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An attempt to estimate duration for short-term SSEs in southwest Japan using the stacking method of GNSS data

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Introduction

Short-term slow slip events (SSEs) with duration of several to ten days occur on a subducting plate interface in southwest Japan. Nishimura et al. (2013) and Nishimura (2014) suggest that short-term SSEs occur not only in a deep part (20 $\sim$ 40 km deep) from the Tokai region to the Bungo Channel but also along the Ryukyu trench from Hyuganada to the Yaeyama Islands. Because displacement signal caused by short-term SSEs is comparable to a noise level of GNSS data, Nishimura et al.(2013) assumed no duration of short-term SSEs and fitted an instantaneous step function with a linear trend to GNSS time-series to estimate a fault model. It is unclear how long the detected SSEs continue.

It is a gap of duration between short-term and long-term SSEs in southwest Japan. Intermediate-term SSEs with duration of one or two months have never been reported. This gap may be artificial due to less sensitivity of observation sensors including GNSS, strainmeters, and tiltmeters to the signal for those periods.

In this study, we try to estimate duration of short-term SSEs using a combination of the detection method of short-term SSEs using GNSS data (Nishimura et al., 2013) and the stacking method for the detection of crustal deformation (Miyaoka and Yokota, 2012).

Data and Analysis

The used data are daily GNSS coordinates (F3 solution) published by the Geospatial Information Authority of Japan. We detected short-term SSEs and estimated their fault models using the method of Nishimura et al.(2013) and Nishimura (2014). And then, we applied the stacking method (Miyaoka and Yokota, 2012) for GNSS time-series using the displacement calculated from the fault model. The detailed procedure of the stacking follows. First, we select a time window of 181 days centering a date of a short-term SSE in NS and EW components of GNSS time-series. We removed a linear trend and calculated RMS (Root Mean Square) using the data in the time window excluding the middle 60 days. The RMS is used as the noise level of the data and the time-series is normalized by the noise level. Next, we calculate signal to noise ratio (SNR) every component of GNSS stations using the noise level and the signal calculated from the fault model. Then, we stack the normalized time-series in order of SNR and calculate the noise level of the stacked time-series. We stop stacking when the SNR of the stacked time-series is the highest. Finally, we estimate the duration of the short-term SSEs by fitting a lamp-type function to the stacked time-series.

Result

Stacking 30 $\sim$ 100 time-series gives the highest SNR for the short-term SSEs along the Nankai Trough. Although it is difficult to recognize transient signals of SSEs in the original time-series, we can visually inspect duration of SSEs using the stacked time-series, which demonstrates effectiveness of the stacking method. The estimated duration for SSEs with good SNR time-series ranges several days to a month approximately. It is longer than that estimated in the previous studies (e.g., Sekine et al., 2010) in some cases. Although such a long duration can be explained by misrecognition for two succeeding SSEs with a short interval, the long duration may be real in some cases. We also report a regional feature of duration, comparison with an activity of low-frequency tremors and Hi-net tilt data by the National Research Institute for Earth Science and Disaster Prevention.

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Reference

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