EGU23-7801, updated on 26 Feb 2024
https://doi.org/10.5194/egusphere-egu23-7801
EGU General Assembly 2023

Advancing slope stability computations in distributed hydrologic computations

Riccardo Bonomelli and Marco Pilotti
Università degli Studi di Brescia, Brescia,Italy (r.bonomelli@unibs.it)

Settlements in mountain areas can be endangered by the occurrence of landslides usually triggered by excessive rainfall events in the catchment. A major issue with hazard mapping is the identification of unstable zones. The Infinite Slope (IS) model coupled with suitable hydrologic hypothesis has frequently been used to assess soil instability at the catchment scale, usually overestimating instability. Moreover, its fundamental assumption that neglects all boundary contributions to equilibrium or motion may become less and less viable with the growing resolution of the elevation data nowadays available. To relax this assumption along the slope length we adopt the Janbu's method applied in a progressive manner. Dividing a generic slope into blocks, the Janbu's method is applied first to a single block (the bottom one) then to the collection of the first and second block, then to the first three and so on, up to the point in which the whole slope is considered. Multiple slopes can be analysed in this way, thus covering the entire catchment with computational costs comparable to the IS approach. Using this method, a slope can turn out as globally unstable due to the action of single blocks located along its length. The method is validated against simple slopes whose stability has already been studied in the geotechnical literature. Transient relative soil saturation at each cell is computed adopting a distributed hydrologic model coupled with the described slope stability model. The hydrologic model uses a raster representation of the watershed elevation that is pre-processed to compute a Space-Filling Drainage Network and a channel network upon which the Green-Ampt method together with the Darcy's equation are solved using suction, porosity, saturated permeability, and soil depth as parameters. A kinematic wave approach has been used to predict runoff and subsurface flows. Validation of the slope stability model shows that the Factor of Safety (FS) computed using the progressive Janbu's method converges to the predictions of more rigorous methods like Finite Elements method within reasonable accuracy on different saturation conditions. Application of the whole modelling chain to a watershed test case show less unstable areas with respect to the predictions of the IS model. This procedure can be applied to entire catchments using rainfall and soil characteristics as boundary conditions and parameters to output the stability of all the cells present in the domain as a function of time. The proposed approach may suggest a more rigorous way to compute the FS with respect to the IS model in catchment scale applications.