



InSAR Imaging of White Island from 2014 to 2020: Insights into the 2019 Phreatic Eruption

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At 14:11 NZDT (01:11 UTC) on 9 December 2019, an explosive eruption (VEI=2) occurred on White/Whakaari Island in New Zealand's northeast Bay of Plenty. The sudden eruption claimed 20 lives among the 47 tourists who were on the island at the time of the eruption. Several volcano-tectonic features overlap in the island such as a major caldera rim collapsing scarp to the west, a landslide, a crater lake and a large shallow hydrothermal system at the center, making complex the understanding of the eruption triggering factors. Here we use Sentinel-1 Interferometric Synthetic Aperture Radar (InSAR) data from 3 different tracks (1 ascending and 2 descending) spanning the period of 2014-2020 to investigate the spatio-temporal surface deformation evolution of White Island in the years before the eruption. By analyzing the InSAR time-series displacements between the two eruptions of April 2016 and December 2019, at least 4 separate stages can be identified that possibly relate to different parts of the volcanic eruptive cycle: 1) During April 2016 - February 2018, the crater lake edge and the western sub-crater wall rapidly moved downslope at a rate of ~6 cm/yr, while the central sub-crater area uplifted at a rate of ~3 cm/yr; 2) From February 2018 to January 2019, both the western and the central sub-craters uplifted at a rate of ~5 cm/yr; 3) During the following six months, from January 2019 to June 2019, the western sub-crater started moving downslope again at a rate of ~3 cm/yr, while the central sub-crater kept moving up at a rate of ~4 cm/yr; 4) And finally, during June 2019 - December 2019 (until the eruption), uplift occurred around the western sub-crater again at a similar rate as in the central sub-crater area (~4 cm/yr). Seismic records before the eruption show that approximately 500 volcanic earthquakes located at a depth of ~5 km occurred at the southwestern part of White Island on June 2019, that may point to a shallow level intrusion of new magma. This upcoming magma might then have pressurized the shallow hydrothermal system during the fourth-stage uplift. Modeling of the uplift during June 2019 to December 2019 indicates a shallow source located at only ~200 m below the surface in the vicinity of the crater lake, likely coinciding with the shallow hydrothermal system responsible for the final 2019 phreatic eruption.