Geophysical Research Abstracts
Vol. 15, EGU2013-2642-1, 2013
EGU General Assembly 2013

The influence of preferential flow on slope stability

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Slope failures triggered by heavy rainfall are common geological disasters around the world, because rainfall caused pore-pressure increase will reduce the soil shear strength and influence the slope stability. Physically-based subsurface hydrological models are frequently integrated with slope stability analysis methods to evaluate which areas are susceptible for landslides. In structured soil, preferential flow can change the pattern of the infiltration process, resulting in more rapid and deeper water movement. For highly-heterogeneous slopes, the influence of preferential flow on the distribution of pore water pressure and slope stability has not been studied thoroughly yet. In this study, the COMSOL Multiphysics finite element software package is used to model the hydrological and soil mechanical processes. A two-dimensional hydro-mechanical model framework composed of a subsurface flow module and a slope stability analysis module was built to evaluate the influence of preferential flow on subsurface flow and consequent slope stability.
The subsurface flow module consists of a dual-permeability model, which can be used to quantify the influence of preferential flow on distribution and timing of the pressure head in a slope. The dual-permeability model divides the soil into matrix domain and preferential flow domain, and the water flow is described by two coupled Richard's equations. The slope stability analysis module is composed of an elastic solid mechanics model and a local factor of safety algorithm. The total principle stress distribution is calculated by a solid mechanics module for plane-strain elastic analyses. The local factor of safety is defined as the ratio of the Coulomb stress at the current state of stress to the Coulomb stress of the potential failure state under the Mohr-Coulomb criterion. In this study the focus will be on the temporal and spatial distribution of the local factor of safety. Eventually, the influence of preferential flow on slope stability can be evaluated by comparing the results of the single-permeability model and the dual-permeability model.