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Crustal deformation in Izu-Oshima Island detected by PS-InSAR analysis and estimation of volcanic deformation source

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Mt. Mihara in Izu-Oshima Island have erupted 21 times in the last 800 years. The latest eruption occurred in 1986 inside the caldera. Though spatially and temporally dense observation network is desired to continuously monitor volcanic activities, it is not easy to construct such a network in a mountainous region. In this study, we conduct time-series analysis of ALOS/PALSAR images over Izu-Oshima Island using persistent scatter interferometric SAR (PS-InSAR) method to detect volcanic deformation.

From the analysis of 20 images collected from ascending track during the period from October 2007 to February 2011, we detect distance change of about 15 cm extension in the line-of sight (LOS) direction inside the caldera. Similarly the extension of about 14 cm is detected at the same location from the analysis of 18 images from descending track during the period from January 2007 to March 2010. Next we compare the LOS distance changes with those converted from GPS coordinate time-series at four continuous sites in the island. The RMS between them are as large as 1.3-3.2 cm, implying that SAR results are good enough to monitor volcanic deformation over the island.

Combining the LOS distance changes from the ascending and descending tracks, we derive quasi-vertical and quasi-east-west components of the displacement. The most remarkable is the vertical displacement of the caldera where the subsidence of about 16 cm is detected during 2007-2010 with small occasional uplifts. Moreover uplift of about 11 cm is recognized in the eastern coastal area of the island during the same period. Based on the quasi-vertical component of the displacement, we estimate a spherical pressure source model (Mogi, 1958) below the island. We assume two sources with different depth and estimate the optimum model using a grid search method. Horizontal position of the shallower source is fixed to coincide with the location of the caldera and its depth is varied every 0.5 km in a range of 2.0-4.5 km. Horizontal position of the deeper source is varied every 2 km and its depth is checked every 0.5 km in a range of 5.0-10 km. The optimum model shows that the shallower source is located at a depth of 3.0-4.5 km where inflation and deflation are occurring alternatively while the deeper source is located at a depth of 6.0-9.0 km where nearly constant inflation rate of about 8 million m3 per year is expected. These results can be interpreted that the deeper magma reservoir continues to expand due to magma supply from the mantle while the shallower reservoir is affected by magma supply from the deeper source and gravitational load of lava that spreads within the caldera.

Keywords: PS-InSAR method, time-series analysis, Izu-Oshima Island, crustal deformation, volcanic deformation source