MODELLING OF CLIMATE CHANGE IMPACT ON HYDROLOGICAL REGIME IN SMALL HEADWATER MOUNTAINOUS CATCHMENT IN SLOVAKIA

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1 MOTIVATION

Quantifying the impacts of climate change on runoff processes has been extensively investigated over the last few decades. However, this topic is still challenging (because of complex runoff mechanisms, etc.) for hydrologists. This study focuses on estimating the impact of climate change on runoff processes in the Myjava River basin in Slovakia. Two climate scenarios (i.e., the Dutch KNMI and German MPI), which were regionally downscaled for the territory of Slovakia, were used. A lumped conceptual rainfall-runoff model (the TUW model) was used for the runoff simulations. The future changes in runoff due to climate change were evaluated by comparing the simulated mean monthly runoff for the current state (1981-2010) and the modelled scenarios.

2 DATA

- This study focuses on one selected basin (i.e., the **Myjava River basin**) in Slovakia (Fig. 1). The Myjava River basin has an area of 641.32 km^2. The mean altitude of the basin is 298 m a.s.l. Most of the basin lies in warm and moderately warm regions with a mean annual air temperature (T) of 9 °C and a mean annual precipitation (P) between 550 and 700 mm.

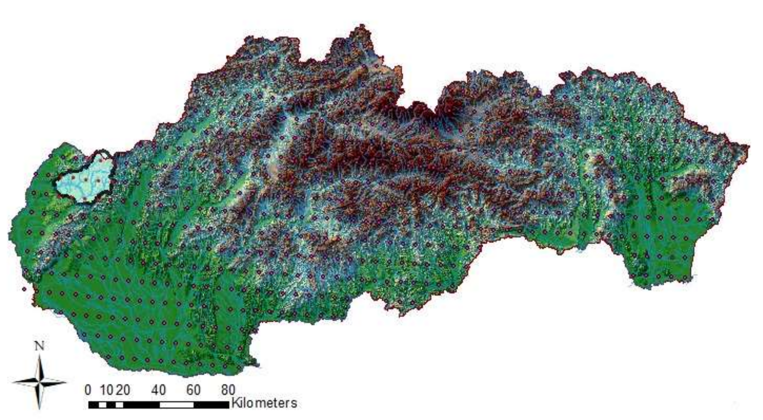

Fig. 1: The location of the Myjava River basin within Slovakia.

- Daily input data:
  (a) from **SHMI/CarpatClim database**: P, T, PET, Q between 1981-2010,
  (b) from **KNMI/MPI climate scenario**: P, T, PET between 1981-2100.

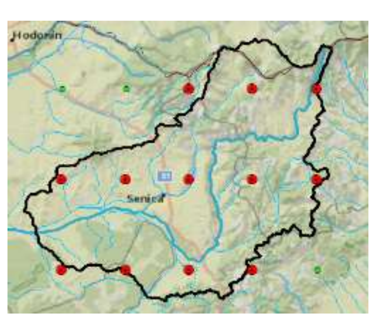

Fig. 2: The Location of 12 points from the CarpathClim database within the basin.

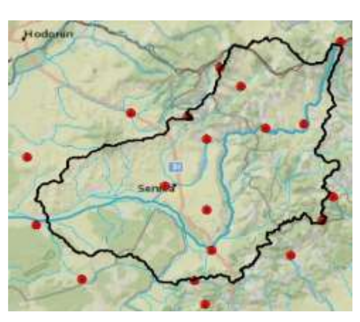

Fig. 3: The Location of 19 rain gauges for the KNMI/MPI scenarios within the basin.

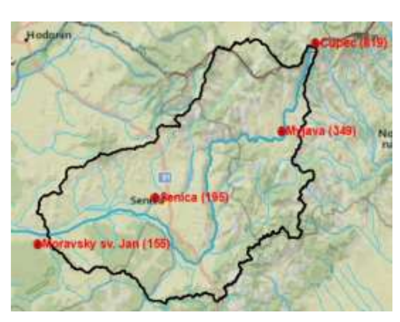

Fig. 4: The Location of 4 climatic stations for the KNMI/MPI scenarios within the basin.

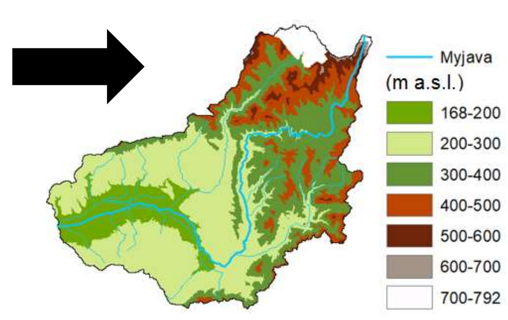

Fig. 5: Map of hypsographic degrees of the Myjava River basin.

