Systematic examination of rupture directivities of small earthquakes offshore eastern Japan from 2003 to 2021

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The rupture processes of small and moderate-sized earthquakes have been modeled as symmetric extensions of circular faults. However, the recent development of observation networks has enabled us to directly estimate the rupture propagation directions of small- and moderate-sized earthquakes (Yoshida, 2019; Yoshida et al., 2019). The estimated rupture propagation directions of earthquakes provide new information on the stress redistribution process associated with earthquakes and the fault structures. Recently, Yoshida et al. (2020, 2021, JpGU), using S-net ocean bottom seismic network data from September 2016 to 2020, found small interplate earthquake ruptures along the Japan Trench tended to propagate in the updip direction.
The state of slip deficit and stress on the plate boundary evolves with time. These changes also may affect the rupture propagation directions of earthquakes. The coverage of the observation network is essential to estimate the direction of rupture propagation. Therefore, the estimation accuracy of rupture direction before the installation of the S-net network is low in eastern Japan offshore. However, the rupture directions may be constrained to some extent only from the onland seismic network. This presentation will introduce some preliminary results on the rupture directivities of earthquakes that occurred off east Japan between 2003 and 2021 based on land-based data.
The earthquakes analyzed were those listed in the F-net catalog. First, the apparent moment rate functions were obtained for each earthquake at various seismic stations from the deconvolution of observed waveforms by the waveforms of nearby small earthquakes (empirical Green's functions). The directions of rupture propagations were estimated by applying the unilateral rupture model of Haskell (1964) to the apparent source time functions.
The rupture propagation directions were estimated for earthquakes along the plate boundary, in the overriding plate, and the subducting slab. For interplate earthquakes, the rupture directions were stably estimated for 100 and 536 earthquakes before and after the Tohoku-Oki earthquake, respectively. The results after the Tohoku-Oki earthquake show that most of the earthquakes propagated in the updip direction, consistent with the previous study that also used S-net data. The rupture directions estimated in this study are consistent with the results of the same earthquakes based on the analysis of S-net data. The results before the Tohoku earthquake show a little larger proportion of down-dip ruptures, but when comparing the rupture directions at close distances, the propagation directions mostly remain the same between before and after the Tohoku earthquake. However, there are some areas where the predominant rupture propagation seems to have temporarily changed immediately after the Tohoku earthquake. The stable updip rupture propagations suggest persistent factors that determine the source and rupture direction of earthquakes, such as deep-seated creep and rising slab-derived fluid.

Keywords: Rupture directivity, offshore eastern Japan, Fault structure

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