Authors' response to Reviewer 1

We thank the reviewer for his/her evaluation of our revised manuscript and accepting it as it currently is. We appreciate the efforts by the reviewer, which helped to improve our manuscript.

Authors' response to Reviewer 2

We thank the reviewer for his/her evaluation of our revised manuscript and his/her helpful comments. Below we address the reviewer's comments (full text) indented by arrows and coloured in blue. We appreciate the efforts by the reviewer, which will help to improve our manuscript.

General comments

1. It is suggested to add a paragraph on the future research direction in the Discussion or Conclusion section to highlight the application potential and frontier of this study. Specifically, this study reveals the systematic control of bedrock geology on catchment hydrological functions (such as the "new water" fraction, storage-release dynamics) and establishes a clear geology-function classification framework. The authors could point out that future research could parameterize such geology-controlled mechanisms (e.g., differences in permeability of different lithologies, thickness of the weathered layer, etc.) and integrate them into distributed hydrological models with a stronger physical basis, thereby enhancing the simulation and prediction capabilities of models in ungauged basins or under changing environmental conditions.

→ Thank you for the suggestion, highlighting the application potential and frontier of the study is an important improvement of the manuscript. We have integrated your suggestion in the second paragraph of the Discussion (lines 505-509 of the track-change manuscript) and created a new paragraph in the Conclusion (lines 690-698).

2. To further enhance the academic depth and foster a closer dialogue with current research frontiers, it is recommended that the authors incorporate citations to the following highly relevant and recent studies in the appropriate sections of their manuscript.
In the first paragraph of the Introduction, the authors rightly point out that an incomplete understanding of the complex interactions within subsurface hydrological systems represents a key obstacle to accurate streamflow prediction. To situate this assertion within a concrete and contemporary research context, I recommend citing the recent work by Ren et al. (2024). Their study provides a compelling quantitative example: in a karst watershed, explicitly accounting for the non-closure of underground catchment boundaries—where the effective contributing area dynamically expands with antecedent rainfall—and the spatial heterogeneity of subsurface water storage capacity can enhance the accuracy of streamflow predictions.
Reference: Ren, Z. L., Li, B. Q., Xiao, Y., Li, K.: Investigating spatial heterogeneity of karst water storage capacity and nonclosure of underground watersheds in karst hydrological simulation. Hydrol. Process., 38(12), e70012, https://doi.org/10.1002/hyp.70012.

→ Thank you for the lead, we cite the recommended article (lines 36-39) in the first paragraph of the Introduction of the revised manuscript.

In the first paragraph of the Introduction, the manuscript correctly identifies the persistent challenge of hydrological prediction in ungauged or dynamically changing catchments. To further strengthen this point by demonstrating a cutting-edge response to this exact challenge, I suggest citing Ye et al. (2024). Their study on a regionalization-strategy-guided LSTM model for flood forecasting in ungauged catchments provides a direct, contemporary example of how the hydrological community is tackling this issue with advanced methods.

Reference: Ye, K. J., Liang, Z. M., Chen, H. Y., Qian, M. K., Hu, Y. M., Bi, C. L., Wang, J., Li, B. Q.: Regionalization strategy guided long short-term memory model for improving flood forecasting. Hydrol. Process., 38(10), e15296, https://doi.org/10.1002/hyp.15296.

→ We cite the recommended article (lines 45-45) in the first paragraph of the Introduction of the revised manuscript.

I suggest citing the recent study by Floriancic et al. (2024) in the Discussion section. This paper systematically analyzes the relationship between new water fractions and catchment properties across 32 Alpine catchments and finds a significant negative correlation with catchment area, baseflow index, and terrain ruggedness. Citing this work would strongly support and reinforce the conclusions of your study.
Reference: Floriancic, M. G., Stockinger, M. P., Kirchner, J. W., Stumpp, C.: Monthly new water fractions and their relationships with climate and catchment properties across Alpine rivers. Hydrol. Earth Syst. Sci.,28, 3675-3694, https://doi.org/10.5194/hess-28-3675-2024.

→ We were in fact referring to the preprint version of that same article in the previous version of the manuscript (line 100 of the old manuscript). We changed it to the actual version of the published article, thank you for pointing this out.

I also recommend citing Sarah et al. (2024), which provides critical complementary evidence. They demonstrate that saturated hydraulic conductivity (Ksat) is the "key control" on baseflow contribution in high-altitude catchments. This finding directly corroborates and quantifies the mechanistic link between bedrock permeability (which Ksat fundamentally reflects) and subsurface water release patterns, strongly supporting the authors' central thesis that geology is the primary filter governing catchment storage-release dynamics.
Reference: Sarah, S., Shah, W. S., Somers, L. D., Deshpande, R. D., Ahmed, S.: Saturated hydraulic conductivity (Ksat) and topographic controls on baseflow contribution in high-altitude aquifers with complex geology. J. Hydrol., 641, 131763, https://doi.org/10.1016/j.jhydrol.2024.131763.

→ This is indeed a great citation to corroborate our thesis on bedrock geology controls on catchment functions. We cite the recommended article (lines 570-573) in the first paragraph of second chapter of the Discussion of the revised manuscript.