Geophysical Research Abstracts, Vol. 7, 02522, 2005
SRef-ID: 1607-7962/gra/EGU05-A-02522

Distributed physically-based slope stability models as forecasting tools to define hydro-climatic thresholds for rainfall-induced landslides.

J.-P. Malet (1), R. Van Beek (1), Y. Thiery (2), O. Maquaire (3)

(1) Faculty of Geosciences, University of Utrecht, The Netherlands, (2) Institute of Global Physics, UMR 7516 CNRS, Strasbourg, France (3) Physical Geography and Environment, UMR 6554 CNRS, Caen, France. (j.malet@geog.uu.nl / Phone: +31-30-253-4014)

Intense or prolonged rainfalls repeatedly trigger shallow soil slips, rock block slides or more complex mudslides-earthflows in clay-shale outcrops of Southeast France. Predictions of Global Change suggest that the Mediterranean environment will experience a higher frequency of extreme rainfall events. This is likely to increase the frequency of saturated conditions and high groundwater levels in soils, triggering more rainfall-induced landslides.

Landslide hazard assessment is often restricted to statistical analyses to define empirical hydro-climatic thresholds based on rainfall intensity-duration curves. This approach ignores the physical processes by which water infiltration affects the stability of hillslopes and limits the ability to predict and quantify the hazard. Therefore, where historical data are not statistically significant, an innovative way to quantitatively assess the stability of hillslopes is the application of physically-based coupled hydro-mechanical models. This approach may mitigate the lack of precise pluviometric data on landslide-prone sites.

The Barcelonnette Basin (Alpes-de-Haute-Provence, France) experiences extensive slope failures induced by rainfall. The three types of landslides observed are clearly related with local geology and climate characteristics. Shallow soil slips are observed along gentle slopes cut in moraine deposits; rock-block slides occurred along clay-shales gullies, sometimes at the shallow regolith-bedrock interface, sometimes in depth along bedding planes and structural discontinuities; finally, mudslides-earthflows are located in large formerly drained thalwegs. The three phenomena are controlled by pore pressure variations resulting from long duration rainfall and snowmelt.

Back-analyses of events representative of the three types of landslides have been performed with a coupled model of transient slope hydrology and stability to establish hydro-climatic thresholds. The model includes an unsaturated/saturated hydrological component incorporating Darcian saturated flow, meltwater flow, and preferential flow through fissures. The model is dynamic and distributed. The stability analysis is a limit equilibrium model based on the Mohr-Coulomb failure criterion.

The calibration of the model allows to define soil moisture and pore water pressure thresholds for slope failures, and to propose climatic physically-based rainfall thresholds for hazard assessment. The relevance of these thresholds is discussed and compared to the statistical thresholds established in the Mediterranean environment.