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Identification of debris flows occurrence thresholds: rainfall spatial aggregation outperforms raingauge sampling

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Regional early-warning systems for debris flows are often based on rainfall thresholds: empirical relationships between the depth (or intensity) and duration of the triggering rainfall identified from past events. Rain gauge based thresholds have been used in different regions worldwide but their implementation is conditional to the existence of in-situ observations and their accuracy is thus limited. Satellite precipitation products provide global debris flow-concurrent estimates over areas poorly covered by rain gauge networks or radar systems. Deriving local, regional or global thresholds from such datasets promises to increase the size of the training datasets and to allow consistently comparing thresholds for different regions and/or periods. However, satellite estimation of debris flow triggering rainfall is hampered by two issues: (a) the coarse resolution of satellite products and (b) the uncertainty related to precipitation retrieval algorithms. This study aims at isolating the contribution of the coarse resolution of satellite precipitation products in the derivation of debris flows occurrence thresholds.

The work builds upon high-resolution (1 km, 5 min), adjusted weather radar estimates for 11 storms, which collectively triggered 99 debris flows in the eastern Italian alps. First, we analyze the impact of spatial aggregation on the identification of triggering rainfall characterized by different return periods and we show how these observations influence the derivation of depth-duration thresholds. Second, we compare the thresholds derived aggregated estimates to the ones obtained from rain gauge networks of different densities. Results from this study are summarised as follows. (a) The impact of spatial aggregation depends on the return period of the triggering rainfall: aggregated estimates for long return periods (>∼10 years) are consistently underestimated while aggregated estimates for short return periods (<∼10 years) are more variable and generally overestimated below ∼15 km grid size. (b) Thresholds derived from estimates aggregated up to 20 km grid size show less than 25% variations, while thresholds from synthetic rain gauge networks of 1/10, 1/20, 1/50 and 1/100 km-2 densities are underestimated by ∼25%, 35%, 50% and 65%, respectively.