Use of tsunami-source data to estimate the rectangular fault plane of a shallow offshore earthquake

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Source imaging for offshore earthquakes using terrestrial geodetic data has a limited estimation performance due to the low data resolution. One promising approach to overcome this problem is the use of seafloor geodetic data. In this study, we focus on tsunami-source data that can be derived from tsunami waveform records. We evaluate how the use of this spatial seafloor geodetic data improves the estimation of a rectangular fault plane.
Here, the fault plane of the 2016 off Fukushima, Japan, earthquake, which was a shallow intraplate earthquake (Mw 7.0), was estimated by two inversions; one uses only terrestrial GNSS data and the other jointly uses the GNSS data and tsunami-source data. For the terrestrial GNSS data, we used two horizontal components of static displacements at 1308 stations of GEONET of GSI. For the tsunami-source data, we used the spatial distribution of seafloor vertical displacements above the source region estimated by Kubota et al. (2021). Based on the tsunami waveforms of the OBPG records at stations of S-net of NIED, Kubota et al. (2021) inverted the spatial distribution of the initial sea-surface height (tsunami source) with the horizontal spatial interval of 2 km, in an area of 50 x 50 km. A rectangular fault plane with a homogeneous slip was estimated following Kawamoto et al. (2016, 2017) and Ohno et al. (2021). Unknown fault parameters were latitude, longitude, and depth at the top center of the fault, strike angle, dip angle, rake angle, fault length, fault width, and fault slip. To obtain the fault parameters of a single rectangular fault plane through the Bayesian framework, we used the MCMC method following Ohno et al. (2021).
The results indicated that the terrestrial GNSS data has a low resolution for the analysis of the offshore earthquake, resulting in a biased solution with large uncertainty. Conversely, the additional use of tsunami-source information significantly improved the resolution and reliability of source imaging and reduced the dependency among fault parameters. These results suggest that the high-spatial-resolution information of tsunami source is a powerful tool for source imaging of shallow offshore earthquakes.

Keywords: Tsunami-source data, Estimation of rectangular fault plane, Terrestrial GNSS data, Bayesian inversion

