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Pressures changes in volcanic systems and volcanic interactions in the Virunga Volcanic Province inferred from lava lake level measurements

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Lava lakes are the uppermost parts of magmatic systems and changes in the height of those lakes provide insight into pressure changes in the magmatic systems. We measure the rise of the crater floor and the lava lake level fluctuations from the module of hundreds of SAR images acquired by RADARSAT, COSMO-SkyMed, SENTIEL-1 and Envisat. The height changes are obtained from the length of the shadow casted by surrounding rims. We develop an automatic method for detecting illumination/shadow transitions using a grid-search strategy among an extensive dictionary of synthetics 1-D transects. Results are validated by comparison with high resolution DEMs obtained from UAV photogrammetry.

This analysis is applied to the Nyiragongo volcano (DR Congo), which hosts a ∼260m wide persistent lava lake nested in a 1.2km wide crater. Recurrent lava overflows inundate the crater, which, after solidification, make the floor to rise up to several dozens of meters per year.

After its co-eruptive drainage in 2002, the crater filled up to ∼400m thickness until 2008. From 2008 to 2012, the variations in lava lake level reduced (level fluctuations of various amplitude and time scales within the pit). In 2012 , after a large volume eruption at neighboring Nyamulagira volcano, the level progressively lowered, reaching ∼70m below the crater floor. It remained at low level until the end of 2015. Early in 2016 a new vent opened within the crater, which intermittently emits important lava flows that blanket the crater. In November 2016, the lake level dropped of a hundred meters in a few hours. Since then, the lava lake level experienced several large amplitude drops.

We compare these measures with other observations, such as seismicity, degassing, ground deformation and visual observations. We infer that these lava lake level changes can be used as a proxy for the pressure changes in the magmatic system.

In addition, petrological studies show that despite a distance as small as 13km, Nyiragongo and neighboring Nyamulagira volcanoes share no common magmatic sources, at least at crustal depth. Nevertheless, comparing volcanic activity at both volcanoes, seismicity, regional ground deformation and lava lake level changes, our study suggests that volcanic activity at one volcano can influence the other volcano.

The SAR shadow measurement method can be applied to some of the other rare volcanoes hosting or having hosted a lava lake, such as Kīlauea or Erta Ale.