Estimation of the spatiotemporal evolution of the slow slip events in the Tokai region, central Japan, since 2013 using GNSS data

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In the Tokai region, central Japan, the previous long-term slow slip event (L-SSE) was very slow and long-term aseismic slip, observed on the subducting Philippine Sea Plate (PSP) from 2000 to 2005. In addition, many short-term slow slip events (S-SSEs) accompanied by low frequency tremors (LFTs), have been detected using not only tiltmeter and high sensitivity seismograph from the NIED Hi-net but also GNSS from the GEONET recently. Although several previous studies have reported the spatiotemporal evolution of L-SSEs, there are few previous studies that estimated the spatiotemporal evolution of S-SSEs. In this study, we applied a time-dependent inversion method to GNSS data to obtain the spatiotemporal evolution of an L-SSE and S-SSEs on the PSP beneath the Tokai region, since 2013.
GNSS data from January 1, 2008 to December 31, 2015 were used in this study. The GIPSY-OASIS II software was used to estimate daily coordinates of 222 GNSS stations from the GEONET in the Tokai region. It is well known that GNSS time series have many systematic signals that do not result from SSEs. These systematic signals include, for example, seasonal variations and post-seismic deformation of the 2011 Tohoku-oki earthquake (Mw9.0). After removing these systematic signals, we applied a modified Network Inversion Filter (NIF) [Fukuda et al., 2008]. The original NIF [Segall & Matthews, 1997] assumes a constant hyperparameter for the temporal smoothing of slip rates and thus often results in oversmoothing of slip rates. The modified NIF assumes a time-variable hyperparameter, so that changes in slip rates are effectively extracted from GNSS time series.
The results indicate that the moment magnitude and maximum cumulative slip of the L-SSE were estimated to be Mw~6.5 and ~6.5 cm from January 1, 2013 to December 31, 2015, respectively. In addition to the L-SSE, we found several periods of slip acceleration that can be regarded as S-SSEs, but we discuss only S-SSEs which are larger than the estimation error. The biggest S-SSE in analysis period occurred at the end of January, 2014 around the Ise Bay. Maximum cumulative slip of this S-SSE was estimated to be~1.1 cm from January 17, 2014 to February 1, 2014, respectively. We also found several other S-SSEs that occurred around the Ise Bay in the down-dip area of the L-SSE. These S-SSEs are correlated with LFTs, suggesting that LFTs were triggered by the S-SSEs.
Our results suggest that the slip peaks of the L-SSE and S-SSEs do not overlap and that the temporal variation of moment in the central area of the L-SSE is smooth and is not affected by the S-SSEs. In addition, LFTs [Obara et al., 2010] do not occur near the center of the L-SSE. In order to further investigate the relationship among the L-SSE, S-SSEs, and LFTs, we additionally processed data from GNSS stations constructed by the Japanese University Consortium for GPS Research and operated by Earthquake Research Institute at the University of Tokyo and allied universities. We will present results of joint analyses of these additional data and the GEONET data in the presentation.

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