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Concepts of Self-Organized Criticality applied in hydro-mechanical modeling of landslide occurrence at catchment scale

Jonas von Ruette, Peter Lehmann, and Dani Or
ETH Zurich, Soil and Terrestrial Environmental Physics, Zurich, Switzerland (peter.lehmann@env.ethz.ch)

Landslide triggering may be characterized by coincidence of hydrologic loading, mechanical weakening and progressive "local" failures. Concepts of Self-Organized Criticality (SOC) enable representation of a catchment as an assembly of many hydro-mechanically linked elements in which exceedance of a local threshold may result in disproportionally large cascade of failures culminating in landslide release. The model consists of hexagonal columns of soil elements whose surface height is determined from digital elevation maps and auxiliary information is used to estimate depth and hydro-mechanical properties. Simple calculations of surface and subsurface water flows and loss to bedrock are made and water content-dependent resistive and driving forces at the shear plane between soil and bedrock are computed (local factor of safety). Cohesive forces at the base and between adjacent soil elements are represented by Fiber Bundle Models (FBM) to accommodate observed progressive failure behavior. In contrast with standard SOC models, stress can only be redistributed to neighbored elements when the fiber bundle in between is intact. The model was tested using a case study where an intense rainfall event triggered 35 landslides in a 1.4 square kilometers catchment in Switzerland. Based on limited information regarding soil depth and distribution of hydro-mechanical properties, we computed position and size of landslides and compared the results with observations.