Author's response to the Reviewer 2

Black text: Referee comment

Blue text: Authors' response

This manuscript examined rain-on-snow (ROS) frequencies, runoff responses, and relationships to hydroclimate variables across Czechia, Switzerland, and Germany. This was accomplished using a hydrologic model and perturbed runs were also examined to simulate climate change impacts to ROS.

This was a well written paper and fits well into this journal. The results are summarized nicely, and the discussion does well highlighting caveats and uncertainty. My only major comment is around more clarification needed for some of the methods. Otherwise, mostly minor comments. I'm giving it a minor revision as I don't think the "major comment" will take all that much work.

Thank you for the review of our manuscript. We greatly appreciate your constructive comments and suggestions. Please find our point-by-point response below (in blue).

Major comments

Several aspects of the data and methods around the HBV model were unclear and could be improved by adding more details. One concern I have that I don't think was addressed was using station-based data as model inputs for the Czech catchments but then using gridded data for the Swiss catchments. Can the authors comment on what impact the station-based vs. gridded inputs might have on the simulations? Also, what was the spatial resolution of the gridded data used? It also was not clear to me what the HBV model inputs were. The historical dataset consists of temperature, precipitation, runoff, and SWE. Were all of these input into the HBV model?

Thank you for this relevant comment. Indeed, different types of input model data (gridded vs. stational) have been used for Czech and Swiss catchments. According to the results presented in Fig. 2, the model performs slightly better for Swiss catchments, where the gridded data has been used. This implies the model should perform better for Czech catchments if gridded data is used. However, only stational data were available at the time of study elaboration. Nowadays, official gridded products are available in Czechia as well, which would potentially enable the model calibrations to be redone using these input data. Although we are planning to do so, this is instead a long-term run and, unfortunately, can't be done for this study.

Nevertheless, we previously used model simulations using stational data in some of our recent studies (e.g., Jenicek and Ledvinka, 2020; Nedelcev and Jenicek, 2021; Hotovy et al., 2023) and did not find any major inconsistencies or errors in the resulting simulations. In the above studies, we also did several tests of the model performance, including its ability to simulate SWE (Nedelcev and Jenicek, 2021) or rain-on-snow events (Hotovy et al., 2023) correctly. These above tests also showed that although the absolute values of runoff signatures may change when different forcing data are used, we expect that the relative differences between individual projections/perturbations (as the major approach used in our study) remain similar for different calibration runs. Thus they will not affect the interpretation of the overall results.

In the revised manuscript, we will add more explanations and discuss this issue. Additionally, we will provide information about the spatial resolution of gridded data (2km for air temperature and precipitation, and 1km for SWE) and better describe the HBV model inputs.

Other comments

Figure1: I think this could be improved. As is, the polygons are very small and hard to see. I might suggest and panel plot with several zoomed maps that also include more detailed terrain.

We agree that it is not easy to find the best way to visualize such data. We will prepare some alternatives to the figure and decide which fits best. Besides the reviewer's suggestion, we could make two different maps separately for Czechia and Switzerland combined in one figure.

I would suggest using the term “perturbations” instead of “projections” throughout the paper. Projections are usually associated with GCM outputs in the future, and the future periods are not directly accounted for in your method.

Thank you for your suggestion. Although we have discussed earlier what terminology should be used here, we will consider your suggestion as we are aware that the term “projections” is consistently used rather for climate model outputs.

Line 190: What is the median objective function? Is a value of 1 a perfect score? Please explain.

Yes, a value of 1 represents a perfect fit. We will consider reformulation in the revised manuscript to be more precise.

Figure 3: Great figure! Is the annual number of ROS days the mean? Median? Please specify in the caption.

Thank you. The annual number of RoS represents the annual mean from 1980-2010. We will specify the figure caption in this respect to avoid confusion.

Figure 7: It looks like the T0_P12 line is drawn wrong in 7b. It shows a solid line and based on the text in lines 276-277 it should be small-dashed.

Thank you for double-checking the figure. Indeed, this is the mistake which we will correct in the revised manuscript.

References

Hotovy, O., Nedelcev, O., & Jenicek, M. (2023). Changes in rain-on-snow events in mountain catchments in the rain–snow transition zone. *Hydrological Sciences Journal*, *68*(4), 572–584. https://doi.org/10.1080/02626667.2023.2177544

Jenicek, M., & Ledvinka, O. (2020). Importance of snowmelt contribution to seasonal runoff and summer low flows in Czechia. *Hydrology and Earth System Sciences*, *24*(7), 3475–3491. https://doi.org/10.5194/hess-24-3475-2020

Nedelcev, O., & Jenicek, M. (2021). Trends in seasonal snowpack and their relation to climate variables in mountain catchments in Czechia. *Hydrological Sciences Journal*, *66*(16), 2340–2356. https://doi.org/10.1080/02626667.2021.1990298