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Lateral lava dome growth monitoring at Nevado del Ruiz Arenas crater using TerraSAR-X amplitude Imagery

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Volcanic processes occurring at the summit of steep explosive volcanoes are often difficult to monitor because of the remote location, the danger from gas and ash emissions and the frequent presence of clouds, impeding a direct view. Nevado del Ruiz, a ∼5300 m high stratovolcano, is characterized by strong degassing, sporadic explosions and dome extrusion from the summit crater Arenas. The Arenas crater is typically covered by dense clouds throughout most of the year. Synthetic Aperture Radar (SAR) active systems are capable to look through these cloud layers, displaying surface characteristics and deformation. For this study, we employed high resolution SAR amplitude imagery from the German satellites TerraSAR-X and TanDEM-X. Pixel dimensions of ∼1 meter and a revisit period of 11 days allowed us to document the extrusion of the summit lava dome for almost four years. We analyzed both descending and ascending amplitude tracks, with different looking angles, identifying the existence of a small lava dome since the end of 2015 using image stacks. During the four years investigated in this study, the dome expansion occurred mainly horizontally rather than vertically, with a phase of increased deformation rate. A comparison of the deformation trends with heat radiation measurements, provided by the MODIS-MIROVA system, and images from Sentinel-2 confirms the presence of a thermal anomaly, with higher intensity in 2016. The spatial extent of the anomaly gradually evolves from a wide area covering the dome surface into a discontinue ring shaped feature at its perimeter. To better interpret the dome lateral expansion and the development of the hotspot patterns, we performed analog experiments using a sandbox to simulate a dome extrusion. We observed that the constant extrusion of a dome-like feature leads to dominant lateral expansion after reaching a critical height. The horizontal spreading is therefore associated with gravitational adjustments represented by radial slumps of the slope. While the growth pattern is in line with the SAR observations, the ruptures occurring around the flat-topped dome can be recognized in the late thermal anomalies, showing circular hot patches. Our study confirms the value of remote sensing to monitor remote volcanoes, since we have been able to document the dome growth at Nevado del Ruiz volcano in detail. We believe that the approach tested in this study can help improving the assessment of volcanic hazards from the collapse of lava domes, represented by the potential to generate explosive eruptions or pyroclastic flows.