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Empirical rainfall threshold for deep-rotational landslides in clay-rich tephra

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Rainfall-induced changes in the hydrological system are among the most important triggers of slope movements. Altered pyroclastic (tephra) deposits are especially vulnerable to slope failure, because they commonly form slopes of high porosity and high clay content. Empirical thresholds relate rainfall characteristics that triggered landslides in the past. They are found useful to predict triggering of shallow-translational landslides in various environments and soil types worldwide. However, till now there is no clear understanding whether or not these rainfall thresholds are applicable to deep-seated rotational landslides. By analyzing a long-term record of rainfall and piezometer data from a slide-prone coastal area in New Zealand, we show that global rainfall thresholds are not only applicable to triggering of shallow-translational but also to deep-rotation landslides in clayey, halloysitic tephra. We combined rainfall characteristics with the pore water pressure development in the slope and found a new threshold which marks the initiation of pore water pressure increase in the slope. For rainfall events above this new threshold, pore water pressure increase reduced the effective stress in the slope to different extent. In our study, slope failure was always triggered when the pore water pressure reduced the effective stress by more than 30 %. We suggest one may use this new effective stress threshold for assessing the beginning of rainfall-induced instability in other regions around the world.