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Frequentist rainfall thresholds for landslide forecasting in the Darjeeling and Nilgiris districts in India

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India is heavily affected by rainfall-induced landslides that cause fatalities and damage. Therefore, the development of effective and reliable models for the landslide forecasting and their possible integration in early warning systems (LEWSs) is necessary to mitigate the risk posed by such phenomena. Within the LANDSLIP (LANDSLIde Multi-Hazard Risk Assessment, Preparedness and Early Warning in South Asia: Integrating Meteorology, Landscape and Society; www.landslip.org) project, we developed threshold-based forecasting models to predict the occurrence of rainfall-induced landslides. The models were calibrated in two Indian pilot areas: the Darjeeling and Nilgiris districts, in the states of West Bengal and Tamil Nadu, respectively. For the purpose, we built two catalogs of 84 and 116 rainfall conditions likely responsible for landslide triggering in Darjeeling and Nilgiris, respectively, and daily rainfall measurements, which were used to define frequentist rainfall thresholds at different non-exceedance probabilities by means of an automatic tool (CTRL-T). A revision of the methodology to identify the rainfall conditions that triggered the failures was necessary due to possible inaccuracies in the landslide occurrence date and the daily temporal resolution of rainfall measurements in India. Triggering rainfall conditions were also related to the different monsoon regimes in the study areas. For a few uncertain events, the rainfall conditions automatically reconstructed by CTRL-T were revised after a consensus among several investigators. In agreement with the rainfall regimes of the two pilot areas, the thresholds for Darjeeling are higher than those for Nilgiris; regardless of the rainfall duration, a larger amount of rainfall is necessary to trigger landslides in the Darjeeling area.

Despite some limitations, mostly due to the daily temporal resolution of rainfall data and the spatial and temporal distribution of the reported landslides, the uncertainties of the calculated thresholds were acceptable (also thanks to the double checking) to allow their implementation in the LANDSLIP prototype LEWS.

The thresholds require ongoing evaluation and refinement. For the purpose, additional landslide and rainfall data were used to validate thresholds and improve forecasts.