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Post-earthquake changes in debris flow susceptibility in the Upper Minjiang catchment (Sichuan, China), as revealed by meteorological and hydro-meteorological thresholds

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On May 12, 2008, a Mw 7.9 earthquake struck Wenchuan, Longmen Shan Area, in western Sichuan, China, at the eastern margin of the Tibetan Plateau. This earthquake was the largest and most destructive event in the last 60 years, causing more than 87000 casualties. The economic loss was estimated at some 1100 billion RMB. The major fault rupture produced surface displacements up to 3-4 meters, spreading from the epicenter (near the town of Yingxiu) for 240 km along the mountain range.

The Wenchuan Earthquake triggered almost 200000 co-seismic landslides over a region larger than 110000 km², leading to the accumulation of large volumes of loose material either along slopes or in gullies. After the earthquake, this material caused a strong increase of debris flow occurrence in the subsequent years, mainly in the worst-hit areas, such as Wenchuan, Beichuan and Mao counties. During the years immediately after the earthquake, the rainfall required for debris flow triggering resulted clearly smaller than before (Guo et al., 2016). Afterwards, the response of the debris deposits to rainfall changed, leading to a general recovery of stability and a reduction of debris flow frequency and magnitude (Domènech et al., 2019).

In this study, the assessment of debris flows occurrence throughout upper Minjiang catchment, to which Wenchuan county belongs, is modeled with two empirical approaches, both based on the available record of precipitations and debris flows in the years 2008-2015. In the first approach, a threshold to predict debris flow occurrence is defined based on intensity and duration of potentially triggering rainfall events (meteorological threshold). With the second approach, also the hydrological conditions predisposing the slopes to debris flows are considered, by assessing the water balance in the catchment with a simplified lumped hydrological model, based on the Budyko framework (Zhang et al., 2008), and defining a threshold to predict debris flows based on rainfall depth and estimated soil storage prior the onset of rainfall (hydro-meteorological threshold).

The obtained results indicate that the hydro-meteorological threshold allows catching the progressive recovery of stability of the debris deposits much better than the meteorological

threshold, leading to identification of increasing thresholds, both in terms of pre-event soil storage and triggering rainfall amount, in the years from 2008 onward. Such a result shows that the adoption of process-based approaches, even empirical and strongly simplified as in the presented case, leads to predictions of debris flow occurrence more robust than those based solely on rainfall information.

References

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