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Rainfall thresholds and susceptibility mapping for shallow landslides and debris flows in Scotland

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Shallow translational slides and debris flows (hereafter 'landslides') pose a significant threat to life and cause significant annual economic impacts (e.g. by damage and disruption of infrastructure). The focus of this research is on the definition of objective rainfall thresholds using a weather radar system and landslide susceptibility mapping. In the study area Scotland, an inventory of 75 known landslides was used for the period 2003 to 2016. First, the effect of using different rain records (i.e. time series length) on two threshold selection techniques in receiver operating characteristic (ROC) analysis was evaluated. The results show that thresholds selected by 'Threat Score' (minimising false alarms) are sensitive to rain record length and which is not routinely considered, whereas thresholds selected using 'Optimal Point' (minimising failed alarms) are not; therefore these may be suited to establishing lower limit thresholds and be of interest to those developing early warning systems. Robust thresholds are found for combinations of normalised rain duration and accumulation at 1 and 12 day's antecedence respectively; these are normalised using the rainy-day normal and an equivalent measure for rain intensity. This research indicates that, in Scotland, rain accumulation provides a better indicator than rain intensity and that landslides may be generated by threshold conditions lower than previously thought. Second, a landslide susceptibility map is constructed using a cross-validated logistic regression model. A novel element of the approach is that landslide susceptibility is calculated for individual hillslope sections. The developed thresholds and susceptibility map are combined to assess potential hazards and impacts posed to the national highway network in Scotland.