3 METHODOLOGY

The rainfall-runoff model

- Lumped conceptual r-r model (the TUW model, Viglione and Parajka, 2014), which follows the structure of the HBV model (Bergström, 1995) was used in this study.
- **TUW model** has 15 parameters.
- The structure of the model (Fig. 6) involves three routines: snow, soil moisture, runoff.
- The model has already been successfully applied in numerous studies (e.g., Parajka et al., 2007; Sleziak et al., 2018).

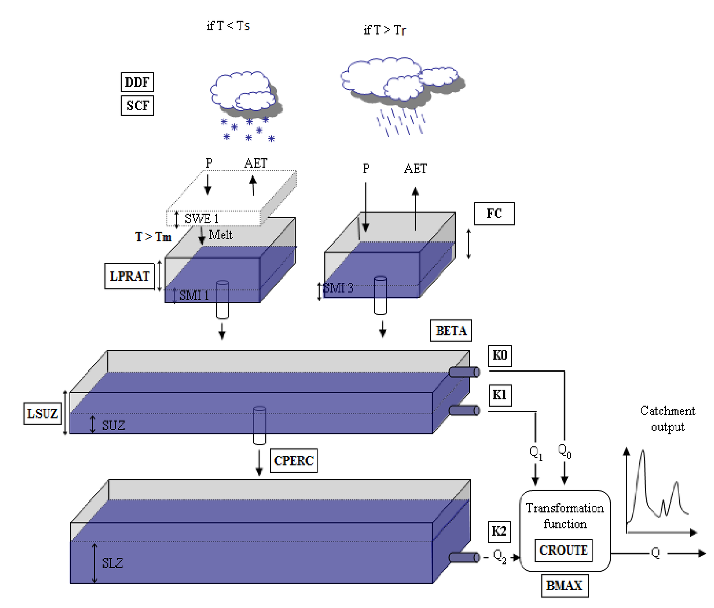

Fig. 6: Structure of the TUW model.

Calibration strategy

- The TUW model was calibrated for the **period of 1981-2010**.
- We use an automatic calibration procedure using a differential evolution algorithm Deoptim (Ardia et al., 2015).
- **Objective function** (*OF*) combines Nash-Sutcliffe coefficient (***NSE***) estimated from normal and logarithmic transformed (**log*NSE***) daily streamflow values:

$$OF = \frac{1-NSE}{2} + \frac{1-\log NSE}{2}$$

- **Fifty calibration runs were performed** with the goal of estimating the uncertainties in the model parameters.
- **According to the NSE** and the volume error (**VE**) (Fig. 7) **the best set of model parameters was chosen.** This set of model parameters was used for the **simulation of runoff for two 40-year periods** (i.e., 2021-2060 and 2061-2100), which should adequately reflect the level of climate change in the future.

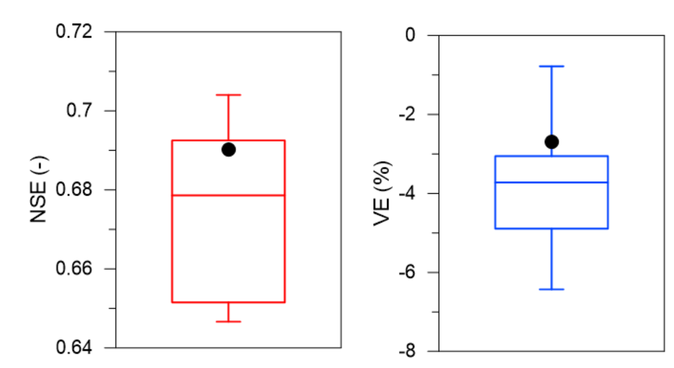

Fig. 7: Comparison of the variability of NSE and VE for 50 calibrations. The black points represent the NSE and VE values on the basis of which the best set of model parameters was chosen.

4 RESULTS

Impact of climate change on runoff

- An evaluation of the scenarios of the long-term mean runoff and their comparison with the reference period of 1981-2010 shows that **changes in the long-term mean monthly flows can be expected**.
- **During the winter periods, an increase in the long-term runoff could be assumed**. This increase is probably related to a rise in temperature and anticipated snowmelt. Conversely, **during the summer periods, a decrease in the long-term runoff could be expected**. These changes are expected to be more pronounced in the period of 2061-2100 than in the period of 2021-2060.
- A comparison of the long-term mean monthly runoff **for the KNMI scenario** in three time periods (i.e., 1981-2010, 2021-2060, and 2061-2100) indicates that **the largest runoff increase will occur in March**. That is also true for the MPI scenario and the periods 1981-2010 and 2021-2060. For the MPI scenario and the period of 2061-2100, the largest runoff increase will occur in April.

