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Exploiting satellite techniques for volcanic deposits mapping: the case of 2021 Mt. Etna eruptions

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During explosive eruptions tephra fallout represents one of the main volcanic hazards and can be extremely dangerous for air traffic, infrastructures, agriculture, and human health.

The technological advancements and increasing availability of high-resolution satellite imagery have offered new possibilities for mapping volcanic deposits related to an individual eruptive event. Spatial resolution is one of the main limitations in deposit mapping, together with the revisit time of satellites, particularly in rapidly evolving situations.

Here we present a new technique aimed at identifying the urban areas covered by tephra after an explosive event based on the processing of PlanetScope satellite imagery. These recent multispectral data are acquired from a constellation of over 180 microsatellites and exhibits a relatively high spatial resolution (~ 3 m pixel size) covering once a day each point in the Earth surface.

Our technique is based on the introduction of a new index that we call 'Tephra Fallout Index (TFI)' computed from the mean reflectance values of the near infrared (NIR) band analyzing pre- and post-eruptive data in paved areas adjacent to the summit craters of Etna and more distal paved areas, to have an overall view of the distribution of the tephra deposit.

The objective of the proposed method is to find any variations between the pre- and post-eruptive reflectance values in the selected areas, exploiting the different ways that different materials exhibit (in this case tephra and cement) to reflect light.

We use the cloud-based geospatial analytic Google Earth Engine (GEE) computing platform and define a dynamic threshold for the TFI of different eruptive events to distinguish the areas affected by the tephra fallout.

We demonstrate our technique by applying it to the eruptive events that occurred in 2021 at Mt. Etna (Italy), which mainly involved the eastern and south-eastern flanks of the volcano, sometimes two or three times within a day, making field surveys difficult. Whenever possible, we compare our results with field data and find an optimal match.

The use of satellite imagery acquired from microsatellite constellations, such as PlanetScope, providing an optimal compromise between spatial and temporal resolution, may prove fundamental for identifying tephra deposits during eruptive episodes, such as those occurred in 2021 at Mount Etna volcano. Our method provides a near real time result, making it ideal also for the mapping of other hazardous events worldwide.

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