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UAV surveys illuminate the morpho-structural and volume changes from the 2019 paroxysmal eruptions of Stromboli volcano (Italy)

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Stromboli Volcano was very active in the summer of 2019: Two paroxysms dramatically changed the summit craters of the volcano on July 3 and August 28. The first intense paroxysmal eruptive sequence involved both the North and the Central-South (C-S) crater areas and has generated an eruptive plume rising 4 km above the summit (924 m a.s.l.) while the incandescent material set fire to vegetation on the flanks of the volcano. Volcanic products from the laterally directed explosions and from the collapse of the external crater terrace generated two pyroclastic flows that travelled down the Sciara del Fuoco (SdF) and for several hundred of meters out to sea. Between July 3 and August 28, the activity was characterised by lava flows in the Southern sector of the SdF and by very intense Strombolian activity at a set of small scoria cones that grew around the vents, particularly in the N crater area. The second paroxysmal eruption occurred on August 28 again involving the two crater areas and producing an eruptive column that rose 4 km above the summit. Material from the eruption and from the collapse of the rim of the C-S area contributed to the generation of a pyroclastic flow that travelled down the SdF and out to sea. Important morphological variations to the crater terrace were evident after the two paroxysms.

We used UAVs to monitor morpho-structural changes of the Stromboli volcano following the paroxysmal eruptions; in particular, five high-resolution UAV survey campaigns have been performed since May 2019. The aerial images were acquired using two different UAVs, a DJI Mavic 2 Pro and a Wingcopter. Using Structure-from-Motion (SfM) techniques we generated DEMs (Digital Elevation Model) and orthoimages with a resolution ranging between 0.2 and 0.5 m. An additional 1 m-resolution DEM was extracted from available tri-stereo Pleiades satellite imagery and chosen as pre-paroxysm surface. Using the orthoimages it was possible to map the distribution of eruption products and determine the morpho-structural changes. Furthermore, the topographic approach (subtraction between two different surfaces DEMs) with a cut-and-fill procedure was chosen to calculate the volume gain (in the southern sector of the SdF) and loss (in

the crater areas).

This work demonstrates the usefulness of the combined use of UAVs and SfM techniques to map volcanic products, to highlight morphological changes and perform volume estimations. The data collected during these field efforts and the temporal comparisons of the DEMs represent a fundamental contribution to both volcanic hazard assessment and risk mitigation, and can be used to support civil protection operations.