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Numerical and physical modeling to assess landslide triggering induced by hydrological hillslope processes

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Landslide triggering induced by high-intensity rainfall infiltration in hillslopes is a complex phenomenon that involves hydrological processes operating at different spatio-temporal scales. Empirical methods give useful information about landslide-prone areas and rainfall intensity and duration that generate slope failures, but they do not provide the theoretical framework needed to achieve an in-depth understanding of the involved physical processes. This fact limits the predictive use of these empirical methods, which are usually site-dependent and unable to assess the landslide hazard with respect to different land uses proposed for mitigation purposes. Depending on rainfall intensity, slope geometry, and soil hydraulic properties, the runoff/infiltration process controls water pressure changes in both the saturated and unsaturated zones, affecting the behavior of shear strength and seepage forces, and, as a consequence, the slope stability. In this study, we tackle the whole process by using both numerical and physical approaches, the former being developed to design (a priori) and analyze (a posteriori) a number of experiments carried out in an ad hoc designed artificial hillslope. The maximum height of the embankment, contained in a reinforced concrete box, is 3.5 m, with length of 6 m and width of 2 m, so that a 2:3 slope can be built. On each lateral side of the box, 50 openings closed with screw caps allow the insertion on properly chosen positions of the control instrumentation (6 tensiometers and 6 TDR sensors). The monitoring network, connected to an automatic acquisition system, is completed by two piezometers, one evaporimeter, and two stream gages able to evaluate both the surface runoff and subsurface contributions to the total outflow. The numerical tool we use is a distributed physically-based catchment simulator (CATHY, CATchment Hydrology) able to model both surface routing and subsurface flow in a coupled fashion. In order to demonstrate the effectiveness of the proposed physical and numerical investigation approach, we report on the arrangement of laboratory facilities (including the non-trivial design and building of the rainfall simulator system), the theoretical design of physical experiments, and a preliminary analysis of experimental evidence.