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Monitoring high geomorphologic dynamics and slope instability at Stromboli volcano

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Slope failures of volcanic edifices produce a wide spectrum of instability phenomena, from small rock-falls to large-scale slope deformation, eventually evolving in rock-slides or debris avalanches With the aim of understanding the relationship between geomorphologic evolution and slope instability at Stromboli volcano (Italy), displacement data from X-band, space-borne, COSMO-SkyMed satellites (CSK-SAR) and a permanent-sited, Ground Based Interferometric Synthetic Aperture Radar (GBInSAR) device were analysed. To track lithological and geomorphological changes in space and time, the evolution of reflectivity (amplitude) of CSK-SAR were also examined.

This study is focussed on Stromboli (Italy) volcano, optimal environmental setting and case history of volcano slope instability phenomena, since: i) it experienced moderate to major instability events, ii) its slopes are prone to mass-wasting phenomena, iii) it is affected by persistent volcanic activity that can significantly affect the stability of slopes, iv) landslides from its flanks could generate tsunamis that could affect areas inhabited, and iv) it is one of the best studied and, among all, monitored volcanoes on Earth, providing exceptional validation data and ground-truth constrains.

GBInSAR data were collected every 11 minutes in the period 1 January 2010 – 18 December 2014, whereas the CSK-SAR images were collected between 22 February 2010 and 18 December 2014. Multi-Temporal InSAR (MT-InSAR) algorithms were used for both CSK-SAR and GBInSAR datasets.

Backscattered intensity of each CSK-SAR image was transformed in amplitude image and then decibel scaled. In order to detect and interpret changes in land-cover in correspondence of the SdF slope, two steps were applied in the employed procedure: i) RGB colour composites, and rationing, ii) texture analysis, using the GLCM (Grey Level Co-occurrence Matrix) method.

The analysis of the entire dataset cover a period characterized by “normal” Strombolian activity, punctuated by episodes of “high-intensity activity”, with the occurrence of overflows from the crater terrace toward the Sciara del Fuoco (SdF), and the 2014 flank eruption. This study highlights that during periods characterized by "normal" Strombolian activity, the production of materials ejected from the crater terrace to the SdF is generally low, and erosion is the prevailing process, mainly affecting the central portion of the SdF. GBInSAR apparatus allows for the identification of very low displacement rates (0.01–0.001 mm/h) related to the creep of the northern sector of the SdF. After the emplacement of the 2014 lava field, high displacements in the area located between the central and the northern portions of the SdF were recorded. The lava accumulation on the SdF slope, especially between its northern and central portions, has favoured the detection of slope instability due to the difference in the involved material (lava flows and breccia layers vs volcaniclastic loose deposits) below the newly emplaced lava.