Use of soil moisture and water table data for rainfall-runoff modelling in alpine catchments

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Prediction of hydrologic response is particularly difficult in alpine regions where data are sparse and the spatial variability of both precipitation and physical controls on runoff generation is considerable. Moreover, alpine catchments are frequently affected by small scale flash floods, which are usually responsible for shallow landsliding and debris flow triggering. Therefore, improving the understanding of the rainfall-runoff processes occurring in these regions represents a relevant scientific topic for hydrologists and operators involved in hydro-geological risk mitigation. Studies undertook in small experimental areas where rainfall and discharge measures and additional hydrological variables are recorded, can address this issue. In this work, soil moisture and water table data are used along with the commonly used rainfall runoff and temperature variables in order to investigate the hydrologic behaviour of the Vauz creek basin (1.9 km^2) located in the central-eastern Italian Alps. Beside this, two micro sub-catchments (Bridge Creek catchment and Larch Creek catchment, of area 0.11 and 0.032 km^2, respectively) were analyzed in order to investigate the influence of spatial and temporal dynamics of soil moisture and water table on runoff response at different scales. Soil water content and groundwater level have been continuously monitored in the snow-free period (from May to September) since summer 2005 with a sub-hourly time resolution.

A continuous rainfall-runoff model (MISDc), developed for the simulation of flood events at the hourly (or less) time scale, was applied to the experimental subcatchments. The model consists of two components: i) a soil water balance model that simulates the soil moisture temporal pattern; ii) an event-based rainfall-runoff model for flood hydrograph simulation whose initial conditions are determined by the first component. By coupling the two models through an experimentally-derived relationship, a single continuous rainfall-runoff model characterized by a parsimonious and robust structure is derived. The model requires, as input data, meteorological variables routinely measured (rainfall and air temperature) and incorporates a limited number of parameters. The simplicity of the model and the low number of parameters involved makes MISDc an appropriate tool to investigate the effects of different data source on the hydrologic response.

For the analysis, the ancillary soil moisture and water table data were used both for the model calibration and for its validation. The modification of the model structure was also tested in order to better reproduce not only the discharge hydrograph but also the dynamics of subsurface water as inferred through the ancillary data set. The results show a good agreement between the simulated and the measured data in different hydrological conditions and highlight the paramount role of antecedent soil moisture conditions on the hydrologic response of alpine catchments. Moreover, in order to extend the results observed for this small experimental areas to larger catchments, the need to establish an appropriate spatial and temporal resolution of soil moisture and groundwater measurements was underlined.