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Raster based snow and glaciers models in large Alpine catchments hydrological balance: the Rhone case study

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A raster based glacier sub-model was successfully introduced in the distributed hydrological model FEST-WB to simulate the water balance and surface runoff of large Alpine catchments. The glacier model is based on temperature-index approach for melt, on linear reservoir for melt water propagation into the ice pack and on mass balance for accumulation; the initialization of the volume of ice on the basin was based on a formulation depending on surface topography. The snow module includes snow melt, accumulation and propagation into the snow pack; the melt model is based on a simple degree day depending on air temperature; the accumulation model provides the partitioning of total precipitation in liquid and solid by using two threshold of temperature below/above which all precipitation falls as snow/rain and they have to be found with calibration; melted water is supposed to flow into the snow pack with a linear reservoir routing scheme.
The calibration and validation of the snow accumulation model and of the glacier melt model were treated, based on multiple data sets: satellite snow cover maps and observed discharge.
The snow accumulation model was calibrated and validated by comparing simulated percentage of snow coverage with the one retrieved by satellite. The results showed a global over-estimation of snow coverage of 9% and good performance also from the point of view of spatial distribution of snow on the basin.
The glacier sub-model was first tested on a sub-basin of the Rhone basin (Switzerland), which is for 62% glaciated; the calibration and validation were based on comparison between simulated and observed discharge from 1999 to 2008. The model revealed to be able to simulate the typical discharge seasonality of a heavily glaciated basin and to well reproduce the annual volume of water (the mean difference in annual cumulated volume is 4.3%). The performance of the model was also tested by simulating discharge in the whole Swiss Rhone basin, in which glaciers contribution is not negligible, in fact in summer about the 40% of the discharge is due to glaciers melt. The model allowed to take into account the volume of water coming from glaciers melt and its simple structure is suitable for analysis of the effects of climate change on hydrological regime of high mountain basins, with available meteorological forcing from current RCM.