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How to account for misclassification costs in shallow-landslide rainfall thresholds?

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Rainfall is one of the most significant triggering factors for shallow landslides. The early warning for such phenomena requires the definition of a threshold based on a critical rainfall condition that may lead to diffuse landsliding. The developing of these thresholds is frequently done through empirical or statistical approaches that aim at identifying thresholds between rainfall events that triggered or non-triggered landslides. Such approaches present several problems related to the identification of the exact amount of rainfall that triggered landslides, the local geo-environmental conditions at the landslide site, and the minimum rainfall amount used to define the non-triggering events. Furthermore, these thresholds lead to misclassifications (false negative or false positive) that always induce costs for the society. The aim of this research is to address these limitations, accounting for classification costs in order to select the optimal thresholds for landslide risk management.

Starting from a database of shallow landslides occurred during five regional-scale rainfall events in the Italian Central Alps, we extracted the triggering rainfall intensities by adjusting rain gouge data with weather radar data. This adjustment significantly improved the information regarding the rainfall intensity at the landslide site and, although an uncertainty related to the exact timing of occurrence has still remained. Therefore, we identified the rainfall thresholds through the Receiver Operating Characteristic (ROC) approach, by identifying the optimal rainfall intensity that separates triggering and non-triggering events. To evaluate the effect related to the application of different minimum rainfall for non-triggering events, we have adopted three different values obtaining similar results, thus demonstrating that the ROC approach is not sensitive to the choice of the minimum rainfall threshold. In order to include the effect of misclassification costs we have developed cost-sensitive rainfall threshold curves by using cost-curve approach (Drummond and Holte 2000). As far as we know, this is the first attempt to build a cost-sensitive rainfall threshold for landslides that allows to explicitly account for misclassification costs. For the development of the cost-sensitive threshold curve, we had to define a reference cost scenario in which we have quantified several cost items for both missed alarms and false alarms. By using this scenario, the cost-sensitive rainfall threshold results to be lower than the ROC threshold to minimize the missed alarms, the costs of which are seven times greater than the false alarm costs. Since the misclassification costs could vary according to different socio-economic contexts and emergency organization, we developed different extreme scenarios to evaluate the sensitivity of

misclassification costs on the rainfall thresholds. In the scenario with maximum false-alarm cost and minimum missed-alarm cost, the rainfall threshold increases in order to minimize the false alarms. Conversely, the rainfall thresholds decreases in the scenario with minimum false-alarm cost and maximum missed-alarm costs. We found that the range of variation between the curves of these extreme scenarios is as much as half an order of magnitude.