Breakdown of the Gutenberg-Richter law after the 2011 Tohoku earthquake

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Before and after the occurrence of the 2011 Tohoku earthquake, both onshore and offshore seismic observation data are available in the Japan Trench subduction zone. However, most of previous studies of local seismicity using ocean bottom seismometer data have often focused only on manual relocation of hypocenters listed in the existing earthquake catalogs. Therefore, the location and frequency of offshore earthquakes with small magnitudes have yet to be elucidated especially after the Tohoku earthquake. Such less complete earthquake catalogs need to be improved to discuss frequency-magnitude distributions (FMDs) and the b-value of the Gutenberg-Richter law (G-R law) which is considered to be related to the differential stress.

We applied an automated method for detection and location of earthquakes along the plate interface to onshore and offshore seismic data for both pre- and post-Tohoku periods. The method is composed of the amplitude-based trigger algorithm and the waveform coherence analysis. Under the assumption that the observed FMD is characterized by the G-R law and the magnitude-dependent detection rate, the statistical analysis shows that the breakdown of the G-R law occurs in some areas for the post-Tohoku period. The deviation from the G-R law is confirmed in the magnitude range greater than ~4, where the observed cumulative number of earthquakes shapes a convex curve. In the area that experienced high frequency radiation at the coseismic slip of the 2011 Tohoku earthquake, a substantial decrease in the b-value is observed from before to after the Tohoku earthquake. Such change in the fraction of earthquakes with a magnitude of ~2 might be occurred due to changes in the stress field and/or frictional properties along the plate interface. The areas adjacent to the northern and southern limits of the coseismic slip zone show low b-value for the post-Tohoku period or decrease in the b-value from before to after the Tohoku earthquake. Such feature can be explained by increase of differential stress originated from the main shock in its surrounding area.

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Keywords: Gutenberg-Richter law, b-value, the 2011 Tohoku earthquake, ocean bottom seismometer data

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