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# GA-SAKe: FORECASTING RAINFALL-INDUCED LANDSLIDES THROUGH A HYDROLOGICAL MODEL. AN EXAMPLE OF APPLICATION TO THE UNCINO LANDSLIDE (CALABRIA)

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Forecasting the timing of rainfall-induced landslides is a fundamental step for Civil Protection purposes. This goal can be obtained by means of either empirical "hydrological" or physically-based "complete" models.
SAKe (Self-Adaptive Kernel) is hydrological model that can usefully be employed for real-time warning purposes and for simulating the ultimate effect of rainfall on slope stability. The model is self-adaptive and is based on the assumption of a linear and stationary response of slope stability to rainfall. The following input data are needed for a given case study/area: i) the series of rains, ii) the set of known dates of landslide activation. Either the mobilizations of a single phenomenon, or those of a homogeneous set of landslides (e.g. soil slips) occurred in a given sector can be analysed.
According to classic hydrologic assumptions made in rainfall-runoff modelling, the output of the model, represented by the mobilization function, Z(t), is defined by means of the convolution between the rains and a filter function (i.e. the Kernel). The triggering of a given case study is allowed to occur when the value of Z(t) gets greater than a given threshold, Zcr. Usually, the set of known dates of landslide activation is not sufficient to determine a unique filter function; conversely, the members of the family gets less numerous as far as the number of dates of mobilization increases.
In the present release of the model, the family of optimal Kernels – i.e. those able to maximize the fitness function – is selected by means of a calibration technique based on elitist Genetic Algorithms. In this way, the values of the model parameters can be iteratively changed, aiming at improving the fitness of the tested solutions. At this purpose, a suitable fitness function needs to be defined, so that the number of false alarms is minimized.
The phase of calibration can be very time-consuming. A possible strategy may take advantage of a proper selection of the temporal window of influence of the rains (the base time of the Kernel), i.e. duration of the period in which the rains may affect slope stability. By the way, thorough geomorphological investigations have first to be performed to properly understand the type of landslide whose triggering conditions are to be simulated.
An example of model optimization is discussed, with reference to the Uncino rock slide (maximum width = 200 m, length > 650 m), developed in clay and conglomerate (Late Miocene) overlaying gneiss and biotitic schist (Palaeozoic). For this study case, that repeatedly threatened the northern rim of a small village in Northern Calabria, n.7 historical dates of mobilization are available. On such occasions, the local railroad connecting Cosenza to the Tyrrhenian coast was damaged or interrupted.
After calibration, the model proved to properly simulate all the available dates of activation by means of a family of Kernels characterized by base times of over 77 days. In such family, based on the difference between Zmin, i.e. the lowest of the peaks of the mobility function in correspondence of one of the dates of activation, and Zcr, i.e. the highest peak of the mobility function just below Zmin, a subset of Kernels can be selected which can be used for early-warning purposes.