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Analyzing the occurrence of rainfall-triggered landslides through hydrologic controls of slope response in pyroclastic deposits

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Rainfall-triggered landslides are widespread geohazards, often characterized by shallow and fast movements. Their occurrence is reported in many mountainous areas, and its cumulative effects are sometimes comparable to great catastrophes (Banco Mundial, 2012). Particularly, southern Apennines of Campania (Italy), commonly covered by pyroclastic deposits laying upon karstic bedrock, are subjected to recurrent shallow landslides (Marino et al., 2021). Different triggering mechanisms have been hypothesized, and investigation on the hydrological processes predisposing slopes to failure is still needed. This study focuses on a slope where hydrometeorological monitoring has been carried out for several years, and landslides recently occurred. To assess the conditions leading to landslides, a 1000-year hourly synthetic dataset, mimicking the hydrological response of the slope to meteorological forcing, was generated. Specifically, a stochastic NSRP rainfall model was coupled with a hydrological model of the unsaturated flow through the soil cover, connected to a perched aquifer forming in the uppermost bedrock during the rainy season. Both the models had been previously calibrated based on field data (Greco et al, 2013, 2018; Marino et al, 2020).

The synthetic dataset was analyzed with k-means clustering and Random Forest techniques, to identify the hydrologic conditions, before the onset of rainfall events, controlling the amount of rainwater remaining stored in the soil cover at the end of rainfall, thus affecting slope equilibrium. Stability was analyzed under the infinite slope hypothesis, considering the contribution of suction to unsaturated soil shear strength.

The results show how the different hydrologic behaviors, related to slope underground water conditions before the onset of rainfall, as well as the total event rainfall, control slope stability. In fact, two different landslide triggering mechanisms are clearly identified. On one hand, when antecedent slope conditions hamper the fast drainage of infiltrating water out of the soil cover through the underlying fractured bedrock, typical of late autumn, slope failure is triggered by infiltration during the largest rainfall events, as almost all rainwater remains stored in the soil cover. On the other hand, when the bedrock is already filled with water previously drained from the soil cover, as at the end of very rainy autumns and winters, landslides can be triggered also by relatively small rainfall, as the bedrock cannot receive more water, and even exfiltration from the

bedrock can occur.

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