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A simplified approach for rainfall-induced shallow landslide and debris flow hazard assessment

Diana Salciarini, Claudio Tamagnini, and Pietro Conversini
University of Perugia, Department of Civil and Environmental Engineering, Perugia, Italy (diana@unipg.it)

As widely known, to produce reliable hazard maps for shallow landslide and debris flow hazard, two information are of primary importance: (i) the location of the triggering areas, and (ii) the traveling distance of the moving mass from the source points. In the current literature, a considerable number of "physically-based" models have been developed to reproduce the landslide triggering process (see, e.g., Montgomery and Dietrich, 1994; Savage et al. 2003; Frattini et. al., 2004; Baum et al. 2008) but, typically, they are unable to combine the simulation of the slope failure inception with the analysis of the subsequent mass propagation at large scale. Due to the complexity of the processes involved, the quantitative analysis of both stages of the phenomenon requires the introduction of several simplifying assumptions.

In this work a simplified approach to forecast the location of the source areas for rainfall induced shallow landslides and their traveling paths is presented. Such an approach is based on a two-step analysis. First, the TRIGRS model (Baum et al. 2008) is adopted to produce susceptibility maps; then, a simple hydrological flow routing (O'Callaghan & Mark, 1984) is used to simulate debris flow runouts resulting from the source areas highlighted by the susceptibility analysis. The two-step approach has been implemented in a GIS platform, to produce hazard maps that include information on the probability that a grid cell of the discretized domain considered can be reached by the mass, in a given return time. Since the simplified flow routing model cannot represent rigorously the physical behavior of a debris flows, and does not consider the geotechnical characteristics of the flow channel, the approach presented herein is mainly aimed at regional-scale forecasts, where a first-order assessment can be used from stakeholders as a starting point for more detailed investigations.

The model has been applied to a study area of about 80 km2, located in the central Italy. For this study, a database of shallow landslides and debris flows occurred in the past has been specifically developed, starting from the information provided by the AVI Project, the Landslide Inventory map produced by the Italian National Research Council (CNR), and the PAI Project. Four scenarios have been considered in the simulations, with rainfalls of different durations and intensities. The comparison of the predictions with the available landslide databases indicates that the model is a robust tool for regional hazard predictions.