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Probabilistic rainfall thresholds for debris flows triggering in pyroclastic soil mantled slopes of Campania (southern Italy)

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As reported by the chronicles of the last century and by the occurrences in recent years, the mountain ranges that surround the Somma-Vesuvius volcano are intensely affected by dangerous rainfall-triggered debris flows, which involve ash-fall pyroclastic deposits mantling slopes. In this framework, the proper identification of rainfall thresholds for landslides triggering is a challenging issue for the risk reduction in the towns located at the feet of the mountain slopes.

We carried out a research focused on the analysis of rainfall conditions that have triggered debris flows events whose occurrences were reported in chronicle sources since the beginning of the last century and collected in landslide archives. The rainfall data of the day of the landslide event and of the antecedent period were chosen among those recorded by the most representative raingauge stations of the area in which the landslides have occurred. The rainfall events, which did not trigger landslides, were also considered through the acquisition of historical rainfall sequences derived from the most representative raingauge stations.

Rainfall thresholds were reconstructed considering two known hydrological empirical models, the first based on the intensity and duration (I-D) of the triggering rainfall and the second based on the triggering rainfall cumulated in the day of the event compared with the antecedent cumulated rainfalls (P-Pa). For each of the examined rainfall conditions that triggered debris flows, the return times were estimated allowing the evaluation of the significance of the collected rainfall data.

The rainfall thresholds for triggering debris flows were calculated with a probabilistic approach by means of the bivariate logistic regression model. Moreover, the conditional probability of the landslide occurrence, considering also the probability of occurrence of rainfall conditions, was estimated. All collected data were used to obtain probabilities of slope failure with different combinations of rainfall intensity and duration as well as different combinations of rainfalls in the day of the landslide event and the antecedent rainfalls.

The logistic regression model was found as a suitable method for analysing the rainfall data, related to landslide and non-landslide events, which were scattered and overlapped due to biasing factors such as the not representativeness of the rainfall records respect to real values fallen in the landslide source area and the different hydrogeomorphologic conditions of each landslides. The obtained results indicated a reduction of the conditional probability of landslide occurrence for rainfall events associated with high values of the return period, while, for the events associated with values of return period under 10 years, a value not very different from the normal probability.