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Altitude control over rainfall-runoff relationship

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Mountainous areas are generally characterized by abundant water resources. In the past, this abundance of water has sometimes been considered as an unlimited resource and led to inappropriate management strategies. In this sense, an important aspect to account for when dealing with water allocation problems is the seasonality of water availability, especially considering the increasing competition between different water uses and the need for a sustainable resource exploitation (e.g. winter tourism, irrigation, hydropower generation). A valuable tool for the control of water management strategies is the runoff regime, intended as the curve of the mean monthly runoff values.

Runoff regime prediction in high elevation sites represents a challenging topic due to a number of factors: i) the dynamics of snow accumulation and melting largely affects the timing and the volumes of runoff; ii) the topographic heterogeneity requires detailed spatial characterization of the hydrologic variables; iii) the high spatial variability of precipitation in general is poorly described by meteorological network measurements.

In this study a conceptual balance model is proposed aimed at the investigation of the fundamental mechanisms that influence the runoff regime in mountainous regions. The model adopts a temperature threshold to partition precipitation into rainfall and snow and to estimate evapotranspiration volumes. A statistical representation of the temperature regime is also introduced in order to capture the sub-monthly temperature variability (which significantly affects the snow processes). The effects of snow accumulation on the rainfall-runoff mechanism is investigated through a specific snowmelt module describing snowmelt as a non-linear function of temperature.

The model is applied to 40 catchments in the North-Western Italian Alps and its performances are assessed by comparing measured and simulated runoff regimes both in terms of total bias and anomalies. The widely reported rainfall underestimation in high elevation measuring sites strongly affects the model performances and calls for a specific correction, which is implemented in a two step precipitation adjustment procedure based on the respect of annual water balance.

The model proves to be able to describe the timing and shape of the runoff regime for most of the basins. Nevertheless discrepancies between simulation and observations exist, especially with regard to the snow storage. Thanks to its parsimony in terms of required input data and parameters, the model is suitable to be applied to ungauged contexts and for large scale investigations on the role of climatic change impacts on water availability.