Anonymous Referee #1

This study investigates the roles of topography and vegetation in hydrological processes within cold alpine basins of the Mongolian Plateau using a stepwise FLEX modeling framework. This manuscript presents a valuable contribution to cold-region hydrology in Mongolian Plateau. The research is scientifically sound, methodologically rigorous, and addresses the gap in hydrological modeling for data-scarce, cryospheric regions in Mongolia. With the suggested revisions—particularly in methodology clarity, discussion depth, and figure improvements—it will be suitable for publication. The manuscript falls between minor and moderate revisions, with the following specific recommendations.

Reply: We sincerely appreciate the constructive comments from Referee #1, which have helped us identify areas for improvement. We are also grateful for the positive evaluation and endorsement of our manuscript's contribution. Detailed responses to all comments are provided below.

Comments

1. The background is well-presented, but the uniqueness of the study area (e.g., extreme climate, sparse vegetation, and cryospheric dynamics) could be emphasized more to justify the novelty. Moreover, this work aligns well with the objectives of the new IAHS HELPING (Hydrology Engaging Local People IN one Global world) Decade (2023–2032), which emphasizes interdisciplinary approaches to address local hydrological challenges. I recommend to add this in either the Introduction or the Discussion.

Reply: We sincerely thank Referee #1 for the insightful comment and valuable suggestion. In the revised paper, we will expand the description of the study area in the Introduction to better emphasize its unique hydroclimatic characteristics—such as extreme temperature gradients, sparse vegetation cover, and active cryospheric processes—that strongly influence regional hydrology. These features highlight the distinctiveness and scientific value of our research site. Furthermore, we will add a new paragraph in the Introduction to explicitly link our study with the objectives of the IAHS HELPING Decade (2023–2032), underscoring the relevance of our interdisciplinary approach to addressing local hydrological challenges in cold regions.

2. The literature review should include more recent studies (post-2020) on cold-region hydrology, particularly those addressing snowmelt and vegetation interactions in similar environments (e.g., Central Asia, Tibetan Plateau).

Reply: We will update the literature review in the Introduction to include more recent studies (post-2020) on cold-region hydrology. In particular, we will add several papers focusing on snowmelt dynamics, vegetation–hydrology interactions, and cryospheric processes in regions such as Central Asia (Feng et al., 2025) and the Tibetan Plateau (Ni et al., 2025). These additions strengthen the scientific context and highlight recent advances relevant to our study.

3. The similar performance of FLEX-T and FLEX-D is attributed to low vegetation heterogeneity. However, is this finding generalizable to other basins with higher vegetation variability? A comparative discussion would be valuable.

Reply: As noted in Section 5.1 (L416–422), the study basin exhibits limited vegetation heterogeneity, which may constrain $FLEX^T$'s performance gains relative to the baseline $FLEX^D$ model. Nevertheless, $FLEX^T$ provides a more detailed representation of individual landscape units, enabling a physically grounded simulation of hydrological processes and their underlying mechanisms. Based on this, we will add a new comparative discussion in Section 5.1 to further examine the generalizability of our findings. Evidence from previous studies indicates that basins with greater vegetation variability exhibit larger differences between $FLEX^T$ and $FLEX^D$, highlighting the broader applicability of $FLEX^T$ across diverse cold-region environments (Gao et al., 2014).

4. Line 428-433: Please provide the exact dates (year, month, and day) of these two

precipitation events to enable a more precise understanding and validation of the related hydrological processes.

Reply: In the revised manuscript, we will specify the exact dates of the two precipitation events: 14 April 2009 and 12 September 2011.

5. The discussion should explicitly address limitations, such as the lack of direct validation (e.g., snowpit measurements, isotope tracers) and the impact of data scarcity on model uncertainty.

Reply: We will clarify the limitations in the revised manuscript. As noted in the original version, the study lacks direct validation data, such as isotope tracers. In the revised version, we will further emphasize this point in the Discussion section and discuss how data scarcity contributes to model uncertainty. We also note that incorporating terrain and vegetation information enables the model to represent the basin's hydrological processes as realistically as possible, despite the absence of direct validation data.

