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Comparison between empirical and physically-based thresholds for the occurrence of shallow landslides in hillslopes with clayey soils of Northern Italian Apennines

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Rainfall thresholds define the conditions leading to the triggering of shallow landslides over wide areas. They can be empirical, which exploit past rainfall data and landslide inventories, or physically-based, which integrate slope physical–hydrological modeling and stability analyses.

A comparison between these two types of thresholds was performed in this work, using data acquired in hillslopes characterized by clayey soils of Oltrepò Pavese (Northern Italian Apennines), to evaluate their reliability. Empirical thresholds were reconstructed based on rainfalls and landslides triggering events collected from 2000 to 2018. The same rainfall events were implemented in a physically-based model of a representative test-site susceptible to shallow landslides, considerino different antecedent pore-water pressures, chosen according to the analysis of field hydrological monitoring data.

Soil hydrological conditions have a primary role on predisposing or preventing slope failures. In clayey soils of Oltrepò Pavese area, cold and wet months are the most susceptible periods, due to the permanence of saturated or close-to-saturation soil conditions. The lower the pore-water pressure is at the beginning of an event, the higher the amount of rain required to trigger shallow failures is. Physically-based thresholds provide a better reliability in discriminating the events which could or could not trigger slope failures than empirical thresholds. The latter provide a significant number of false positives, due to neglecting the antecedent soil hydrological conditions. These results represent a fundamental basis for the choice of the best thresholds to be implemented in a reliable early warning system.