New approaches for the assessment of the return period of shallow landslides

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Rainfall–induced shallow landslides have been recognized as important sources of risk in mountain areas. In order to study these phenomena in the framework of natural hazards, it is important to assess both the potential location of landslide-prone areas, and the return period of the landslides.

Different GIS-based models have been developed to deal with the first issue. These analyses have been favoured by the development of simplified 1D hydrological models (Montgomery and Dietrich, 1994; Iverson, 2000) and the availability of new high resolution DTMs.

The assessment of return period of rainfall-induced landslides has been normally performed by associating rainfall I-D frequency curves (IDF) with landslide-triggering rainfall thresholds (Iida, 2004; Rosso et al, 2006; D'Odorico and Fagherazzi, 2003). This is a strong simplification because, in general, the same rainfall I-D leads to different landslide probabilities according to different initial water content.

In this contribution, we develop a method that allows to calculate rainfall I-D frequency curves (IDF) accounting for the antecedent rainfall conditions. The corrected IDF are then used to assign return periods to probabilistic landslide-triggering rainfall thresholds developed using two different approaches. First, we apply a logistical regression model to discriminate between rainfall events that triggered or not landslides, and we obtain a set of thresholds, that express the I-D needed to trigger landslides with different levels of probability. Then, we develop a stochastic simulation of rainfall-induced landslide triggering by using a diffusive transient physically based model (Iverson, 2000), and we derive a set of thresholds, that express the I-D responsible to destabilize different percentages of the area with different probabilities of failure.

By assigning a return period to the triggering thresholds, we develop exceedence probability-intensity functions for shallow landslides, where the intensity of landsliding is expressed as the percentage of the area that can be destabilized during a single event. These curves, coupled with maps of landslide susceptibility, can be finally used for a rigorous assessment of landslide hazard.

We applied this approach in a study area located on the eastern side of Lake of Como

(Lombardy Region, Northern Italy). The area includes the Pioverna and Esino river basins, 180 km2 in size, and is situated between 200 m and 2600 m a.s.l.. This area has been selected because of the availability of pre-existing hydrological, physical, and mechanical soil data needed for model calibration (Crosta and Frattini, 2003; Bathurst et al, 2005).