Tsunami analysis using the S-net pressure gauge records during the Mw 7.0 Off-Fukushima earthquake on 22 Novenver 2016 to reduce the effects of tsunami-irrelevant pressure components

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Following the 2011 Tohoku-Oki earthquake, the seafloor observation network for earthquakes and tsunamis along the Japan Trench (S-net) was developed by the National Research Institute for Earth Science and Disaster Resilience (NIED, Kanazawa et al. 2016). This network employs a Digiquartz Series 8B pressure sensor (8B7000 or 8B8000) manufactured by Paroscieitific, Inc. Each of the observatories equips two pressure sensors for redundancy, which were not directly exposed to seawater but put in an oil-filled metal housing. Since this network was constructed, several tsunami events have been observed; the largest one is the Mw 7.0 Fukushima-Oki earthquake on November 22, 2016 (Gusman et al. 2017; Suppasri et al. 2017; Nakata et al. 2019). In this presentation, we examine the features of the S-net pressure records during this event.

We first removed the tidal component from the S-net pressure record. We confirmed tsunami-related pressure changes with amplitudes up to 40 cm. Some stations also included drifts with rates of a few hPa/hour, which were much larger than the long-term drift observed in the Paroscientific sensors (~8.8 hPa/year, Polster et al. 2009). In addition, at stations near the epicenter, step-like pressure offset changes were recorded just after the earthquake. For example, at the station S2N15, located ~60 km from the epicenter, an abrupt pressure offset increase of ~30 hPa was recorded. Pressure offset changes are often recognized as a result of seafloor vertical crustal deformation; however it was quite unlikely that such a large crustal deformation occurred at ~60 km away from the epicenter and thus these offset changes are not related to the crustal deformation.

We then compared the pressure waveform with those of the other pressure sensor at the sites where large pressure steps were observed. At the observatories, which were revealed to have significantly rotated during the earthquake based on the analysis of the co-located accelerometer (Takagi et al. 2019), the offsets of two sensors were not coincided with each other, whereas at the other sites where the rotation was insignificant, the offsets coincided well. For example, at the observatory S2N15, where a sensor rotation of 5.88° was observed (Takagi et al. 2019), one had an offset increase of ~30 hPa and ~37 hPa for another. Chadwick et al. (2006) pointed out that the offset of the Paroscientific pressure sensors has strong dependency of the sensor rotation angle. The rotation angle of ~10° corresponds to the pressure offset change of ~5 hPa at maximum. The differences in the offsets between two sensors might be related to differences in the sensors' sensitivity to the rotation angle. In addition, because it is unlikely that the offsets are identical to each other considering the differences in the sensitivity to the rotation, the pressure steps should be related to the observation system including the housing in addition to the pressure sensor itself.

We finally estimated the initial sea height distribution by the waveform inversion to evaluate how useful the S-net pressure data are. We applied the bandpass filter with passbands of 100-3600 s to avoid the drift and used the method of Kubota et al. (2018), which uses time-differentiated pressure waveforms to reduce the effect of the step. The time window for the inversion was determined by visual inspection. The distribution was consistent well with this event' s normal-faulting mechanism, which shows that the S-net tsunami records are very useful even if they are contaminated by the tsunami-irelevant signals. The distribution extended about 30 km along the strike direction and was slightly smaller than that expected from the scaling law (~40 km, Wells and Coppersmith 1991). This suggests that the fault dimension of this event was smaller than that of typical earthquakes.

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