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Towards More Reliable Debris Flow Rainfall ID Thresholds under Changing Climate Scenarios

Early warning systems (EWSs) are recognized globally as the most efficient and cost-effective strategy for mitigating debris flow risk. Most contemporary EWS rely on Rainfall Intensity-Duration (ID) thresholds due to their extended lead time. However, two critical limitations challenge the efficacy of conventional methods: data scarcity in remote or hazardous areas often precludes the derivation of robust thresholds, and the increasing complexity of unpredictable climate change compromises thresholds built solely on historical records.
Here, we propose a novel physics-informed framework to generate and validate ID thresholds applicable under various climatic conditions. Our approach begins by developing a calibrated physical model of a small catchment. We then bypass the historical data dependency by utilizing stochastic generation to produce thousands of idealized rainfall scenarios. The model enables more accurate rainfall ID thresholds to be determined and allows us to successfully identify debris flow event. Furthermore, this study offers effective, transferable support for establishing highly reliable rainfall EWSs, particularly in ungauged and data-scarce catchments highly vulnerable to climate shifts.

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