P118

Detection of Microseismicity in Offshore Fukushima Using A Deep Learning Module

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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 VLFE. 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 in order to understand the wide spectrum of rupture processes in the subduction zone.

Here, we perform detection and phase picking of microearthquakes to a data set of an OBS network deployed in offshore Fukushima near the trench to develop a high-quality offshore seismicity catalog, with applied the Earthquake Transformer (EQT) [Mousavi et al., 2020]. The EQT has already been trained with a set of onshore seismic and ambient noise signals [Mousavi et al., 2019]. We attempt to apply the trained model directly to the OBS data to examine its performance on offshore environment. Our OBS data set is composed of 3 mini-dense arrays and 3 single station OBSs. Frist, 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 number of events than the earthquakes located by the JMA in the same region during the observation period. Next, the detected events are further inspected both of P-wave and S-wave arrival times if it also cataloged in the JMA unified catalog. They are cross-checked with P-wave and S-wave arrival times manually picked for the same OBSs we used in the experiment [Shinohara, personal communication]. Despite of success in the detection of a huge amount of micro earthquakes, the automatically picked P-wave and S-wave arrival times deviate from manually picked arrival times for 0.16 seconds and 0.12 seconds on average, respectively. The failure in accurate automatic pick suggests need of tuning of the EQT model for our OBS data set with a transfer learning method [e.g., Chai et al., 2020].