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東北地方太平洋沖地震で励起された沿岸近傍の地盤変動による初期水位変動
Small-amplitude water oscillation near the coast generated by local crustal deformation of the 2011 Tohoku earthquake

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Small-amplitude water oscillation is observed at several tsunami stations along the Pacific coast of the Tohoku region just after the origin time of the 2011 Tohoku earthquake and before arrivals of main tsunami waves. To investigate the cause of the small-amplitude water oscillation, we focus on the tsunami wave data recorded at the huge tsunami meters deployed by the Japan Meteorological Agency (JMA). We selected the data sets observed at the 3 stations (Miyako, Ofunato and Ayukawa) where the amplitude of the water oscillation is relatively high and waveforms are reasonably clear. The maximum amplitude of the water oscillation observed at the selected stations is about 50 cm, and the dominant period ranges from 60 s to 300 s.

Synthetic tsunami waveforms were calculated for the above-mentioned 3 stations using a tsunami simulation code in order to compare the observed waveforms of the water oscillation with the calculated ones. Firstly, uniformly distributed crustal displacement was assigned to all the mesh cells in the 50 m mesh-sized areas. The given crustal displacement changes in the time domain for 30 s based on the horizontal displacement of the GEONET data by Geospatial Information Authority of Japan (GSI) with the sampling rate of 1 s. The displacement data are obtained from the nearest GEONET station to each tsunami station (Miyako, Ofunato and Ayukawa). Second, tsunami simulation was carried out based on the non-linear shallow water theory using the created crustal deformation data and tsunami waveforms were calculated at the selected tsunami stations. Finally, a band-pass filter was applied to the calculated tsunami waveforms and the observed ones to alleviate the contamination of short-period noise and the long-period trend related to the main tsunami waves. Cross-correlation coefficients between the calculated tsunami waveforms and the observed ones were subsequently calculated to estimate the coherency of those waveforms.

A comparison of the calculated waveforms and the observed ones indicates that the observed small-amplitude water oscillation may be generated by the horizontal displacement near the Pacific coast in the Tohoku region due to faulting of the 2011 Tohoku earthquake. In addition to the similarity between calculated waveforms and observed ones, the dominant period of the observed water oscillation is consistent with the theoretically calculated natural period of water oscillation trapped in the bay. Since relatively small earthquakes along the plate boundary do not produce such large crustal deformation near the coast, this phenomenon may be characteristic of great earthquakes such as the 2011 Tohoku earthquake.