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Time shift in slope failure prediction between unimodal and bimodal modeling approaches

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Together with the need to use more appropriate mathematical expressions for describing hydro-mechanical soil processes, a challenge issue relates to the need of considering the effects induced by terrain heterogeneities on the physical mechanisms, taking into account the implications of the heterogeneities in affecting time-dependent hydro-mechanical variables, would improve the prediction capacities of models, such as the ones used in early warning systems. The presence of the heterogeneities in partially-saturated slopes results in irregular propagation of the moisture and suction front. To mathematically represent the “dual-implication” generally induced by the heterogeneities in describing the hydraulic terrain behavior, several bimodal hydraulic models have been presented in literature and replaced the conventional sigmoidal/unimodal functions; this presupposes that the scale of the macrostructure is comparable with the local scale (Darcy scale), thus the Richards’ model can be assumed adequate to mathematically reproduce the processes. The purpose of this work is to focus on the differences in simulating flow infiltration processes and slope stability conditions originated from preliminary choices of hydraulic models and contextually between different approaches to evaluate the factor of safety (FoS). In particular, the results of two approaches are compared. The first one includes the conventional expression of the FoS under saturated conditions and the widespread used hydraulic model of van Genuchten-Mualem. The second approach includes a generalized FoS equation for infinite-slope model under variably saturated soil conditions (Lu and Godt, 2008) and the bimodal Romano et al.’s (2011) functions to describe the hydraulic response. The extension of the above mentioned approach to the bimodal context is based on an analytical method to assess the effects of the hydraulic properties on soil shear developed integrating a bimodal lognormal hydraulic function within the Bishop stress theory framework (Ciervo et al., 2015). The proposed work tends to emphasize how a more accurate slope stability analysis that accounts dual-structure could be useful to reach a more accurate definition of the stability conditions. The effects in practical analysis may be significant. The highlighted discrepancies between the different approaches in describing the timing processes and strength contribution due to capillary forces may entail no negligible differences in slope stability predictions, especially in those cases where the possibility of a failure in unsaturated terrains is contemplated.