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Numerical investigations of triggering mechanisms of shallow landslides due to heterogeneous spatio-temporal hydrological patterns.

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Rainfall is one of the major triggering factor of shallow landslide around the world. The increase of soil moisture in the soil influences the stability of a slope through the increase of soil bulk density, the reduction of soil apparent cohesion (due to suction stress), and the increase in pore water pressure.The spatio-temporal transformations of such properties of soil are know to be heterogeneous and under constant change. For instance, there may be a condition where, in cracked clay-soil, water, during a rain event, produces a rapid increase of pore water pressure along preferential flow-paths (crack or roots), while soil moisture and suction within the soil matrix change minimally. An another site in a sandy soil, the situation might be very different where the increase of soil moisture and pore water pressure, and the decrease of soil suction take place more or less simultaneously across the entire soil profile. In both of these cases topography plays a major role in determining the accumulation of water along the slope through different subsurface flows intensities and directions. In many documented cases in the Alps, shallow landslides may also be triggered by the punctual exfiltration of water from bedrock or weathered geological strata. The hydro-geological characteristics of the catchment control this mechanism. These different situations aim to give an idea of the large spectrum of hydrological triggering conditions of shallow landslides.

The heterogeneities of these hydrological conditions represent a difficult issue in modeling shallow landslide triggering mechanisms. In the simplest models, hydrology is assumed to influence changes in pore water pressure only, mostly using one dimensional vertical infiltration models. More advanced models consider changes in apparent cohesion due to changes in soil moisture or include more complex hydrological models to simulate water flow and distribution during a rainfall event. However, most models at the regional scale rely on the infinite slope assumption for stability calculations and on continuous hydrological properties of the soil.

The objective of the present study is to investigate the influence of non-continuos hydrological features (such as ephemeral springs) on the triggering mechanisms of shallow landslides using a discrete element model (SOSlope) in which the stress-strain behavior of soil is explicitly considered. The application of a stress-strain calculation allows for the simulation of local versus global loading due to hydrological processes. In particular, this study investigates the effects of different types of hydrological loading on the force redistribution on a slope associated with local displacements and following failures of soil masses. Strength and stiffness of soil are considered heterogeneous and are calculated based on the assumption of root distributions within a forested hillslope.