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1 Identification of critical rainfall thresholds for shallow landslides. Application for hazard assessment.

J.-P. Malet, Van Beek L.P.H., Van Asch Th.W.J.
Faculty of Geosciences, Utrecht University, The Netherlands.

Analyzing the relationship between slope failure and rainfall is of paramount importance to quantify landslide hazard. However, landslide hazard assessment is often restricted to statistical analyses to define critical thresholds based on rainfall intensity-duration curves. This approach ignores the physical processes by which water infiltration affects the stability of the hillslopes and limits the ability to predict and quantify the hazard. Therefore, where historical data on landslide triggering dates are not statistically significant, an innovative way to quantitatively assess the stability of the hillslopes is the application of physically-based hydro-mechanical models. This approach may also mitigate the lack a close pluviometric network in the study area

The Barcelonnette Basin (South French Alps) experience 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 or colluvial 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. The model

includes an unsaturated/saturated hydrological component incorporating Darcian saturated 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 thresholds for hazard assessment. The threshold relation indicates that for rainfall of short duration (about 1 h), intensities > 36 mm.h^{-1}, are required to trigger landslides. These storms trigger mostly shallow soil slips and rock block slides by causing an excess pore pressure in shallow colluvial zones. At the opposite, low average intensities of about 4 mm.h^{-1} appear to be sufficient to cause the reactivation of medium-depth mudslides-earthflows.