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Shallow Seismicity near the Japan Trench Revealed by the Ocean Bottom Seismometer

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The Japan Trench subduction zone is a cradle for wide spectrum of seismic activities, from a fast-rupturing event such as the Mw 9.0 Tohoku-Oki earthquake, to a slow-rupturing event such as very low frequency earthquakes [Matsuzawa et al., 2015; Baba et al., 2020]. In past few years, the S-Net, the cabled network of ocean bottom seismometers (OBSs) and dense networks established by free-fall type OBSs reveal tectonic tremor in a shallow portion of the subduction zone [e.g. Nishikawa et al., 2019; Tanaka et al., 2019; Ohta et al. 2019]. However, rich OBS data sets have not fully utilized to understand micro-seismicity of the same region in contrast to tectonic tremor activity. The OBS networks are often used to relocate hypocenters of earthquakes cataloged in the JMA unified catalog which if from the onshore seismic network [e.g. Shinohara et al., 2012]. Meanwhile, it is uncommon attempt to detect micro-seismicity exclusively visible from offshore seismic network despite of its necessity to fully-expose interplay between fast, standard seismicity and slow seismicity at the shallow trench. As Obana et al. (2021) reported synchronization of shallow tremor activity and seismicity near the Japan Trench using a short-term observation data, development of a high-quality offshore earthquake catalog has high demand to shed right on earthquake potential near the trench.

Here, we perform detection and phase picking of microearthquakes to a data set of an OBS network deployed in offshore Fukushima near the trench with applied the Earthquake Transformer (EQT) [Mousavi et al., 2020]. Our OBS data set is composed of 3 mini-dense arrays and 3 single station OBSs. For the analysis we select one OBS from each array in the network as well as the single station OBSs. As a result of our experiment, the EQT detects more than 5000 microearthquakes, which is six times more number of events than the earthquakes located by the JMA in the same region during the observation period.

The picked arrival times are used to estimate event hypocenters with hypomh package, which locate earthquake based on the Bayesian approach [Hirata and Matsu'ura, 1987].

The developed earthquake catalog is then compared with the shallow tremor catalog of Ohta et al. (2019). First, we prepared cumulative event frequency time series for each activity. The time series are then detrended with best-fit linear trend to remove yearly mean activity rate, which aim is to emphasize occasions with anomalous change in the seismicity. Based on the detrended cumulative event frequency time series, we discovered that the seismicity near the trench has strong correlation with the shallow tremor activity. Within 5 tremor bursts observed in a year, 4 of them accompanies anomalous increase in the seismicity. The earthquake bursts delay for 4 – 6 days from the bursts of the migrating shallow tremors, indicating that the migrations of the shallow tremors trigger the bursts. The frequent synchronization of the shallow tremor and the earthquake indicates importance on monitoring both activities to asses seismic potential of shallow subduction zone.