Geophysical Research Abstracts
Vol. 14, EGU2012-5378, 2012
EGU General Assembly 2012

Rainfall triggered landslides in unsaturated soils: a numerical sensitivity analysis for rainfall threshold

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Catastrophic precipitation-induced landslides have frequently hit villages, towns and roads in Black Sea Region in northern Turkey, causing extensive damage and many fatalities. Due to global climatic changes, the intensity and frequency of extreme rainfall events are expected to increase. In addition, due to limited available land on level ground, urbanization continue to increase on sloping ground which increases the exposure and elements at risk. Most available methods for predicting rainfall-induced slope instability are based on statistical data of past slope failures and rainfall events. These may often give conservative or unconservative faulty warnings, so a physically-based model that takes into account the mechanism of the problem should be incorporated for more accurate warning system.

In this study, main aspects of rainfall triggered landslides, such as infiltration in an unsaturated soil profile, changes in soil suction and shear strength, development of instability in terms of factor of safety and deformations have been studied numerically. The factors/issues that govern this mechanism have been evaluated and a sensitivity analysis is performed using finite element method. We propose a simple 2D numerical approach that is able to predict the evolution of the key factors governing slope stability as a tool to predict the onset of slope failure, with potential benefits for early warning systems. The effect of antecedent rainfall, and different rainfall intensity-duration schemes (short duration intense rainfall, prolonged low intensity rainfall etc.) are considered in evaluating the threshold critical rainfall that may trigger landslides. The approach is calibrated through a well-documented case history, for which the results will be presented in terms of soil suction, deformation and factor of safety versus time and predicted triggering rainfall. The proposed method can be a first-step towards an integrated early warning system for rainfall triggered landslides that considers the physical mechanism of the problem.