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Comparison of 2D and 3D assessment of slope stability using the Local Factor of Safety concept

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Landslides occur as a result of failure in mechanical balance within slopes and any factor that influences the stress distribution can change the slope stability. It is well-known that slope stability is influenced by subsurface hydrological processes, since changes in water content of the soil as a result
of infiltration impact the matric suction and weight of the slope material and therefore the effective stress distribution. Consequently, slope morphology, soil depth, and soil hydraulic and mechanical properties are among the key factors determining slope stability. Most of the available models that couple hydromechanical processes use 1D or 2D representations of the subsurface, which may lead to an overly simplified representation of hydromechanical processes in the case of more complex subsurface layering. Therefore, the aim of this study was to develop a three-dimensional coupled hydromechanical model that is able to predict the spatial distribution of water content and stress at each point within the 3D hillslope and to compare slope stability predictions obtained from 2D and 3D models. For coupling the hydrological and mechanical processes, we relied on COMSOL Multiphysics. The Richards equation was used to describe transient unsaturated water flow, and the Local-Factor-of-Safety (LFS) concept was used to assess slope stability assuming linear elastic behavior until the point of slope failure (i.e. plastic deformation was not considered). In a first step, the 2D and 3D model implementations were successfully verified with an available 2D benchmark model that provides the LFS for a simple slope geometry. In a next step, slope stability predictions for 2D and 3D slopes with two layers of variable thickness and hydraulic parameters are compared in terms of water content and stress distribution and the resulting LFS distribution. The results show that simplified 2D simulations of hydromechanical processes lead to under- or overestimation of slope stability.