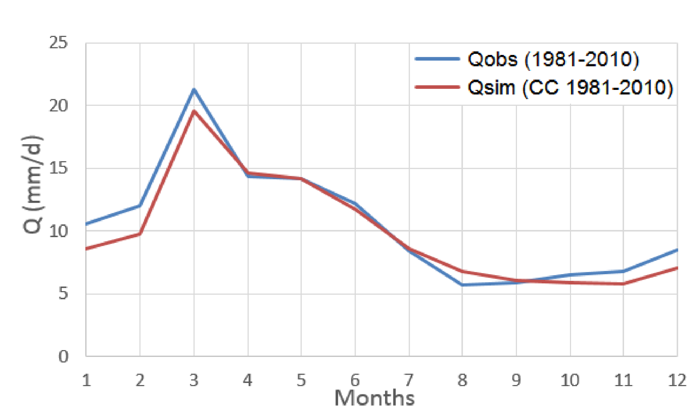

Fig. 8: Comparison of the observed and simulated mean monthly runoff in the reference period of 1981-2010.

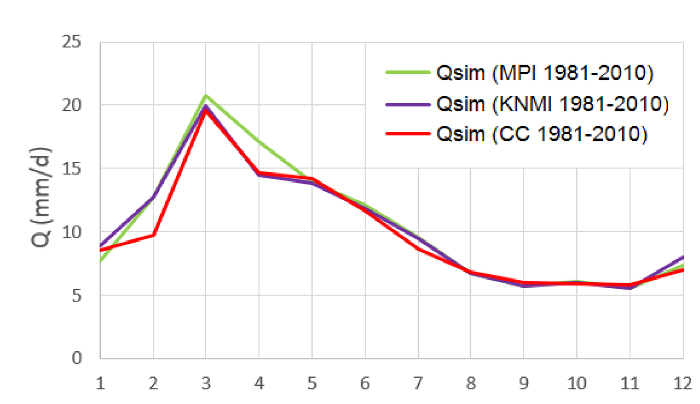

Fig. 9: Comparison of the simulated mean monthly runoff for several scenarios in the period of 1981-2010.

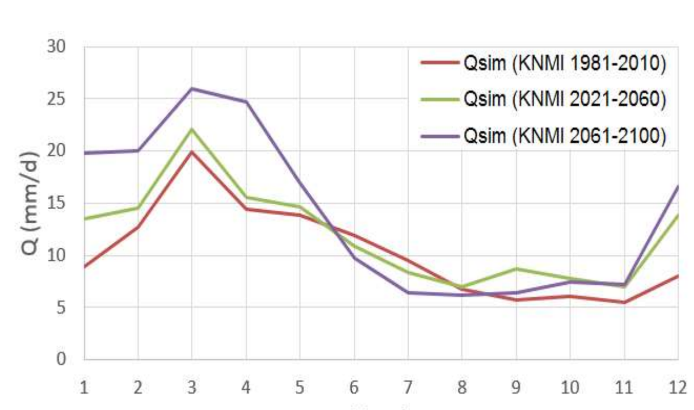

Fig. 10: Comparison of the long-term mean monthly runoff for the KNMI scenario in three time periods (i.e., 1981-2010, 2021-2060, and 2061-2100).

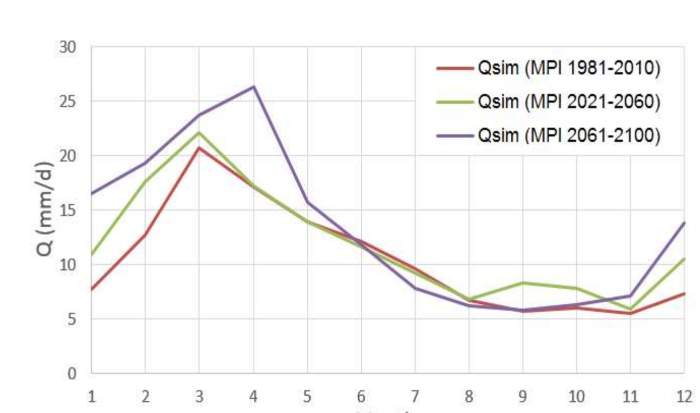

Fig. 11: Comparison of the long-term mean monthly runoff for the MPI scenario in three time periods (i.e., 1981-2010, 2021-2060, and 2061-2100).

5 CONCLUSIONS

- Our findings point to the fact that in the future, there should be greater differences in runoff between the winter and summer. From a water management point of view, this means that capturing winter flows for subsequent use in dry summer periods will become even more important in the future.

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