Preliminary assessment of quality of the S-net long-term ocean bottom pressure observation in the northern part of the Japan Trench for detecting crustal deformation

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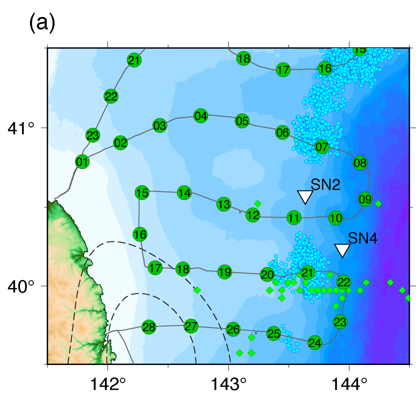
Ocean bottom pressure gauges (OBPs) installed in the deep-sea have played important roles in detecting crustal deformation due to slow-slip events or postseismic deformation and in understanding their mechanics (e.g., Ito et al. 2013 Tectonophys; Iinuma et al. 2016 Nature Comm; Wallace et al. 2016 Science). Following the 2011 Tohoku-Oki Earthquake, the Seafloor observation network for earthquakes and tsunamis along the Japan Trench (S-net) has been installed (Kanazawa et al. 2016). It is expected that the S-net OBPs play significant role in detecting crustal deformations in the Tohoku subduction zone. In this study, we report the preliminary results of the assessment of the quality of the long-term S-net OBPs records, with a time scale of several days to weeks, based on the comparisons with the pop-up recovery type OBPs installed by Tohoku University (Hino et al. 2014 Mar Geophys Res).
We focused on the S-net OBPs installed off Sanriku, northern Japan, where the low-frequency tremors (Tanaka et al. 2019 GRL; Nishikawa et al. 2019 Science) and very-low-frequency earthquakes (Matsuzawa et al. 2015 GRL; Nishikawa et al. 2019) are active (Figure 1a). The S-net observation has started from March 2016 in this region. We picked up the OBP sites where the data have relatively better quality that clearly capture the ocean-tide signals based on eye-inspection (Chikasada et al. 2020 JpGU S-CG70). Here, we compared the S-net OBP records with those installed by Tohoku University (TU-OBP), using the records in 2016 where the observation periods are overlapped. The records were resampled to 30-min samples. We used the BAYTAP-G tidal analysis program (Tamura et al. 1991 GJI) to estimate the ocean-tide components. We also estimated the linear drift components.
As a result, the estimated tides were in good agreement with all OBPs (Figure 1b-1e). We excluded the tidal and the linear drift components from the TU-OBP time series to obtain the standard deviations σ of σ= 2.6 hPa for the site SN2 (Figure 1b) and σ= 2.2 hPa for SN4 (Figure 1c). We also obtained σ= 11.4 hPa for the S-net S4N11 (Figure 1d) and σ= 3.5 hPa for S4N22 (Figure 1e), which are located near the TU-OBP sites. We found the standard deviations of the S-net OBPs, including the other stations not shown here, were systematically larger than the TU-OBPs. In addition, S-net OBP records contained pressure fluctuations of more than 10 hPa with time scale of several days (Figure 1de). However, such fluctuations were not observed in the closely-located TU-OBPs, which indicates these fluctuations are not attributed to oceanographic signals. In addition, since both OBPs use the same sensors manufactured by Paroscientific, Inc., it is unlikely to be due to differences in sensors. One big difference between these two OBP observations is that the S-net the pressure sensors are sealed in a metal housing, which is filled with oil and thus are not directly exposed to the seawater. In order to clarify the cause of these several-days scale pressure fluctuations, we need to examine the relationship between the pressure fluctuation and the housing more carefully.

As a summary, it is considered that the quality of the S-net OBPs for detecting the crustal deformation is not so high as the TU-OBPs, even if the station with best quality (S4N22) is used. In addition, the S-net OBP at S4N11, and some other OBPs, might contain the large (> ˜10 hPa) pressure fluctuations over several days, which suggests that it is sometimes difficult to detect crustal deformation with time scale of several days. Although the detectability of the crustal deformation detectability will be improved by the removal of non-tidal components (Inazu et al. 2012; Otsuka et al. 2020 JpGU S-CG66), we need to investigate the causes of those "unclarified" pressure fluctuations in more detail.

