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A flash flood early warning system based on rainfall thresholds and daily soil moisture indexes

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Main focus of the paper is to present a flash flood early warning system, developed for Civil Protection Agency for the Sicily Region, for alerting extreme hydrometeorological events by using a methodology based on the combined use of rainfall thresholds and soil moisture indexes.
As matter of fact, flash flood warning is a key element to improve the Civil Protection achievements to mitigate damages and safeguard the security of people. It is a rather complicated task, particularly in those catchments with flashy response where even brief anticipations are important and welcomed. In this context, some kind of hydrological precursors can be considered to improve the effectiveness of the emergency actions (i.e. early flood warning).
Now, it is well known how soil moisture is an important factor in flood formation, because the runoff generation is strongly influenced by the antecedent soil moisture conditions of the catchment. The basic idea of the work here presented is to use soil moisture indexes derived in a continuous form to define a first alert phase in a flash flood forecasting chain and then define a unique rainfall threshold for a given day for the subsequent alarm phases activation, derived as a function of the soil moisture conditions at the beginning of the day.
Daily soil moisture indexes, representative of the moisture condition of the catchment, were derived by using a parsimonious and simply to use approach based on the IHACRES model application in a modified form developed by the authors. It is a simple, spatially-lumped rainfall-streamflow model, based on the SCS-CN method and on the unit hydrograph approach that requires only rainfall, streamflow and air temperature data. It consists of two modules. In the first a non linear loss model, based on the SCS-CN method, was used to transform total rainfall into effective rainfall. In the second, a linear convolution of effective rainfall was performed using a total unit hydrograph with a configuration of one parallel channel and reservoir, thereby corresponding to ‘quick’ and ‘slow’ components of runoff. In the non linear model a wetness/soil moisture index, varying from 0 to 1, was derived to define daily soil moisture catchment conditions and then conveniently linked to a corresponding CN value to use as input to derive the corresponding rainfall threshold for a given day.
Finally, rainfall thresholds for flash flooding were derived using an Instantaneous Unit Hydrograph based lumped rainfall-runoff model with the SCS-CN routine for net rainfall.
Application of the proposed methodology was carried out with reference to a river basin in Sicily, Italy.