Spatial heterogeneity of shallow tremor activity near the Japan Trench

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The Japan Trench subduction zone hosts various types of seismic activities, such as Mw 9.0 Tohoku Oki megathrust event, tectonic tremors, and VLFEs. Recent development of S-Net (cabled network of OBSs) and intense free-fall type OBS observations near the trench revealed very frequent activity of shallow tremor along the whole subduction margin [Nishikawa et al., 2019; Ohta et al., 2019; Tanaka et al., 2019]. The tremor identified in these studies have poor resolution in their depth, since they located the tremor with the envelope cross correlation method. From 2016 to 2017, we had deployed an array of 3 dense OBS arrays near the trench axis of offshore Fukushima region. Taking advantage of the array analysis, we have shown that the shallow tremor observed in the offshore Fukushima region is predominantly occurring at the plate interface [Ohyanagi et al., 2019 JpGU]. However, in this research, epicenter of the tremor is located solely based on arrival direction of tremor wave estimated at 3 arrays. Due to limitation of the method, tremor cannot be located in some area within the array of arrays network. Thus, distribution of tremor hypocenters has spatial gap which may caused by methodological issues.
Here, we updated hypocenters of ambient tremors and dynamically triggered tremors using the Multi Beam Back-Projection method [Ghosh et al., 2009; 2012] to verify if tremors are occurring at the spatial gap. Ghosh et al. (2009; 2012) does not evaluate uncertainty of located tremor explicitly. In our study, we evaluate uncertainty of located hypocenters following a method proposed in Arnadottir and Segall (1994). Succeeded in locating the tremors, we estimated their energy rate. The site amplification factor of each OBS is corrected between 2Hz –8Hz by the coda normalization method (e.g., Sato and Fehler, 1998). After the site amplification factor is corrected for each OBS, we evaluate seismic energy of the tremors at each array. At certain array, time delay is applied to waveforms of the tremors according to their slowness and arrival direction acquired through beamforming. The delayed traces are stacked to suppress ambient noise. The stacked traces at each array is then collected for geometrical spreading and intrinsic attenuation to estimate seismic energy at the source. At last, the estimated energy is divided by duration of the tremor to convert to the energy rate.
The updated location still shows spatial heterogeneity within a shallow tremorgenic region. The ambient tremor activity is more frequent in the up-dip part of the region, and less frequent in the down-dip part. Although spatial distribution of the energy rate of the tremors is more or less homogeneous within the whole region, some of the tremors occuring up-dip have about 2 order larger energy rate than others. The frequent and potential of high energy rate activity of the tremor in the up-dip part may be related to the crustal deformation observed near the trench axis in offshore Fukushima [Iinuma et al., 2016; Tomita et al., 2017].

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