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Geomorphological response to volcanic activity at Stromboli volcano using multi-platform remote sensing

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Steep volcano flanks are geomorphological systems highly responsive to both exogenous dynamics and endogenous forcing. While the external (gravitational) processes lead to a shift of material from steeper slopes to areas with lower gradients (erosion of loose deposits, rockfall of lavas/welded material), magmatic and tectonic activity can have either a constructional (accumulation) or a destructive effect (triggering moderate- to large-scale mass-wasting). Remotely sensed data have often been used to map areas affected by lithological and morphological changes, i.e. to identify areas impacted by eruptive and post-eruptive (landslides or floods) phenomena, as well as to quantify topographic changes.

In this work, the geomorphological evolution of the Sciara del Fuoco (SdF) depression on the Island of Stromboli (Italy) between July 2010 and October 2019 has been reconstructed by using multi-temporal, multi-platform remote sensing data. Digital elevation models (DEMs) from PLEIADES-1 tri-stereo images and from LiDAR acquisitions allowed the topographic changes estimation. Data comprised also high-spatial-resolution (QUICKBIRD) and moderate spatial resolution (SENTINEL-2) satellite images allowing to map areas affected by major lithological and morphological changes. SdF was selected being the optimal test-site for monitoring the effect of volcanic eruption on steep-slope volcano flank, since: i) it is affected by persistent volcanic activity, ii) it is prone to mass-wasting phenomena, and iii) it is one of the best studied and, among all, monitored volcano on Earth, providing exceptional validation data and ground-truth constrains.

During the analysed period, the volcano experienced two eruptions (summer 2014 and summer 2019), with the emplacement of two lava flow fields on the SdF. Before the 2014 effusion and in between the two eruptions, geomorphological changes consisted of volcanoclastic sedimentation and some overflows outside the crater. The effusive (and partially explosive) activity produced larger topographic changes, related to the emplacement of the two lava flow fields and to the accumulation of a volcaniclastic wedge on the SdF. This work shows that, at Stromboli, the emplacements of lava flow fields were preceded and accompanied by the accumulation of volcanoclastic wedges on the SdF. The quantification of these volcanoclastic wedges is relevant because they are composed of the same material that was involved in the 30 December 2002

tsunamigenic landslide, besides being located in the same area.

PLEIADES tri-stereo and LiDAR DEMs have been quantitatively and qualitatively compared, providing a first indication on the differences between two largely used methods for modelling topography. Although there are small artefacts in smaller ridges and valleys, there is still a clear consistency between the two DEMs for the main valleys and ridges. This analysis can be used by the volcanological community and the civil protection authorities in case of a cost-benefit analysis for planning the best method for updating topography and quantify morphological changes of an active volcano.