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Modeling the hydrological and mechanical effect of roots in shallow landslide analysis

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The additional cohesion exercised by vegetation roots (cr) provides an important contribution to the slope stability. This study proposes a methodology for estimating the cr term in a hillslope landslide analysis within a coupled ecohydrological-stability model. The coupled model simulates the spatial distribution and temporal dynamics of the Factor of Safety (FS) as a function of soil moisture dynamics, by taking into account the hydrological effects of vegetation through the root water uptaking.
The additional mechanical root cohesion is estimated in a Fiber Bundle Model framework that allows for the evaluation of the root strength as a function of stress-strain relationships of populations of fibers. The use of such a model requires the knowledge of the root architecture to evaluate the additional reinforcement from each root diameter class. The root architecture is reproduced by fitting a probability density function to the distribution of the number of roots with depth, within a branching topology scheme based on the Leonardo's rule that gives an estimation of the root diameters. The methodology has been tested in a simple synthetic hillslope with different configurations of vegetation types, i.e. tree and shrubs, and soil types, i.e. clay and loam. Parameters of the topological model have been calibrated through observed depth profiles of root number, diameters and area of two species representative of the two considered vegetation types.
Preliminary results demonstrated the high flexibility of the topological model here used, with consistent and promising outcoms in terms of root cohesion, significantly lower than values obtained with the more popular Wu/Waldron model. The simple case study highlighted the importance of both the root mechanical resistance and the root interactions with the main eco-hydrological processes. The hydrological effect of roots can be more significant than the mechanical one, especially for tree species on clayey soils. The root cohesion effect becomes particularly significant at low values of FS (i.e. $\sim$1, failure proximity), especially for tree species. Further improvements of the work could take into account the weight of the plants, here neglected.