Geophysical Research Abstracts
Vol. 20, EGU2018-3630, 2018
EGU General Assembly 2018

Drone-based acquisition and SfM-MVS Photogrammetry as revolutions to study volcanoes and map the related hazards in complex tropical environment

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Satellite remote sensing is sometimes the best way to get information on areas where the socio-political instability recurrently prevents the use of ground-based approaches. This is for example the case in the North Kivu province, D.R. Congo. The ∼800,000 inhabitants of the city of Goma are directly threatened by one of the most active volcanoes on Earth, i.e. Mount Nyiragongo. The scientific knowledge on this volcano remains limited and the direct observation of its current eruptive activity, which corresponds to the presence of a persistent lava lake in its summit crater, is difficult to implement. If remote sensing is already used to study and monitor Nyiragongo, the tropical environment of this region of Central Africa strongly limits its proper application. The frequent cloud cover and the volcanic gas emissions most of the time prevent the use of optical imagery, such as Sentinel-2, Landsat, SPOT or Pléiades images. In addition, the dense vegetation on the flanks of the volcano restricts the observation of ground deformation by SAR interferometry (InSAR) to some parts of the volcanic field.
Since 2013, we take advantage of the helicopter support provided by the United Nations to the Goma Volcano Observatory to acquire different sets of cloud-free optical images at low altitude, over the Nyiragongo main crater. Since 2016, annual expeditions on top of the volcano also allow the acquisition of images using an Unmanned Aircraft System (UAS). Thanks to Structure-from-Motion Multi-View Stereo (SfM-MVS) photogrammetry, topographic models of the Nyiragongo crater are produced. The time-series of 3D models allows quantifying the major changes in the Nyiragongo crater, including ground deformation, lava volume accumulation, lava lake level variations and cliff erosion. As both image and ground control points acquisitions remain challenging in this complex volcanic environment, the data processing has been adapted accordingly.
In this study, we present the methodology developed and its adaptation to the local context. Results on Nyiragongo are interpreted together with SAR and InSAR measurements. The application of the developed approach over the city of Goma is also presented, revealing its huge potential for the very-high-resolution hazard and vulnerability mapping.