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Hydrological Modelling of Slope Stability

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Landslides of any type, and particularly soil slips, pose a great threat in mountainous and steep terrain environments. One of the major triggering mechanisms for slope failures in shallow soils is the build-up of soil pore water pressure resulting in a decrease of effective stress. However, infiltration may have other effects both before and after slope failure. Especially, on steep slopes in shallow soils, soil slips can be triggered by a rapid drop in the apparent cohesion following a decrease in matric suction when a wetting front penetrates into the soil without generating positive pore pressures. These types of failures are very frequent in pre-alpine and alpine landscapes. The key factor for a realistic prediction of rainfall-induced landslides are the interdependence of shear strength and suction and the monitoring of suction changes during the cyclic wetting (due to infiltration) and drying (due to percolation and evaporation) processes. The non-unique relationship between suction and water content, expressed by the Soil Water Retention Curve, results in different values of suction and, therefore, of soil shear strength for the same water content, depending on whether the soil is being wetted (during storms) or dried (during inter-storm periods). We developed a physically based distributed in space and continuous in time model for the simulation of the hydrological triggering of shallow landslides at scales larger than a single slope. In this modeling effort particular weight is given to the modeling of hydrological processes in order to investigate the role of hydrological triggering mechanisms on soil changes leading to slip occurrences. Specifically, the 3D flow of water and the resulting water balance in the unsaturated and saturated zone is modeled using a Cellular Automata framework. The infinite slope analysis is coupled to the hydrological component of the model for the computation of slope stability. For the computation of the Factor of Safety a unified concept for effective stress under both saturated and unsaturated conditions has been used (Lu Ning and Godt Jonathan, WRR, 2010). A test case of a serious landslide event in Switzerland is investigated to assess the plausibility of the model and to verify its perfomance.