftershocks. Finally, by plotting the resultant seismicity rates in maps, we searched regions where seismic activity significantly changed. By the same method, we also examined seismicity rates of interplate earthquakes in the source region of the 2011 Tohoku earthquake, based on data selected from the F-net CMT catalog.

Our results show that when two and a half years passed since the 2011 earthquake, seismicity of interplate earthquakes had been lower than the background, throughout the source region of the 2011 Tohoku earthquake except for a region off Iwata. High seismic activities for a year since the 2011 earthquake were found in Iwaki, the middle and northern parts of Akita, the southern part of the Kanto region, and also in regions near active volcanos (Bandai, Nikko-Shirane, Kusatsu-Shirane, Naeba, and Fuji mountains). When two and a half years passed, seismicity in many regions of eastern Japan had been lower than the background, including the activities near Bandai, Naeba, and Fuji mountains. However, activities in Iwaki, the middle and northern parts of Akita, the southern part of the Kanto region, and near Nikko-Shirane and Kusatsu-Shirane mountains continued to be high.

Furthermore, we carefully examined seismic activity in the regions where we detected significant changes of seismic activity. In many regions of eastern Japan, we found that locations of earthquakes and focal mechanisms were changed before and after the 2011 Tohoku earthquake.

Using JMA hypocenters, we also attempted to apply the modified Omori's law for seismic activity after the 2011 earthquake in the regions with significant changes of seismic activity. The modified Omori's law could roughly model the changes of seismic activity in many regions, even when a region is inland, away from the source region. The Omori's regression parameter, p, was estimated in a range from 0.2 to 1.1. The values ranged between 0.2 and 1.1 in the regions where seismic activity has been high for 2.5 years, whereas they were between 0.8 and 1.1 where high seismic activity for the first 1 year decreased in 2.5 years since the 2011 earthquake. In the southern part of the Kanto region, the value of p (0.2) was extremely low, compared to the other regions, which implies that the seismic activity decays very slowly. In the regions near active volcanos, the values of p tended to be high. In the source region of the 2011 Tohoku earthquake, we estimated the values of p in three regions; a whole source region, an afterslip region, and a region excluding the afterslip region. The values ranged from 1.0 to 1.1, and there was no significant difference in the three regions.