6. Line 582: Provide a clearer explanation of the relationship between the proportion of snowfall in precipitation (Ps/P) and the contribution of snowmelt to streamflow (QM/Q), while ensuring that the related terminology and trend descriptions are accurate and consistent, to enhance the coherence between figures and text, as well as overall readability.

Reply: We will clarify the relationship between the proportion of snowfall in total precipitation (P_s/P) and the contribution of snowmelt to streamflow (Q_M/Q). Ps/P denotes the fraction of total precipitation that falls as snow, while QM/Q represents the fraction of streamflow derived from snowmelt. Our analysis indicates that basins with higher P_s/P generally exhibit higher Q_M/Q, suggesting that a greater snowfall fraction contributes more substantially to streamflow. All terminology will be standardized, and trend descriptions are now accurate and consistent, enhancing the coherence between figures and text.

7. Line 673-675: The description of high infiltration rates in dry grassland soils leading to reduced runoff in arid regions is rather general; it is recommended to provide relevant references to strengthen the argument.

Reply: We will revise the manuscript to provide more specific support for the statement that high infiltration rates in dry grassland soils reduce runoff in arid regions. In arid regions, coarse-textured soils typically enhance infiltration due to their large pores, while sparse vegetation reduces surface cover and interception. Together, these factors can lead to increased infiltration and, under certain conditions, reduced surface runoff, although local topography and rainfall intensity may modulate this effect (Xue et al., 2025).

Minor Comments

1. Some acronyms (e.g., SWE, HRUs, NDVI) should be defined at first use.

Reply: Thank you for the suggestion, and we will define all acronyms at their first mention.

2. The use of technical terms throughout the manuscript should be consistent (e.g., “modelling” and “modeling”, “elevation zones” and “elevation areas”).

Reply: In the revised manuscript, the use of technical terms will be standardized for consistency.

3. Line 193: The URL http://srtm.csi.cgiar.org is hosted by the CGIAR Consortium for Spatial Information (CGIAR-CSI), rather than the International Center for Tropical Agriculture (CIAT). Please revise the data source attribution to reflect this accurately.

Reply: This was an error, and the data source attribution will be corrected accordingly.

4. .3 illustrates the elevation band division based on DEM data, it would be more

appropriate to place it in Section 3.2.

Reply: This is a good suggestion, and Fig. 3 will be moved to Section 3.2 accordingly.

5. Some figures (e.g., Fig. 5, Fig. 8) need clearer labels and legends. Fig. 13 needs better visualization.

Reply: We will improve the labels and legends in Figs. 5 and 8 and enhance the visualization of Fig. 13.

6. Line 692: "soi/rock" should be "soil/rock".

Reply: This typo will be corrected from “soi/rock” to “soil/rock”.

7. Please correct the punctuation errors (e.g., Line 637, Line 711).

Reply: In the revised manuscript, the punctuation errors will be corrected as indicated.

8. The conclusions are well-supported but should be more concise.

Reply: The Conclusions section will be revised to be more concise while retaining all key findings and supporting evidence.

References:

Feng, J., Alifujiang, Y., Kozhokulov, S., Jiang, Y., Yang, P., 2025. Quantifying hydrological sensitivity in Central Asia: A multi-factor budyko framework analysis (2000–2020). Journal of Hydrology: Regional Studies, 61, 102746, https://doi.org/10.1016/j.ejrh.2025.102746.

Ni, J., Chen, J., Tang, Y., Xu, J., Xu, J., Dong, L., Gu, Q., Yu, B., Wu, J., Huang, Y., 2025. Duration of vegetation green-up response to snowmelt on the Tibetan Plateau, Biogeosciences, 22, 2637–2651, https://doi.org/10.5194/bg-22-2637-2025.

Gao, H., Hrachowitz, M., Fenicia, F., Gharari, S., Savenije, H.H.G., 2014. Testing the realism of a topography-driven model (FLEX-Topo) in the nested catchments of the Upper Heihe, China. Hydrol. Earth Syst. Sci., 18(5): 1895-1915. DOI:10.5194/hess-18-1895-2014

Xue, D., Tian, J., Zhang, B., Kang, W., He, C., 2025. Evaluating the effect of vegetation type and topography on infiltration process in an arid mountainous area: Insights from continuous soil moisture monitoring network. Agricultural Water Management, 315, 109537, https://doi.org/10.1016/j.agwat.2025.109537.