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# Spatial estimation of debris flows-triggering rainfall and its dependence on rainfall severity

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Forecasting the occurrence of landslides and debris flows (collectively termed 'debris flows' hereinafter) is fundamental for issuing hazard warnings, and focuses largely on rainfall as a triggering agent. Debris flow forecasting relies very often on the identification of combinations of depth and duration of rainfall – rainfall thresholds - that trigger widespread debris flows. Rainfall estimation errors related to the sparse nature of raingauge data are enhanced in case of convective rainfall events characterized by limited spatial extent. Such errors have been shown to cause underestimation of the rainfall thresholds and, thus, less efficient forecasts of debris flows occurrence.
This work examines the spatial organization of debris flows-triggering rainfall around the debris flow initiation points using high-resolution, carefully corrected radar data for a set of short duration (<30 h) storm events occurred in the eastern Italian Alps. The set includes eleven debris-flow triggering rainfall events that occurred in the study area between 2005 and 2014. The selected events are among the most severe in the region during this period and triggered a total of 99 debris flows that caused significant damage to people and infrastructures.
We show that the spatial rainfall organisation depends on the severity (measured via the estimated return time-RT) of the debris flow-triggering rainfall. For more frequent events (RT<20 yrs) the rainfall spatial pattern systematically shows that debris flow location coincides with a local minimum, whereas for less frequent events (RT>20 yrs) the triggering rainfall presents a local peak corresponding to the debris flow initiation point. Dependence of these features on rainfall duration is quite limited.
The characteristics of the spatial rainfall organisation are exploited to understand the performances and results of three different rainfall interpolation techniques: nearest neighbour (NN), inverse distance weighting (IDW) and ordinary kriging (OK). We show that the features of the spatial organization of the debris flow triggering rainfall explain the biases in the identification of the rainfall thresholds when these thresholds are identified by using raingauges at a given distance from the debris flow initiation point. More specifically, rainfall overestimation (underestimation) is reported for more (less) frequent events. Overall, the method which uses the nearest measurement points (NN) is always characterised by less bias and high estimation variance with respect to the other interpolation techniques.