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Derivation of landslide triggering thresholds in Sicily through artificial neural networks

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Landslides are among the phenomena that can cause casualties among the population and provoke considerable damage to infrastructures, and public and private assets. Precipitation must be mentioned as the main natural driver of these phenomena. Over the years, landslide early warning systems (LEWS), aiming at reducing the exposure of the population, have been developed based on rainfall thresholds derived mostly by empirical methods, i.e. on finding a statistical link between the characteristics of precipitation (e.g. intensity and duration) and the occurrence of landslide movements. Commonly, landslide early warning thresholds are derived in the form of a power-law between rainfall intensity (or event rainfall) and duration.

One of the limitations of this approach is that using a predetermined form of the law may reduce its performances. In this work we investigate the advantages of removing such constraint by using artificial neural networks, which impose very low restrictions on the functional form of the threshold. We investigate this issue with reference to Sicily, Italy, where several landslide events have been documented in the past decades. In particular, we use rainfall data from almost 300 rain gauges from different monitoring network as the Sicilian hydrological observatory (Osservatorio delle Acque), the SIAS (Sicilian Agro-meteorological Information Service), the Department of Civil Protection (DPC) and almost 250 landslide events from FraneItalia (Calvello and Pecoraro, 2018). We then apply the CTRL-T code (Melillo et al., 2018) to automatically reconstruct rainfall events, identify the most probably rainfall condition that leads to slope failures and derive the traditional power-law threshold. Then, the pattern recognition skills of artificial neural networks (ANN) are exploited to search the possible empirical relationship between rainfall characteristics and slope failure. Several options for the ANN structure are investigated. Finally, we show a comparison between the results of the two approaches, based on Receiver Operating Characteristic (ROC) analysis. Results show some potential of the ANN-based approach in improving landslide forecasting, although some limitations may exist due to possible quality issues of landslide and rainfall data.

References

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