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Detection of short-term slow slip events using GPS data in southwestern Japan (Part 2)

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Nishimura and Suito (2011) reported that GPS was able to detect short-term slow slip events (SSEs) which had been observed only by tiltmeters and strainmeters on the plate interface of the Philippine Sea plate. Here, we present a method to detect the deformation associated with the SSEs in southwestern Japan and fault models of the SSEs inverted from GPS data. We also compare them with a tremor activity (Maeda and Obara, 2009; Obara et al., 2010) and the fault models of the SSEs estimated from tilt data (Sekine et al., 2010).

Daily coordinates of 565 GEONET stations in southwestern Japan were used to detect the deformation of the SSEs. We fitted a step function to the filtered daily coordinates to detect displacements in a direction of N130^{o}E which is opposite to the relative plate motion between the Philippine Sea plate and southwestern Japan. The candidate dates of the SSEs are determined if the significant displacements were detected. And three components (i.e., EW, NS, and UD) of the displacement were inverted to estimate a rectangular fault model. We finally recognized SSEs if the observed displacement were well reproduced by the fault model.

201 candidates of SSEs were found in a period from June 19, 1996 to August 14, 2011. They were categorized into 88 certain SSEs, 51 probable SSEs and 62 non-SSEs. Moment magnitude (M_w) of the 137 certain and probable SSEs ranges between 5.4 and 6.4. SSEs with M_w => 6.2 have occurred only in western and central Shikoku 7 times. No certain SSEs occurred in the Kii Channel and east of 137.5^{o}E (Lake Hamana). A couple of certain SSEs have occurred in Ise Bay where the tremor activity is weak.

Comparing the fault models from GPS with those from tilt data (Sekine et al., 2010), we found 27 SSEs included in both catalogues. There is no systematic difference of their M_w estimated from GPS and tilt. SSEs with M_w => 6.1 were included in both catalogues. However, 25 and 17 SSEs were detected solely from GPS and tilt data, respectively. Those SSEs must be real slip events because they accompany tremor activities. It, therefore, suggests that the detectability of neither GPS nor tiltmeter is perfect for small SSEs. We calculated moment released by SSEs in each segment along the Nankai Trough. The moment rate is roughly constant in western Shikoku for 15 years but it increases around 2006 in eastern Shikoku. The increase may reflect a long-term change of conditions on the plate interface because similar increase is also observed in tremor activities (Obara et al., 2010). However, we cannot rule out that the increase is artificial due to replacement of GPS antennas and additional GPS stations.

Keywords: short-term SSE, GPS, southwestern Japan