Geophysical Research Abstracts, Vol. 9, 04361, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-04361

Statistical and physically-based approaches for probabilistic rainfall thresholds of shallow landslide

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Rainfall ID (Intensity-Duration) thresholds for the triggering of shallow landslides are useful technical tools in managing hazard deriving by exceptional rainfall events. In order to define rainfall thresholds accounting for different triggering probability, we developed and compared two different approaches. First, we applied logistic regression to reclassify the rainfall events into "landslide" and "non-landslide" events and to define, for each combination of intensity and duration, the probability to belong to the "landslide" rainfall events. We interpret this membership probability as a triggering probability. Then, we applied a Monte Carlo simulation to a simple spatially distributed pore-pressure diffusion model. For each rainfall duration and intensity (I-D), we obtained different percentages of unstable area associated to different failure probabilities. Observing the percentage of unstable area as a function of the rainfall intensity, for fixed rainfall durations and failure probabilities, we found a logarithmic behaviour that describe a slope-gradient exhaustion model. From the simulation results, we could trace two different typologies of rainfall thresholds: (1) "degree of severity" thresholds, that account for the percentage of potential unstable area at a fixed of failure probability, and (2) stochastic thresholds, that account for the failure probability at a fixed percentage of unstable area. In order to assign a return period to the triggering rainfall, we applied a Gumbel scaling model to obtain IDF (Intensity-Duration-Frequency) functions for the study area. Considering that the pore-pressure linear diffusion model is valid only with quasi-saturated soils, we built different IDF by imposing a condition of increasing antecedent rainfall. This condition guarantees in simple terms a quasi-saturated hydrological state. As a result, the return period of triggering rainfall increases up to several order of magnitudes especially for short-duration rainfall. Examples have been prepared for a study area located in the Italian Central Alps (Esino and Pioverna river basins, 300 sqkm).