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Physically based modeling of rainfall thresholds for the onset of landslides

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Empirical rainfall-based thresholds for landslide triggering are widely used for early warning in mountainous regions. These often site-specific and method-sensitive thresholds use rainfall intensity-duration relations deduced from historical records irrespective of initial soil moisture conditions and recent rainfall. The study seeks to inject various physical insights to such practical and useful thresholds by linking rainfall with soil water state and soil mechanical thresholds. The physical links are established via systematic evaluation of scenarios generated by a hydro-mechanical landslide model STEP-TRAMM. The STEP-TRAMM combines hydrological description of infiltration and flow with spatially resolved (local) landslide threshold mechanics applied at catchment scales. Model inputs are derived from publically available DEM, soil type, land cover and precipitation record that enable application of the threshold construction for any region globally. We modelled landslide triggering in several catchments by varying initial wetness and rainfall intensity-duration to identify critical landslide triggering scenarios (and resulting landslide characteristics). The resulting rainfall-based thresholds improve predictability (less false positive predictions) relative to traditional rainfall intensity-duration relations due to simultaneous consideration of rainfall metrics (amounts) and antecedent wetness of the landscape. We envision applications of the method to regions (i) lacking historical landslide record, (ii) experiencing rapid and massive land-use changes (deforestation) and (iii) for prediction of potential impacts of climate change (rainfall characteristics) on landslide hazard.