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Forecasting the occurrence of rainfall-induced landslides by means of a self-adaptive model

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In Italy, as in many parts of the world, most of the landslides are triggered by rainfall. To model the relationships between rainfall and landslide occurrence, studies in literature generally follow two distinct approaches: i) "empirical" or "hydrological"; ii) "complete" or "physically-based". At this latter purpose, numerical models are employed, which require a notable (and expensive) amount of data.
As far as hydrologic models are concerned, several valuable methodological proposals can be found in literature, generally focused on thresholds for either single phenomena or specific types of slope movements within a homogeneous geo-environmental setting. As concerns shallow landslides, which are commonly triggered by intense and short-lasting storms, relationships usually refer to rain intensity and durations, sometime considering also antecedent rains. On the other hand, the mobilization of deeper phenomena commonly requires greater rainfall amounts, protracted over longer periods. Difficulties in modelling landslide activation increase, both in physical and economic terms, when dealing with deeper and larger landslides.
Hydrological models generally employ kernels – defined in terms of simple, continuous analytical functions – to express the influence of rainfalls on runoff and groundwater dynamics. In this type of models, the "base time" expresses a sort of geo-hydrological memory of the basin with respect to rainfalls.
Aiming at performing stability analyses, both the shape and the base time of the kernel must be properly selected by considering the type and the dimension of the investigated phenomena, and the geologic characteristics of the affected slopes. Unfortunately, in many real cases, the above cited simple, analytical functions do neither allow to properly capture the observed complexity of groundwater dynamics, nor the related gravitational effects in terms of landslide activations. The predictive ability of such models may get even worse when the set of available dates of landslide triggering increases. In this respect, the adoption of discretized kernels, automatically calibrated through iterative computational techniques, may offer effective solutions.
In this study, the hydrological model SAKe (Self Adaptive Kernel) to forecast the triggering of slope movements is described. Model calibration can be performed by adopting different automated tools, based on iterative cluster modification or Genetic Algorithms, to identify optimal, discretized kernels, obtained from initial standard analytical functions. Examples of application of the model to medium-scale and shallow landslides in Southern Italy are discussed, together with the results of a preliminary, parametric analysis performed to investigate the role of the main parameters. Temporal validation is finally discussed, together with the possibility of early-warning applications for Civil Protection purposes.