Detection of local surface deformation using InSAR: a case study of the 2015 phreatic eruption of Hakone Volcano

Ryosuke Doke[1]

1 Hot Springs Research Institute of Kanagawa Prefecture
E-mail: r-doke(at)onken.odawara.kanagawa.jp

Recent advances in interferometric synthetic aperture radar (InSAR) techniques have enabled us to perform high-resolution mapping of surface deformations. The InSAR technique is a useful method for monitoring volcanic activities because a set of InSAR images is transformed into a high-resolution surface displacement map in satellite line-of-sight without the help of observations on the ground or underground. Moreover, small-scale surface displacements can be detected in a wide range of observation areas from a set of InSAR images. In the case of the 2018 phreatic eruption of Iwoyama, Mt. Kirishima in Japan, InSAR images detected very local surface uplifts of about 15 cm toward the satellite before the eruption [Geospatial Information Authority of Japan (GSI) 2018].

The 2015 unrest of Hakone Volcano is another example of very local surface displacements detected by InSAR before the phreatic eruption, which occurred on June 29, 2015, in the Owakudani fumarole field until July 1 (Fig. 1). During the unrest, abnormal blowouts occurred on steam wells (facilities supplying hot spring water) after May 3, 2015, in the displaced area. Therefore, the displacement indicates that pressure in the shallow part of Owakudani had increased during the unrest. The phreatic eruption occurred on the southern edge of the displaced area, and four new craters were formed (Mannen et al. 2018).

Moreover, InSAR pairs before and after the 2015 phreatic eruption may have detected displacements related to changes in the underground hydrothermal system beneath the area around Owakudani. The distribution of the surface displacements obtained by the InSAR analysis can be explained by a crack opening and a sill deflation at the elevations of about 530–830 m and about 225 m, respectively (Fig. 2). This result shows that the hydrothermal fluid migrated from the sill (considered as a reservoir) to the shallow crack and triggered the phreatic eruption at Owakudani, which located the northernmost tip of the crack.

Reference

Doke et al. (2018) *Earth, Planets and Space*, 70. doi: 10.1186/S40623-018-0834-4
GSI (2018) https://www.gsi.go.jp/BOUSAI/h30kirishima_ebino.html
Mannen et al. (2018) *Earth, Planets and Space*, 70. doi: 10.1186/s40623-018-0844-2

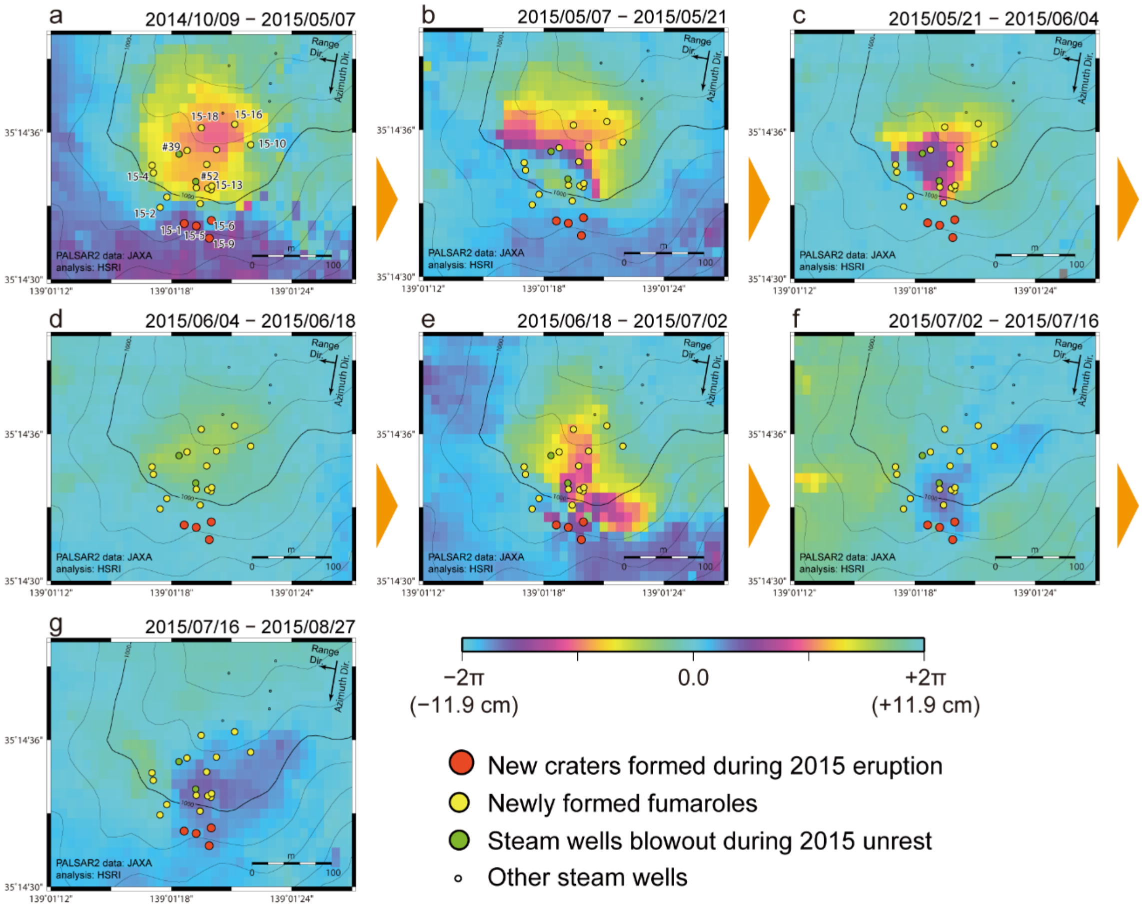

Fig. 1 Temporal change of local swelling at Owakudani (Doke et al. 2018). The color shows wrapped phase difference between 0 and +2π radian. The phase difference of 2π radian corresponds to a slant-range change of 11.9 cm. Contour intervals are 25 m in height.

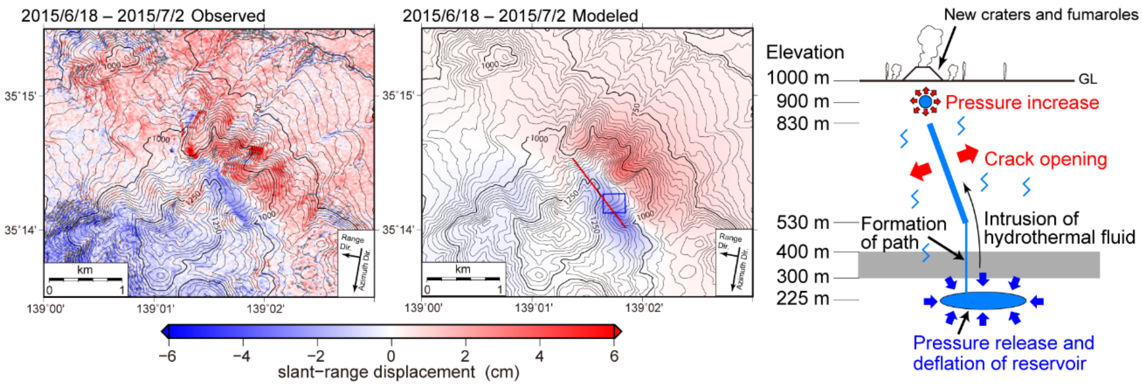

Fig. 2 Surface displacement maps from the InSAR analysis of ALOS-2/PALSAR-2 images and the result of the inversion estimating the open crack and deflation sill model. The red line and blue rectangle show the estimated open crack and deflation sill, respectively.