Multitemporal UAV remote sensing surveys of volcano unstable flanks: the case of Stromboli

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The UAV-based photogrammetric mapping is a cost-effective technique that allows to generate three-dimensional surveys with centimetric precision and accuracy in short times. When carefully performed, the outcomes can be comparable to the ones coming from other expensive techniques that require longer time such as aerial or terrestrial laser scanning. Consequently, it is becoming increasingly popular even in application fields that, until recently, were deemed unsuitable to the technique. Depending on the characteristics of the investigated scenario, the generation of three-dimensional (3D) topographic models may in fact be affected by significant inaccuracies unless site-specific adaptations are implemented into the data collection and processing routines.

In this context, we present a tailored approach using high-resolution aerial photogrammetry for the multitemporal analysis of the unstable Sciara del Fuoco (SdF) slope on Stromboli Island, Italy. Landslides in this region have the potential to generate tsunamis that could affect the shores of Stromboli and the adjacent coastline. The surveys were carried out using the Saturn drone developed by the Civil Protection Centre of the University of Florence. Ongoing experimentation and technical improvements allow the drone to be adapted to different scenarios, thus facilitating comprehensive modelling of the entire SdF and extending the applicability of photogrammetry. In this region, the use of this technique presents inherent challenges due to the uniform appearance of the grey ash slope, making it difficult to easily identify matching points across continuous images. Moreover, due to site accessibility issues, Ground Control Points (GCPs) cannot be positioned to constrain georeferencing. Therefore, 3D point clouds were georeferenced using GCPs acquired in a 2019 survey together with stable Virtual Ground Control Points (VGCPs) belonging to a LiDAR survey carried out in 2012. Alignment refinement was then performed by means of an iterative algorithm based on closest points.

The procedure succeeded in correctly georeferencing 11 high-resolution point clouds acquired from April 2017 to February 2023, whose time-focused analysis made it possible to track several geomorphological structures associated with the continued volcanic activity, including minor structures not identifiable by aerial/satellite surveys. The procedure can be further extended to smaller-scale analyses such as the estimation of locally eroded/accumulated volumes and pave the way for rapid UAV-based georeferenced surveys in emergency conditions at the SdF.

At the same time, accurate and up-to-date 3D models provide the basis for analysing ground deformation data obtained from terrestrial and satellite sensors. They also provide essential input for carrying out stability analyses of the SdF slope.