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Effect of soil heterogeneity on precursor events and landslide patterns

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Prediction of onset of hydrologically-induced shallow landslides is hampered by incomplete information regarding soil heterogeneity and hydrologic pathways which may result in abrupt and seemingly random soil mass release. Geomorphic and supplemental soil properties information is useful, but presently has been used primarily for producing conservative landslide susceptibility maps, disregarding the inherently local and progressive triggering mechanisms. We applied a physically-based hydro-mechanical landslide triggering model to systematically evaluate effects of soil heterogeneity on failure propagation and approach to criticality of a hillslope under hydrologic loading (rainfall). The model considers soil columns interconnected by mechanical bonds represented by virtual fiber bundles that capture multiscale mechanical elements (grain cementing agents, capillary water bonds, frictional forces and roots). The fiber bundle model capture progressive (local) failures that do not necessarily result in a landslide as load is redistributed to neighboring intact bonds. The accumulation and statistics of such precursor events reflect on the mechanical state of a hillslope and its attainment of criticality or eminent failure. The role of discontinuities in soil properties on the hydro-mechanical behavior of a hillslope and onset of landslide dynamics and patterns was studied numerically. Evidence suggest that with increasing degree of heterogeneity the likelihood of occurrence of large and disastrous landslide volumes diminishes due to multiple failure initiations at weak mechanical bonds disrupting and containing failed soil volumes.