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InSAR and GPS ground deformation along the Kivu segment of the East African Rift during the 2011-2012 Nyamulagira eruption

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Along the East African Rift lie several active volcanoes characterized by different eruptive styles and magma plumbing systems. In this particular environment it is crucial to study ground deformation to better understand the interaction between tectonic, local stress and magma movements.
Here we used InSAR and GPS data to measure ground displacement associated with the 2011-2012 Nyamulagira eruption. Nyamulagira is an active shield volcano with a central caldera, located in the Democratic Republic of Congo along the Kivu segment of the East African Rift. It is characterized by cycle of short-lived flank eruptions (sometimes accompanied by intra-crateral activity) every 1-4 yr, and less frequent long-lived eruptions usually emitting larger volumes of lava from eruptive vents most of the time located >8 km from the central caldera and with longer repose time. The 2011-2012 Nyamulagira eruption is one of these long-lived events. The eruption lasted from November 6 2011 to April 2012. This is the last Nyamulagira eruption, even if, since 2014, an intermittent lava lake re-appeared within the caldera. Nyamilagira is located within the Virunga National park and is surrounded by a dense tropical forest. This limit the use of the InSAR technique and, with the frequent political instabilities, make difficult to access the area to install monitoring stations (that are located at >10 km from the caldera).
However, InSAR data from different satellites allowed measuring ground displacements associated with the eruption. In particular, deformation time series, obtained with the short revisiting time COSMO SkyMed satellite, allowed detecting a very fast (one day) magmatic intrusion below the eastern flank two days prior to the eruption onset. It also allowed the detection of the subsequent intrusion that brought the magma up to the two eruptive vents located 11km ENE from the caldera.
Using analytical models we jointly inverted two interferograms with different looking geometries to assess source parameters and mechanisms of magma emplacement. We tested different type of sources to find the most suitable one for this eruption, given the observed deformation and the volcano-tectonic context. Considering also the GPS and seismic data acquired during the eruptive period by four stations, our analysis suggest that the eruption was a complex sequence of a deflation of a shallow magma chamber (∼3km below the caldera) that fed a sill intrusion toward the ENE direction (parallel to the rift axis) that twisted into a dyke and brought the magma up to the surface. Furthermore, the geophysical observations suggest the presence of a deep magmatic source that possibly fed the shallower magmatic system. This event contrasts with classical flank eruptions, which commonly involve only a shallow magma chamber that fed sub-vertical dykes aligned NW-SE suggesting a different control mechanisms of magma emplacement.