Detectability of short-term seafloor deformation by S-net pressure observation

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Long-term continuous observation of seafloor pressure is effective for detecting unsteady seafloor vertical deformations associated with transient tectonic phenomena such as slow slip event. A series of crustal vertical movements that occurred before and after the 2011 Tohoku-Oki Earthquake were captured by seafloor pressure observations and played significant roles in constraining the distributions of coseismic slip and aseismic slip preceded the mainshock, and the contribution of viscoelastic relaxation in the postseismic crustal deformation. Recently, number of new discoveries have been made in the slow earthquake activities along the Japan Trench. The continuous seismic records over a wide offshore area obtained by Seafloor observation network for earthquakes and tsunamis along the Japan Trench (S-net) showed that low-frequency tectonic tremors occurred repeatedly. It is expected that a slow slip event (SSE) occurs in the background of the tremor activity. If the crustal deformation caused by SSEs can be detected, it will greatly contribute to a comprehensive understanding of interplate coupling in the area. In this paper, we report quality of seafloor pressure data obtained by S-net in the geodetic frequency band, as the first step to capture the seafloor vertical motions associated with SSEs.
The characteristics of continuous records at all of the 150 stations from August 2016 to January 2020 were examined based on the RMS amplitudes of the pressure time series after the tidal components were removed. To remove the tidal components, a “tide killer filter”, a low-pass filter that effectively removes each tidal tide component. The filter output is composed of pressure variations with periods of two-days or more. Looking at the time series for about 3.5 years, it turned out that many records contain remarkable slow fluctuations with a time constant of several months or more. There are irregular variations of unknown cause that cannot be interpreted as fluctuations due to pressure sensor drift or transient fluctuations during the settlement of instruments on the seabed after the deployment. Since we can expect that the duration of SSE is about 1 to 2 weeks, which is the duration of low-frequency tremor activity episodes, the accompanying crustal movements may be detected even if long-period noise levels are high and we inspected the RMS amplitudes in a time window of 100 days. Only ~40 out of 150 stations provide pressure data with noise levels less than 10 hPa (10 cm in terms of vertical displacement), which is a guideline for detecting transient crustal movements, whereas about a half of the S-net stations show noise level more than 20 hPa. The noise level of the S-net pressure data is considerably higher than the data obtained by the pop-up type ocean bottom pressure gauge (OBP) used in many previous studies. It is thought that the difference in performance is related to the difference in the sensor installation method on the seafloor and also in the structure of the instruments. The longer path of pressure transmission to the sensor and the larger amount of self-heating of the device can raise noise level of pressure data. However, the noise level of the pressure data by DONET, another submarine cabled observation system, is not inferior to the data obtained by OBPs. We will inspect characteristics of the noises in S-net pressure data more in detail to identify the causes and also to find a way to reduce the noise so that the S-net pressure records can be used to monitor the SSEs along the Japan Trench.

Keywords: Seafloor pressure measurement, Slow Slip Event, noise characteristics

