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# Regional distribution of seafloor displacement detected by bathymetric surveys after the 2011 Tohoku-oki earthquake

FUJIWARA, Toshiya[1*] ; KODAIRA, Shuichi[1] ; DOS SANTOS FERREIRA, Christian[2] ; FUJIE, Gou[1] ; KAIHO, Yuka[1] ; KANEDA, Yoshiyuki[3] ; KASAYA, Takafumi[1] ; NAKAMURA, Yasuyuki[1] ; NO, Tetsuo[1] ; SATO, Takeshi[1] ; STRASSER, Michael[4] ; TAKAHASHI, Narumi[1] ; TAKAHASHI, Tsutomu[1] ; WEFER, Gerold[2]

[1]Research and Development Center for Earthquake and Tsunami, JAMSTEC, [2]MARUM, Center for Marine Environmental Sciences, University of Bremen, [3]Disaster Mitigation Research Center, Nagoya University, [4]Geological Institute, ETH Zurich

After the 11 March 2011 Tohoku-oki earthquake ($M_W$ 9.0), we have carried out multibeam bathymetric surveys in the rupture zone. Some survey tracks were aligned along the tracks obtained before the earthquake across the Japan Trench, and we analyzed the difference in bathymetry before and after the earthquake in the area near the trench. For the analysis, apparent offsets of the absolute values of depth soundings and the uncertainty of ship position were examined on the seaward side because the seaward was thought to have suffered little change from the earthquake. Although the results may incorporate errors of several meters in vertical displacement and about 20 m in horizontal displacement [e.g. Fujiwara et al., MGR 2014], the extraordinary coseismic seafloor displacement caused by the 2011 earthquake was detected by the bathymetric surveys. For the survey track crossing the trench axis at 38$^o$05'N, off the coast of Miyagi Tohoku, near the epicenter, there were large relative differences landward extended up to the trench axis, suggesting the earthquake fault rupture reached the trench axis [Fujiwara et al., Science 2011; JpGU 2012]. The seafloor after the earthquake is shallower throughout the landward side. Notably, on the outermost landward slope, the 40-km-wide area between the slope break and the trench axis, the difference shows the seafloor is shallower than 10 m on average. This uplift was likely an important factor contributing to the generation of the huge tsunami. The observed seafloor elevation change on the outermost landward slope corresponds to a sum of vertical displacement and additional uplift for the sloping seafloor due to horizontal coseismic displacement. We estimated the horizontal displacement by calculating the offset distance to maximize the cross-correlation of bathymetry. The estimated displacement is approximately 50 m in the east-southeast toward the trench. Furthermore, locally upward and downward changes in seafloor elevation of $\pm$50 m are evident at the axial seafloor of the survey track. This morphological structure is interpreted as compressional (thrust-up structure) with reverse faults branching from an interface in the subducting sedimentary layer, which is interpreted as the coseismic master fault. The structure where subsidence was observed is interpreted to have formed by slumping, which may have caused gravitational instability [Kodaira et al., Nature Geosci. 2012; Strasser et al., Geology 2013]. The size of this deformed morphological structure is 3 km across the trench and 13 km along the trench within a confined area. For the track crossing the trench axis at 38$^o$35'N, about 50 km north of the 38$^o$05'N track, bathymetric data comparison shows the same trend and there are relative differences landward extended up to the trench axis. However, change in seafloor elevation along this track is of smaller magnitude than that along the 38$^o$05'N track and shows direct evidence indicating smaller coseismic displacement along this track. The horizontal seafloor displacement seems to be difficult to resolve accurately due to the estimation errors. For the track crossing the trench axis at 37$^o$25'N, off the coast of Fukushima, about 70 km south of the 38$^o$05'N track, change in seafloor elevation along this track is even smaller than that along the 38$^o$35'N track. Also, we didn't observe significant deformed structures at the axial seafloor outside of the extra-large displacement area at 38$^o$05'N.

Keywords: 2011 Tohoku-oki earthquake, tsunami, Japan Trench, multibeam bathymetry, seafloor displacement