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Along-strike variations in relationship among slow slip events, low-frequency tremor and very low-frequency earthquakes

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In southwest Japan the Philippine Sea Plate is subducting beneath the continental plate. Dense and high-quality observation networks such as NIED Hi-net have revealed that various types of slow earthquakes have occurred repeatedly on the plate interface. In the case of western Shikoku, simultaneous occurrences of the short-term slow slip event [SSE; Obara et al., 2004] with the magnitude of about 6.0, the nonvolcanic deep tremor [Obara, 2002] and the very low-frequency earthquake [VLFE; Ito et al., 2007] have been observed. In this study, we compare the slip process of short-term SSE with the tremor and VLFE activities which occurred from December 23, 2011 to January 10, 2012 around western Shikoku. This short-term SSE, whose magnitude is estimated to be 6.2 by a preliminary analysis assuming a rectangular fault with a uniform slip, is one of the largest events in western Shikoku. Moreover, this is the first case that an episode of tremor activity and short-term SSE occurs in a wide area from Bungo channel to central Shikoku.

In order to estimate the detailed slip process of this SSE, we apply a time-dependent inversion method [Segall & Matthews, 1997; Hirose & Obara, 2010] to a set of ground tilt data recorded by Hi-net high-sensitivity accelerometers (tiltmeters). From the hourly-resampled ground tilt data, tidal and atmospheric pressure effects are removed using the BAYTAP-G program [Tamura et al., 1991]. The plate interface configuration in the target area is modeled by placing 17 x 7 subfaults with the size of 10 x 10 km^2, referring to Shiomi et al. [2008].

The estimated cumulative slip distribution shows two separate areas with the large slip in western and mid Ehime prefecture and a gap area with the small slip between them. The location of the large slip area in western Ehime prefecture coincides with the area where the large slip occurs when the short-term SSEs occur repeatedly at approximately 6-month interval [Hirose & Obara, 2010]. After January 3, a large slip of the SSE developed beneath western Ehime prefecture and then the slip area jumped to mid Ehime prefecture while the tremor activity migrated from western Ehime to mid Ehime continuously. As a result, in two large slip areas, the slip and the tremor activity occurred simultaneously, and in the gap area, the tremor activity increases without the large slip. In the case of the VLFEs, some VLFEs occurred when slip occurred in the large slip area in western Ehime, and a VLFE occurred in the other large slip area. In the gap area, VLFEs were not detected.

In the episode of slow earthquakes from December 2011 to January 2012, we can show that the relationship among the slip of the SSE, tremor activity and very low-frequency earthquakes varies along the strike of the subducting Philippine Sea slab. In most of the tremor activities and short-term SSEs in western and central Shikoku, the migration of the source area stopped when the source area reached to the gap area. Moreover, only two and no VLFEs have been detected in the large slip area in mid Ehime prefecture and in the gap area, respectively, while many VLFEs have occurred in the other large slip area. Therefore, the along-strike variation in the relationship among three types of the slow earthquakes during the target episode would be caused by a spatial difference in the slip property on the plate interface.

Keywords: subduction zone, slow earthquake, short-term slow slip event, deep low-frequency tremor, deep very low-frequency earthquake, tilt change