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A modified frequentist approach for susceptibility-based antecedent rainfall thresholds for landslide occurrence

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Rainfall is widely recognized as an important trigger for landslides, posing an increased threat to people and economies worldwide under climate change conditions. While major improvements have been made towards more reproducible techniques for the identification of triggering conditions for landsliding, the now well-established rainfall intensity or event – duration thresholds for landsliding suffer from several limitations. Here, we propose a new rainfall threshold approach fundamentally different from previous research and based on the trigger - cause relation between antecedent rainfall and landslide susceptibility through a modified frequentist approach which quantitatively exploits the lower parts of the cloud of data points, most meaningful for threshold estimation. Adopting a bootstrap statistical technique for the identification of threshold uncertainties at different exceedance probability levels, it results in thresholds expressed as AR=($\alpha \pm \Delta\alpha$)*S^($\beta \pm \Delta\beta$), where AR is antecedent rainfall (mm), S is landslide susceptibility, α and β are scaling parameters, and $\Delta\alpha$ and $\Delta\beta$ are their uncertainties. This method has the main advantage of directly mappable susceptibility-dependent rainfall thresholds. Six-week long antecedent rainfall is calculated using a newly developed exponential filter function with a time constant scaled by a power of daily rainfall accounting for the dependence on rainfall intensity of the decaying effect of rain water in the soil. The approach is designed for the use of spatially continuous satellite rainfall data, allowing threshold calibration for areas lacking a dense rain gauge network. We apply our approach in the western branch of the East African Rift based on landslides that occurred between 2001 and 2018, satellite rainfall estimates from the Tropical Rainfall Measurement Mission Multi-satellite Precipitation Analysis (TMPA 3B42 RT), and the continental-scale map of landslide susceptibility of Broeckx et al. (2018) and provide first regional rainfall thresholds for landsliding in tropical Africa.