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A non-linear runoff generation model for alpine catchments

A. Bertagnoli, **B. Majone** and A. Bellin

Dipartimento di Ingegneria Civile ed Ambientale, Università di Trento, via Mesiano 77, 38050 Povo - TRENTO (Italy)

In small catchments runoff assumes different characteristics depending on the meteorological forcing and seasonal climatic changes. In mountain areas the catchment responds quickly to intense storms activating preferential flow pathways and pipe-flow, while in absence of precipitations the runoff is sustained by the underlying fractured rock aquifer. Furthermore, there is clearly a link between the multiplicity of time scales observed in the runoff signal (Labat et al., 2000) and the hydraulic property variations of the aquifer feeding the river network. However, this link is non-linear because of both the selective effect of the hydrological input on the activated scales and the dependence of the travel time from the hydraulic head (pipe-flow), which in turn depends on pre-event soil water content. In recent years, many theoretical and experimental studies have been conducted to improve our understanding of these hydrological processes and to simulate the underlying dynamics. A plurality of models ranging from "empirical" models with a lumped model structure to "physically based", complex and spatially distributed modeling schemes were developed. These models can be used for simulating the long-term water balance at several temporal resolutions and also for real-time forecasting. However, it is well recognized that the available approaches are often far from providing a satisfactory representation of the rainfall-runoff transformation (Sivapalan, 2003), particularly for small to medium size basins. The model prediction uncertainty can be considerably high, and using more complex modeling framework concepts often result in small to negligible improvements in prediction capabilities. In this work we propose a simple continuous model for modeling the complexity observed in the hydrological response of a few small alpine catchments. The model couples the Geomorphological Instantaneous Unit Hydrograpgh (GIUH) approach with a non linear model for water-soil dynamics including evapotraspiration

and snowmelt. The model performed well in modeling the catchments response to meteorological forcing, in a karst system and in two small alpine catchments. The model is sensitive to uncertainty in the input data, particularly to the temperature. Another important result is that routing along the river network is well described by the GIUH model with the travel time pdf showing a $1/f^{\beta}$ power spectra, which is consistent with the gamma distribution. The model performed well also in a small karst catchment, where the surface network is absent and the routing is controlled by the structure of the underlying karst system.