Detecting surface displacement accosiated with the 2018 slow slip event around Boso peninsla by use of Sentinel-1 InSAR with atmospheric correction

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The slow slip, also denoted as the slow eathquake, is known to release accumulated strain energy with no or slight seismic wave radiation. The slow slip is usually detected by highly accurate geophysical measurements such as the Global Navigation Satellite System (GNSS) and seismometers because of very small surface deformation on the order of millimeters to centimeters, and small ground oscillation (named as a tremor). Until now, several papers reported slow slip events, for example, at Tokai area (e.g. Yamamoto et al. 2005, EPS; Ozawa et al. 2016, EPS), Cascadia (e.g. Dragert et al. 2004, EPS; Hawthorne and Bartlow 2018, JGR), and Nankai Trough (e.g. Kobayashi 2017, EPS; Ozawa 2017, EPS). The area around Boso Peninsla is also a location where slow slip events have occuered with intervals of several years (Fukuda 2018, JGR). However, most of the reffered papers here used GNSS observations that have a limitation of low spatial resolution (Usually a few tens of kilometers between ground stations). In this study we conducted the InSAR analysis to detect the surface displacement accosiated with the 2018 slow slip event near the Boso peninsla by use of Sentinel-1 observations and numerically-derived atmospheric models.

In the InSAR andalysis we used Sentinel-1 TOPS IW data with three satellite paths (path 39, 141, and 46). Paths 39 and 141 are ascending direction and path 46 is descending direction. The interferometric analysis was conducted by GAMMA software with the 1-arcsecond SRTM DEM for the topographic fringe simulation. All of the InSAR pairs have absolute perpendicular baselines below 200m, indicating most InSAR pairs showed good coherence. Because the expected surface displacement has an amplitude of 2cm or below (by GNSS observations), we performed the stacking analysis for each paths to enhance the detectability of line-of-sight (LOS) displacements. In addition, we applied the MSM-based atmospheric delay correction to each interferograms to further increase the detectability of the surface displacement signal.

The stacking result showed that the surface displacement signal with an amplitude of approximately 1 cm in the LOS direction was clearly detected in path 141. The displacement signal extended spatially to approximately 20 km in both north-south and east-west direction. The spatial distribution and amplitude of InSAR-detected displacement was consistent with the GNSS observation. On the other hand, There were no clear displacement signal in the stacked interferogram in paths 39 and 46. This would be due to the significant atmospheric delay effect in several interferograms of these paths. Therefore we only used the stacking interferogram in path 141 for the fault modeling.

We also performed the assessment of the atmospheric delay correction effectiveness. Phase standard deviations (SDs) calculated on the area outside of the expected displacement signal clearly showed the effectiveness of the atmospheric delay correction. Before the correction, SDs of the stacked interferograms were 5.9 cm, 7.5 cm, and 4.2 cm for paths 39, 46, and 141, respectively, which decreased to 2.7 cm, 4.6 cm, and 1.6 cm after the correction. Although the spatial and temporal resolutions of MSM were 10 km and 3 hours that were not significant for the InSAR atmospheric delay modeling, it showed good performance for the InSAR stacking.

Based on the derived displacement signal in path 141, we performed a forward modeling to estimate preliminary fault parameters using the simple Okada fault model. The estimated fault model suggested that the upper-left corner of the fault was located at 140.8 degrees in longitude and 34.98 degrees in latitude with the depth of 15 km, which was consistent with the boundary of the Phillipine plate. The fault length and width were set to 50 km and 30 km with the dip angle of 18 degrees. The estimated slip amount was 13 cm with the rake of 105 degrees, which was equivalent to the moment magnitude of 6.6.

Keywords: InSAR, Atmospheric delay correction, Slow Slip