Geophysical Research Abstracts,
Vol. 10, EGU2008-A-11356, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-11356
EGU General Assembly 2008

The real-time warning system for hydrogeological risk mitigation of the Calabria region

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The framework of the regional real time warning system managed by the Centro Funzionale Idrometeorologico of the Calabria region (South Italy) designed for hydrogeological risk mitigation and civil protection purposes is described.

The system is targeted to the monitoring, analysis and forecasting of future critic events and to support the decision making of administrations that issue natural risk warning. This note deals with the mathematical models operationally used within the meteo-hydrologic flood forecasting chain.

The available forecasting tools consist of several models:

- first (low) level models represented by rainfall thresholds;
- upper level models which aim to simulate the main hydrological processes and/or the relationships between observed variables and land effects.

Hydrometeorological data from the regional real time operating network are automatically supplied as input to all available models in real time. Each model refers to a specific risk scenario. Moreover, risk scenarios can be divided into local events (landslides, soilslip, flash floods) and areal events (large areas flood events).

Rainfall thresholds are precipitation values potentially critic for the region considered: when rainfall exceeds the threshold value, relevant land effect are expected. A rainfall duration and a return period are associated to each risk scenario according to historical damages in order to define the rainfall amount that leads to issue warnings. Three

thresholds related to a warning level code which depends on the degree of danger (low, moderate, high) are defined for each kind of event. Rainfall thresholds can be applied to rainfall forecasting supplied by meteorological models or to observed rainfall from the regional monitoring network of the national technical service.

Second level models are represented by time variable dynamic rainfall thresholds, able to account for initial conditions, which are deemed to have a strong influence on the occurrence of hydrogeologic catastrophes.

Upper level models, which are rainfall-runoff models of increasing complexity, directly consider discharge in selected sites as indicator of a possible flooding and to issue warnings.

Third level models account for simple and robust hydrologic models with few parameters and quite easy to use: in particular lumped, event based model, which can be easily applied to ungauged basins.

Finally, the fourth level consists of more complex and expensive models, which ranges from conceptual semi-distributed to physically based distributed rainfall-runoff models. The former is essentially an object-oriented model in which several methods are available for each hydrological object (basin, reach, reservoir) to simulate different watershed processes, and the latter is a process-oriented continuous model conceived for applications to small size catchments, which provides several contributions to storm runoff (hortonian and saturation excess overland flow, return flow, fast lateral sub-surface flow), spatially distributed over the catchment.

This work evaluates system's forecasting skill from the application over the whole region of a second level model: an event-based, lumped, conceptual rainfall–runoff model. The rainfall–runoff transformation process is performed by an abstraction loss component, aimed at estimating the rainfall excess through the Soil Conservation Service Curve Number method, and a runoff routing component which uses the Nash cascade form of the Instantaneous Unit Hydrograph (IUH) approach. The adopted approach provides an easy framework to account for parametric uncertainty in peak flow prediction. The model is applied in a probabilistic framework, performing multiple runs through Monte Carlo generation accounting for uncertainty in parameters estimation, and relating parameter sampling distributions to basin geomorphoclimatic characteristics. Results from the application of the system to a set of ungauged watersheds in southern Italy, confirm the suitability of the adopted approach and the capabilities of the system to adequately provide warnings for the observed events.