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Spatiotemporal hazard assessment of rainfall-induced shallow landslides in Italy

L. Montrasio (1), R. Valentino (1), G.L. Losi (1), A. Corina (2), L. Rossi (3), and R. Rudari (3)

(1) Department of Civil, Environmental, Territory Engineering and Architecture University of Parma Viale G.P. Usberti 181/A 43100 Parma - Italy, (2) Department of National Civil Protection Via Vitorchiano 2 00189 Roma – Italy, (3) CIMA Research Foundation – International Centre on Environmental Monitoring Via A. Magliotto 2 17100 Savona – Italy

The use of real-time early warning systems for shallow rainfall-induced landslides is attracting the attention of the scientific community, even if effective landslide warnings are far from reality in most landslide-prone areas. Some of these systems, which are based on empirical precipitation thresholds for landslide occurrence, are starting to be used more and more as a tool in territory administration, since they allow a “dynamic” (time varying) monitoring on regional scale and environmental management. It is clear that the most innovative systems require coupling between rainfall amounts, hydrological models, and slope-stability models, without disregarding the interaction between the different aspects of the problem. The paper deals with the application, on a regional scale in the Italian territory, of a physically-based stability model (SLIP - Shallow Landslides Instability Prediction). The SLIP model has been firstly developed at the Department of Civil Engineering of University of Parma since 1997, to describe the triggering mechanism of soil slips. More recently the SLIP model has been adopted by the Department of National Civil Protection as a prototype early warning system for rainfall-induced landslides in Italy, using rainfall data and geospatial datasets. The model, which is based on the limit equilibrium method, is deliberately simplified, in order to evaluate the safety factor of a slope in function of the geotechnical characteristic of soil, of geometrical features of the slope and of rainfall depth.
A back analysis concerning the occurrence of some recent case-histories of soil slips in the Italian territory is carried out and the main results are shown. The main features of the SLIP model are briefly recalled and particular attention is devoted to the discussion of the input data, which have been collected through a Geographic Information System (GIS) platform. Results of the slope-stability analysis on national scale, over a one year time interval (October 2009 – October 2010), are finally presented. The results predicted by the SLIP model are analyzed in terms of safety factor (Fs) maps, corresponding to some particular rainfall events. The paper shows the comparison between observed landslide localizations and model predictions. Notwithstanding an improvement in terms of accuracy is needed, the application of the model on the study area guarantees a good agreement between the instability condition and the expected date and localization of the considered events. The obtained results suggest that the output of the SLIP model could be used to define different levels of “dynamic” susceptibility. If coupled with a model of forecast rainfall, SLIP could be the basis for the development of an early-warning alert system against the phenomena of interest, especially if adopted as a local scale tool, in the framework of an alert system at a wider scale.