# Analysis of ocean bottom pressure gauge data by a hybrid method of MSSA and fitting of a parametric function

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It is known that slow-slip events (SSE) have repeatedly occurred off the Boso Peninsula, with a recurrence interval of several years. Earthquakes are rapid slips on fault surfaces, on the other hand, SSEs are slow slips on them. SSEs are considered one of stress release mechanisms that a fault slips slowly at the plate boundary. Thus, understanding of SSEs is important for a full understanding of tectonic behavior at plate boundaries. To detect vertical motion of ocean floor during the Boso SSEs by using ocean bottom pressure gauge (OBP) data, we propose the following method. First, we applied Multi-channel Singular Spectrum Analysis (MSSA) to extract and remove short-term (up to 20 days) periodic components from the OBP data. Next, we fit a parametric function to the remaining long-term periodic components of the OBP data. The parametric function represents the annual and semi-annual seasonal variations, and the vertical offset due to the Boso SSE. To verify the method, we applied the method to OBP data which include the 2018 Boso SSE.

We observed ocean bottom pressure from August 2016 to September 2018 using 4 OBPs that are composed of pressure gauges of Paroscientific Inc. During of this period, it was clarified that the SSE occurred in June 2018 from the GNSS data.

Sea water depth changes converted from observed pressure changes have not only transient displacements due to the SSE but also several components which affect the sea water depth. First, we removed tidal components and smoothed the time series by calculating a 7 day moving average to remove periodic variations which have up to about several days’ periods. Next, to remove periodic variations such as atmospheric pressure changes, oceanic changes, and so on, which have from several to about 20 days periods, we applied MSSA with the window interval of 20 days to the smoothed time series. Results of MSSA extracted principal components (PC) 1 and 2 which about annual to semi-annual periods were distinguished, PC3 and 4 which about 20 days periods were distinguished, and noise components which contributed to the time series lesser than them.

We considered that PC3 and 4 were variations due to atmospheric pressure changes, oceanic changes, and so on. Thus, we removed them as well as noise components. We reconstruct signals by summing the remaining PC1 and 2. We assumed that the long-term periods included in the reconstructed signals were the same as them included in the GNSS time series. Then we fitted a parametric function which represents the annual and semi-annual seasonal variations, and the vertical offset due to the Boso SSE to the reconstructed signals. The fitting results extracted up-lifts of all stations. They (and root-mean-square error) were 15.5 mm (13.8 mm) at BOSO1, 23.6 mm (6.7 mm) at BOSO2, 21.0 mm (6.5 mm) at KAP2, and 13.1 mm (6.9 mm) at KAP3.

To verify the present method, we estimated the slip distributions of the 2018 SSE from displacements extracted from the following two methods. One is the conventional method which only the fitting of the parametric function was performed. The other is the present method. Comparing the RMS of residual of the vertical motion at the OBP stations, the RMS of the present method is 58% smaller than that of the conventional method. Therefore, we can extract the vertical motion due to the SSE more correctly when MSSA and the parametric fitting are used together.

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Keywords: Slow Slip Event , ocean bottom pressure gauge, Multi-channel Singular Spectrum Analysis

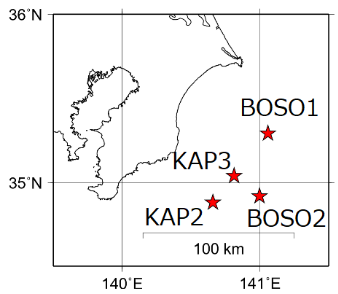


図1.BOSO1、BOSO2、KAP2、KAP3の各観測点の配置

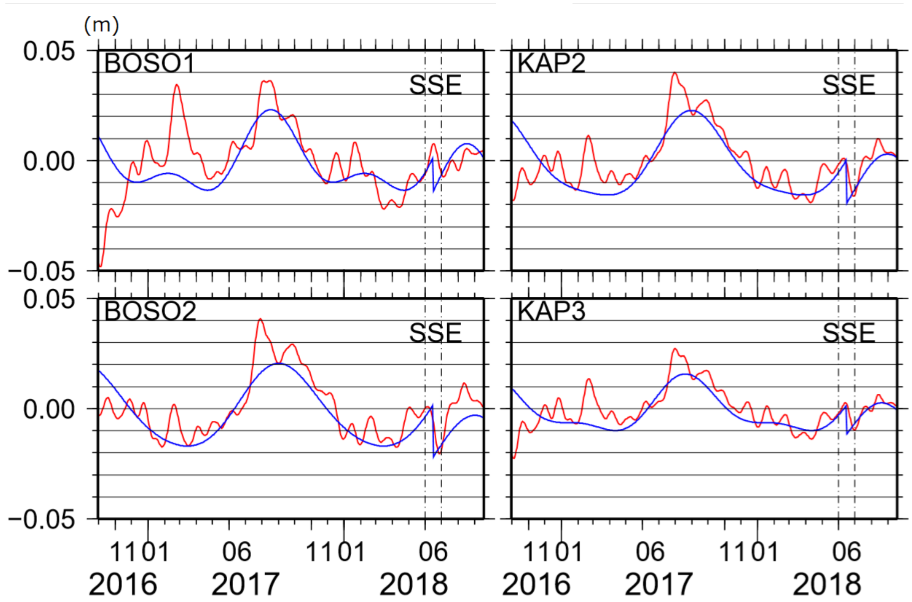


図2.各観測点の再構成信号(赤線)とフィッティング曲線(青線)