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Snowmelt contribution to seasonal runoff: Lessons learned from using a bucket-type model on a large set of catchments

Michal Jenicek[1] and Ondrej Ledvinka[2]
[1]Charles University, Department of Physical Geography and Geoecology, Prague, Czechia (michal.jenicek@natur.cuni.cz)
[2]Czech Hydrometeorological Institute, Prague, Czechia (ondrej.ledvinka@chmi.cz)

The streamflow seasonality in mountain catchments is largely influenced by snow. However, a shift from snowfall to rain is expected in the future. Consequently, a decrease in snow storage and earlier snowmelt is predicted, which will cause changes in spring and summer runoff. The objectives of this study were to quantify 1) how inter-annual variations in snow storages affect spring and summer runoff, including summer low flows and 2) the importance of snowmelt in generating runoff compared to rainfall. The snow storage, groundwater recharge and streamflow were simulated for 59 mountain catchments in Czechia in the period 1980–2014 using a bucket-type catchment model. The model performance was evaluated against observed daily runoff and snow water equivalent. Hypothetical simulations were performed, which allowed us to analyse the effect of inter-annual variations in snow storage on seasonal runoff separately from other components of the water balance. This was done in the HBV snow routine using the threshold temperature T_T that differentiates between snow and rain and sets the air temperature of snowmelt onset. By changing the T_T, we can control the amount of accumulated snow and snowmelt timing, while other variables remain unaffected.

The results showed that 17-42% (26% on average) of the total runoff in study catchments originates as snowmelt, despite the fact that only 12-37% (20% on average) of the precipitation falls as snow. This means that snow is more effective in generating catchment runoff compared to liquid precipitation. This was documented by modelling experiments which showed that total annual runoff and groundwater recharge decreases in the case of a precipitation shift from snow to rain. In general, snow-poor years are clearly characterized by a lower snowmelt runoff contribution compared to snow-rich years in the analysed period. Additionally, snowmelt started earlier in these snow-poor years and caused lower groundwater recharge. This also affected summer baseflow. For most of the catchments, the lowest summer baseflow was reached in years with both relatively low summer precipitation and snow storage. This showed that summer low flows (directly related to baseflow) in our study catchments are not only a function of low precipitation and high evapotranspiration, but they are significantly affected by previous winter snowpack. This effect might intensify the summer low flows in the future when generally less snow is expected.

Modelling experiments also opened further questions related to model structure and

parameterization, specifically how individual model procedures and parameters represent the real natural processes. To understand potential model artefacts might be important when using HBV or similar bucket-type models for impact studies, such as modelling the impact of climate change on catchment runoff.