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Mapping failure probabilities over complex alpine terrain through transient hillslope hydrological modelling

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We present an innovative approach to investigating slope stability using a quasi-3D, physically based hydrological model, GEOtop, coupled with an infinite-slope type of stability model designed to handle uncertainty due to soil properties heterogeneity.

Many assumptions are usually made when dealing with forecasting landslide triggering; those assumptions mainly focus on steady-state hydrology and uniform soil properties and soil depth. The presented work is an effort toward removing these assumptions to better reproduce the physics of the triggering. The hydrology is reproduced through an improved version of the GEOtop model, which runs on a 3-dimensional grid built on a detailed topography and describes the temporal and spatial evolution of the water table, of the soil moisture content and of the matric suction. It also simulates the transient pore water pressure due to infiltration and redistribution processes, which is of primary importance in landslide triggering.
The stability analysis incorporates the dynamic description of soil moisture and tackles the heterogeneity of soil mechanical properties through a probabilistic approach which describes soil parameters as random variables. This approach not only maps the failure probability for a given area, but also allows to estimate the volume of sediment available for failure, providing, in such a way, a useful tool for planning and safety purposes.

To assess the capability of the model to reproduce the dynamic hillslope hydrology, triggering shallow landslides over complex topography, we have applied GEOtop and GEOtop-FS to an alpine area in Trentino region (Corda river basin, Italian Alps) in typical late spring conditions, when the snow melt plays an important role in hillslope hydrology. In addition, the availability of volumes of sediments potentially unstable over the all catchment area have been computed. Results have been compared to SHALSTAB
ś, underling the differences between a steady-state versus a dynamic approach and a uniform versus a probabilistc and heterogeneous approach.