

Long-term slow slip events and slow earthquake activities around the Bungo channel region, southwest Japan

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In southwest Japan, a variety of slow earthquakes with various time scales have occurred. In particular, (i) nonvolcanic tremor (Obara, 2002), (ii) deep very low-frequency earthquakes (D-VLFE; Ito et al., 2007), (iii) short-term slow slip events (S-SSE; Obara et al., 2004), and (iv) long-term slow slip events (L-SSE; Hirose et al., 1999) have been observed in the Bungo channel region, the western end of the tremor belt-like distribution (Obara, 2002), by nationwide seismic and geodetic observation networks. Previous studies show that (i)-(iii) occur spatiotemporally correlated in the transition zone on the subduction plate interface between a shallow locked zone and a deep steady sliding zone (Ito et al., 2007; Hirose and Obara, 2010). However, the spatial and temporal relationship between a detailed slip process of the L-SSEs and the activities of the S-SSEs and tremor is unknown.

In 2009-2010, a recurrent L-SSE is observed by NIED Hi-net high-sensitivity accelerometers (tiltmeters) and the Geospatial Information Authority of Japan's (GSI) GEONET GPS array. In addition, an array monitoring system based on the accelerometer data (Asano et al., 2008) detects an activation of shallow very low-frequency earthquakes (S-VLFE; Obara and Ito, 2005) off Cape Ashizuri during the L-SSE. We study the source process of the L-SSE by using both the tilt and GPS data, and discuss the spatiotemporal relationship with the other slow earthquakes, including tremor, S-SSEs, and VLFEs.

We used tiltmeter records at a group of the NIED Hi-net stations and displacement data at the GEONET GPS stations. We applied a time-dependent inversion method that is based on the Kalman filter (Hirose and Obara, 2010) to both the tilt and GPS data simultaneously. The L-SSE in Bungo channel seems to start about September, 2009 around a northern part of Cape Ashizuri as the slip rate gradually increases. The slip area begins to migrate to westward, the Bungo channel area, with the acceleration of the slip near the end of February 2010 coincident with the occurrence of an S-SSE in western Shikoku. Slip with the similar slip rate continues until June 2010 with the slip area gradually expands, and then start to decelerate. In addition, the inversion result not only shows the slip history of the L-SSE, but also images that of S-SSEs which are occurring in western Shikoku.

The moment release history after the acceleration phase in February 2010 correlates well with the nonvolcanic tremor activity on northern part of the Bungo channel. In contrast, the activation of the S-VLFEs corresponds to the acceleration phase of the L-SSE and ends well before the deceleration of the L-SSE. These features in the temporal changes are also observed during the previous L-SSE in 2003. The difference in the temporal change of the tremor and S-VLFE activity suggests that the sensitivity to the stress change caused by the L-SSE and the magnitude of the stress change are different for the tremor and the S-VLFEs.