Keywords: S-net, Ocean bottom pressure gauge, Off Sanriku, Crustal deformation



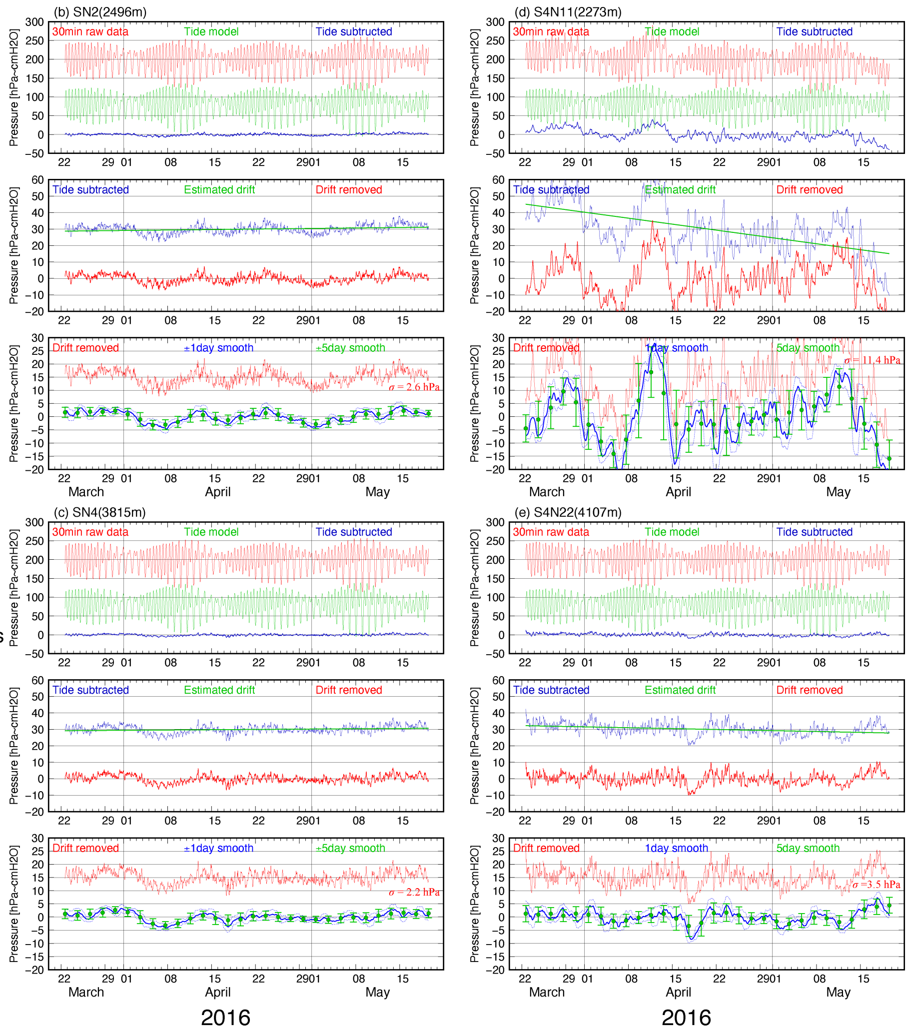


Figure 1.
(a) Locations of the OBP stations (Tohoku University: inverted triangles; S-net colored circles).
Small light blue dots are low-frequency tremors (Tanaka et al. 2019) and green diamonds are very-low-frequency earthquakes (Nishikawa et al. 2019).

(b–e) Results of the data processing for (b) SN2, (c) SN4, (d) S4N11, and (e) S4N22.
Top panel shows the raw data, estimated tide, and tide-subtracted time series.
Middle panel shows the tide-subtracted time series, estimated drift, and drift-removed time series.
Bottom panel shows the drift-removed data and temporally smoothened time series.