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High-resolution topography of 1974 Mount Etna lava flow based on Unmanned Aerial Vehicle (UAV) surveys and Structure from Motion (SfM) photogrammetry

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The production of high resolution Digital Elevation Models (DEMs) of lava is of increasing interest in volcanology because the time scales of change are fast and involve vertical and planimetric changes of millimeters to meters. Among the wide range of terrestrial and aerial methods available to collect topographic data, the use of unmanned aerial vehicle (UAV) acquiring platform and structure from motion (SfM) photogrammetric technique is especially useful because it allow collecting data of inaccessible, kilometer scale areas, with low cost and minimal hazard to personnel.
This study presents the application of UAV-SfM method to generate a high-resolution DEMs and orthomosaic of the 1974 Mount Etna lava field. The UAV was flown over lava field at flight altitude to about 70 m above ground level (AGL) and acquired 2781 photographs. SfM-photogrammetry applied to these images enabled the extraction of very (20 cm) high-resolution DEMs and 3 cm orthomosaic for a total area of 1.35 square kilometers.
The data produced by the UAV-SfM was compared with airborne LiDAR data. Such comparison gives a root mean squared error between the two DEMs of 0.24 m. The unprecedented topographic resolution obtained with UAV-SfM methods enabled us to derive morphometry of sub-meter-scale lava features, such as folds, blocks, and cracks, over kilometric scale areas. The 3 cm orthomosaic allowed us to further push the analysis to dm-scale grain distribution of the lava surface.
This study shows that SfM and UAV platforms can be effectively used for mapping volcanic features producing topographic data in a manner not possible with the 1-m LiDAR-derived DEM. The spectral analysis of surface folding support this analysis showing a much larger spectrum of frequencies of the SfM-derived DEM than the LiDAR DEM.