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Oscillations starting immediately after the 2011 Tohoku earthquake in Japan Sea

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The tsunamis from the March 11, 2011 Tohoku earthquake were recorded in the Japan Sea. At some tide gauge stations along the Japan Sea coast of Honshu and the Russian coast, sea surface disturbances were observed immediately after the earthquake, followed by tsunami propagated through the Tsugaru Strait between Honshu and Hokkaido. Using tsunami numerical computations from seafloor displacements including the effect of the horizontal displacement and seafloor slope, the oscillations starting immediately after the origin time were reproduced. We interpret that these tsunami forerunners were generated from horizontal motion of seafloor slopes in the Japan Sea.

The tsunami forerunners were particularly remarkable at Awashima (JCG), Sado, Noto Toyama and Fukaura (JMA) tide gauge stations along the Japan Sea coast of Honshu and at Rudnaya Pristan, Preobrazhenie, and Nakhodka stations along the Russian coast of Primorye (Shevchenko et al., 2013: Pageoph). The 2011 tsunami originated in the Pacific Ocean would pass the Tsugaru Strait 1.5 hours after the earthquake. It indicates that these forerunners were different from the tsunami originated in the Pacific Ocean.

We made the tsunami numerical computation to reproduce these forerunners from seafloor displacements in the Pacific Ocean and Japan Sea. We used the source model of Satake et al. (2013, BSSA). According to Tanioka and Satake (1996, GRL), if the ocean bottom contains steep slopes or steps, the effect of the horizontal displacement of ocean bottom cannot be neglected. Computation including this effect showed the oscillations starting immediately after the origin time. However, the short-period components about a few minutes are not well reproduced. Use of finer bathymetry grid than we used (30' and 5') may better reproduce the short-period components of the Japanese tide gauge stations. Seismograms at nearby stations suggest that some of the short-period components may be the seismic ground motion. When we applied low-pass filter to the observed waveforms, the agreement between the observed and synthetic waveforms on tide gauges became better.

Because the Russian stations are about 500 km away from the source area, we also computed the synthetic tsunami waveforms from seafloor displacements computed on the spherical Earth model (Sun et al., 2009: Geophys. J. Int.). However, the computed waveforms from the spherical models are not very different from those computed on Cartesian coordinate system. It is necessary to compute the tsunami waveforms using the finer grid including the shape of the bay.

Keywords: the 2011 Tohoku earthquake, the 2011 Tohoku tsunami, Japan Sea, seafloor displacement