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Prediction of rainfall-induced shallow landslides at national scale in Italy

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In Italy, landslides are very frequent, widespread and dangerous phenomena. In the last decades, climate changes, which provoked weather conditions characterized by localized rainfall events of high intensity and short duration, together with modifications of land use and an increase of urban areas, have led to a progressive increase of the frequency and extent of rainfall-induced landslides. These phenomena caused, in turn, considerable damage to structures, infrastructure and crops, as well as casualties. These natural and anthropogenic factors determine a series of hydrogeological problems for both land resource and for inhabited areas, industrial areas and for the infrastructural network. The need for a continued monitoring activity that ensures the preservation of life and human activities, and for a real-time assessment of landslide risk, in close correlation with rainfall forecasts, is therefore increasing.
The paper deals with the application, on national scale in the Italian territory, of the physically-based stability model SLIP (Shallow Landslides Instability Prediction). The SLIP model has been firstly developed at the Department of Civil Engineering at the University of Parma since 1997, in order to describe the triggering mechanism of rainfall-induced landslides. More recently, the SLIP model has been tested 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 characteristics of the soil, the geometrical features of the slope and the rainfall depth.
A back analysis concerning the occurrence of some recent case-histories of rainfall-induced shallow landslides 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 two year time interval (2011 – 2012), 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 selected 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.