Validating Slip Distribution Models of the 2011 Tohoku Earthquake based on Diffracted Tsunami and Uplift-induced Sea Waves in the Back-arc Region

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The 2011 Tohoku earthquake tsunami propagated around Kyushu Island before reaching the southern coast of Korea. This diffracted wave was considerably attenuated during its propagation from the source region towards Korea and was perturbed by Kyushu Island. Thus, when the waves reached the Korean coast, its heights substantially diminished. Moreover, seafloor deformation by the earthquake also caused small sea waves with a short-period oscillation in the back-arc sea basin which are capture by several tide gauges along the eastern coast of Korea. This wave has different characteristics with general tsunami. In this study, we investigate how precisely slip-distribution models of the 2011 Tohoku earthquake reproduce the tsunami in terms of diffracted tsunamis and uplift-induced waves along the back-arc region of the Japanese Island Arc. Many slip distribution models have been presented to characterize the source of this earthquake using a variety of observation data and it is common to compare synthetic waveforms with tsunami observations in order to confirm the validity of the earthquake source model.

We conducted tsunami simulations using seven previously defined slip distribution models of the Tohoku earthquake and compared the synthetic waveforms to observations not only in the Pacific Ocean but also in the southern offshore region of Korea and the coastal back-arc region. To compare their accuracy in replicating Tohoku tsunami observations, we set three criteria: delay time of the first tsunami peak, mean normalized residuals, and mean normalized RMS misfits. The best performance model differed depending on the region where the tidal gauge was installed. This allows us to discriminate differences more clearly by comparing records from the southern coast of Korea and the coasts of the back-arc basin. Thus, we consider diffracted waves as one of the constraints on the models. Specifically, for the tsunami generated by the Tohoku earthquake, which occurred along the outer rim of the fore-arc sea basin of the Japanese Island Arc, uplift-induced sea waves in the sea basin can be used to constrain the extent and polarity of seafloor deformation, which is appropriate for a feasible finite-fault model.