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How to model the stability of terraced slopes? The case study of Tresenda (northern Italy)

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Terraces are very common morphological features all around the Mediterranean Basin. They have been built to adapt the natural morphology of the territory to the development of anthropogenic activities, particularly agriculture. However, the increasing land abandonment during the last century is leading to soil degradation and stability issues, mainly due to lack of maintenance of these peculiar environments.
The objective of this study was to develop a coupled hydrologic-stability model to identify possible triggering areas of superficial landslides during intense rainfall events. The model was tested on a slope uphill of the village of Tresenda, in Northern Italy, which experienced several superficial landslides in the last 35 years.
Distributed stability analyses are usually carried out using an infinite slope approach, but in the case of terraces some basic assumptions of this method fail: the parallelism between topographical surface and potential sliding surface and the high ratio between slope length and failure surface depth are the most important examples. In addition, the interest is more on the stability of the terrace system (dry stone retaining wall and backfill soil) and not on soil alone. For these reasons, a stability analysis based on the global method of equilibrium is applied and soft coupled to a well know hydrological model (STARWARS). Sections of terrace, one cell wide, are recognized from the base of a wall to the top of the closest downstream one, and each cell (1 x 1 m2) is considered as a slice. The method of Sarma for circular and non-circular failure is applied. The very fine horizontal resolution (1 m) is crucial to take into consideration the hydrogeological and mechanical properties of dry stone walls (0.6-1.0 m wide). A sensitivity analysis was conducted for saturated water content, initial volumetric water content, the cohesion and friction angle of soil and walls and soil depth. The results of the sensitivity analysis showed that instability never occurs if less than 60% of the soil depth is saturated. In addition, a variation of 10% in the cohesion and friction angle of soil leads to changes in critical acceleration (factor of safety) of 4% and 5%, respectively. On the other hand, a variation of 10% in wall cohesion and friction angle leads to changes in the critical acceleration of around 4% and 1.5%, respectively. The use of a soil depth map with slightly different depths caused a different distribution in the number and location of instabilities. This underlines how this parameter, which is difficult to determine at high resolution, plays a central role in controlling location and volume of potential unstable masses. The model was finally evaluated on historical events and it demonstrated to be a good and reliable instrument to reproduce water levels and localise the most critical area for the triggering of superficial landslides on terraced slopes. In detail, field-measured water levels are modelled with a normalized RMSE of about 10%. Regarding stability, the triggering areas of the two superficial landslides occurred in May 1983 were well reproduced both temporally and spatially.