Flood and Landslide Warning based on rainfall thresholds and soil moisture indexes: the SySAlert model for Sicily

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Main focus of the paper is to present an early warning system, developed for Civil Protection activities 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, flood warning is a key element to improve the Civil Protection achievements to mitigate damages and safeguard the security of people.

The Regional Civil Protection Department issues daily alert bulletins, both for flooding and for landslide, for all the Sicily Region, subdivided in 21 "Alert Zone". In the daily alert bulleting each Alert Zone is characterized by different colours (green, yellow, orange, red) that correspond to a different level of alert condition, linked to a particular critical level (Quiet, Ordinary, Moderate, High).

In this forecasting chain, an hydrological model developed by the authors (Model SMA) provide daily soil moisture indexes in a continuous form to define the first alert phase (green alert), unique both for landslide and for flooding, while daily rainfall threshold, function of the soil moisture conditions estimated at the beginning of the day, are derived, both for flooding and for landslide, for the subsequent alert phase activation (Yellow, Orange and Red Alert).

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 daily conceptual model specifically developed for these purposes. 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.

Rainfall thresholds for flooding were derived for each catchment in Sicily characterized by an area bigger than 50 Km2 by using an Kinematic Instantaneous Unit Hydrograph based lumped rainfall-runoff model with the SCS-CN routine for net rainfall.

When the critical discharge is defined as input in the model, the code has to solve two phases: the first one performs the rainfall-runoff transformation through the SCS-CN technique; the second one carries out the convolution that is not solvable in closed form, but through a numerical procedure of minimization of an objective function.

Because we have a rainfall threshold for each Alert level (yellow, orange, red) three critical discharge values have to be defined. According to Civil Protection directive critical discharge corresponding to 5, 10 e 20 years return period were derived and assumed as input to derive these curves.

Rainfall threshold for landslide are derived, at different exceeding probabilities and at different soil moisture conditions, on a empirical basis starting from a catalogue of 265 shallow landslides in Sicily in the period 2002-2012.

Finally, Delft-FEWS operational forecasting platform was used to link input data and developed models to produce, for each "Alert Zone" and for each considered catchment, forecast on a daily basis.