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A coupled stability and eco-hydrological model to predict shallow landslides

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Knowledge of spatio-temporal dynamics of soil water content, groundwater and infiltration processes is of considerable importance for the understanding and prediction of landslides. Rainfall and consequent water infiltration affect slope stability in various ways, mainly acting on the pore pressure distribution whose increase causes a decrease of the shearing resistance of the soil. For such reasons rainfall and transient changes in the hydrological systems are considered the most common triggers of landslides.
So far, the difficulty to monitor groundwater levels or soil moisture contents in unstable terrain have made modeling of landslide a complex issue. At the present, the availability of sophisticated hydrological and physically based models, able to simulate the main hydrological processes, has allowed the development of coupled hydrological-stability models able to predict when and where a failure could occur.
In this study, a slope-failure module, with capability to predict shallow landslides, implemented into an eco-hydrological model, tRIBS-VEGGIE (Triangulated Irregular Network (TIN)-based Real-time Integrated Basin Simulator with VEGetation Generator for Interactive Evolution), is presented. The model evaluates the stability dynamics in term of factor of safety consequent to the soil moisture dynamics, strictly depending on the textural soil characteristics and hillslope geometry.
Failure criterion used to derive factor of safety equation accounts for the stabilizing effect of matric suction arising in unsaturated soils. The eco-hydrological framework allows also to take into account the effect of vegetation with its cohesive effect as well as its weight load.
The Mameyes basin, located in the Luquillo Experimental Forest in Puerto Rico, has been selected for modeling based on the availability of soil, vegetation, topographical, meteorological and historic landslide data. A static analysis based on susceptibility mapping approach was also carried out on the same area at a larger spatial scale, providing the hot spot of landsliding area. Application of the model yields a temporal and spatial distribution of predicted rainfall-induced landslides.
Moreover, stability dynamics have been assessed for different meteorological forcing and soil types, to better evaluate the influence of hydrological dynamics on slope stability.