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Study of the 2012-2020 pit crater evolution in the summit caldera of Nyamulagira volcano using multiple satellite sensors and UAS-based photogrammetry

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Since its last flank eruption in 2011-2012, the activity of Nyamulagira volcano (Virunga Volcanic Province, DR Congo) has been characterized by pit crater collapse, lava fountaining and intermittent lava lake activity. No more flank eruption occurred since this concentration of the eruptive activity at the summit. As Nyamulagira is located in a remote area of the Virunga National Park, field observations remain limited. As a consequence, observations of the ongoing changes at the summit of the volcano mostly rely on satellite observations. Time-series of very-high to high resolution optical and SAR amplitude images for instance provide the required information to follow the evolution of the pit crater, from the first signs of collapse to its filling by lava. Hotspot detection from the combination of MODIS and Landsat-type images (including Sentinel-2) allows detecting the first appearance of lava in the pit crater and describing the intermittence of the lava lake activity that has developed since 2014. The OMI and TROPOMI instruments allow measuring the evolution of SO₂ emissions. Thanks to few aerial surveys and the use of Unoccupied Aerial Systems (UAS or "drone"), the volume of lava accumulated within the pit crater since 2014 was measured. All these satellite and drone-based observations were finally compared with the known historical eruptive activity, in terms of lava and gas discharge rates and type of summit eruptive activity. The presented work shows how combining various remote sensing techniques that make use of recent generations of satellite images and UAS acquisitions allow a detailed interpretation of the evolution of the volcano, even when field access is an issue.