Response to Reviewer 2

1. Line 18: It is recommended to describe the results using the conditions of the emission scenario rather than the version of the scenario.

We appreciate your comment. In the revised version, we will replace SSP126, SSP245, and SSP585 with concerted mitigation efforts, limited mitigation efforts, and no mitigation efforts in the abstract section. Furthermore, we will update all references to SSP126, SSP245, and SSP585 in the manuscript, adopting the terms SSP1-2.6, SSP2-4.5, and SSP5-8.5. Additionally, we will provide a detailed explanation of these three emission scenarios in Section 2.2.

2. Line 36: Please supplement which secondary disasters.

Thanks for your comment. The secondary hazards mentioned primarily include mountain floods, landslides, and debris flows. We will incorporate this information in the revised version.

3. Line 63: How did previous hydrological models simulate DFAA? How has the reservoir module progressed in hydrological models?

We sincerely appreciate your comment. Existing studies primarily utilize specific indices, such as LDFAI (Long-cycle Drought-Flood Abrupt Alternation Index) and SDFAI (Short-cycle Drought-Flood Abrupt Alternation Index), to quantify DFAA events. These indices leverage precipitation and runoff data to characterize meteorological and hydrological DFAA events. Hydrological DFAA events specifically require the use of hydrological models. A discussion on these aspects is currently presented in Section 2.5 of the manuscript. In the revised version, we intend to relocate this discussion to the introduction part and further refine it. Additionally, we recognize the scarcity of existing research on DFAA events in the LMR Basin. To address this, we plan to incorporate a discussion on DFAA events in other basins within the introduction. Moreover, we aim to provide an enhanced review of the reservoir module within hydrological models.

4. Line 78: Where is the population data obtained?

We appreciate your query. The population data cited is sourced from Sabo et al., 2017, and Luo et al., 2023, and we intend to include this reference in the revised version.

5. Line 100: Are there any other GCMs? Are only these five available, or do these five have better effects?

We appreciate your comment. We selected the five GCMs that are widely applied and demonstrate robust performance in the LMR Basin. Their reliability has been confirmed by studies such as Li et al. 2021, Yun et al. 2021a, and Yun et al. 2021b.

6. Section 2.2: There need usage instructions for the data. For instance, if the precipitation and temperature of ERA5 are used to correct GCMs, then what is the potential evapotranspiration used for?

Thank you for your comment. The evapotranspiration data of ERA5_Land dataset are utilized to derive the evapotranspiration data in the future period. The Van Peltetal method (Van Pelt et al., 2009) is implemented for this purpose. The detailed description of the methodology and its calculation formula will be included in the revised version. Additionally, we will enhance the description of other data-related content in the revised version.

7. **Section 2.3: As the core method of this section, the main formulas of MBG should be listed.**

We appreciate your suggestion. In the revised version, we will incorporate the two most critical formulas of the MBCn (Multivariate Bias Correction via N-dimensional Probability Density Function Transform) method (Cannon, 2018):

(1) Random Orthogonal Rotation:

$$\tilde{\boldsymbol{X}}_T^{[j]} = \boldsymbol{X}_T^{[j]}\boldsymbol{R}^{[j]}$$

$$\tilde{\boldsymbol{X}}_S^{[j]} = \boldsymbol{X}_S^{[j]}\boldsymbol{R}^{[j]}$$

$$\tilde{\boldsymbol{X}}_P^{[j]} = \boldsymbol{X}_P^{[j]}\boldsymbol{R}^{[j]}$$

This formula outlines the process of transforming historical observations $\boldsymbol{X}_T^{[j]}$, historical climate model simulations $\boldsymbol{X}_S^{[j]}$, and climate model projections $\boldsymbol{X}_P^{[j]}$ using a random orthogonal rotation matrix $\boldsymbol{R}^{[j]}$ during the j-th iteration. The rotated data are represented as $\tilde{\boldsymbol{X}}_T^{[j]}$, $\tilde{\boldsymbol{X}}_S^{[j]}$, and $\tilde{\boldsymbol{X}}_P^{[j]}$. This procedure is pivotal for MBCn's multivariate joint distribution correction, as it transforms the original variable space into new random orientations. In contrast to conventional uni-variate correction approaches, MBCn employs a random orthogonal matrix to mix variables, thereby breaking their independence.

(2) Quantile Delta Mapping:

$$\Delta^{(n)[j]}(i) = \tilde{x}_P^{(n)[j]}(i) - F_S^{(n)[j]^{-1}}(F_P^{(n)[j]}(\tilde{x}_P^{(n)[j]}(i)))$$

$$\hat{x}_P^{(n)[j]}(i) = F_T^{(n)[j]^{-1}}(F_P^{(n)[j]}(\tilde{x}_P^{(n)[j]}(i))) + \Delta^{(n)[j]}(i)$$

The formula defines how quantile delta mapping is applied to n-th dimension of the rotated climate model projection data $\tilde{x}_P^{(n)[j]}(i)$ within the rotated space of the j-th iteration. Here, $\Delta^{(n)[j]}(i)$ represents the quantile difference between the historical climate model simulations and climate model projections in the j-th iteration and the n-th dimension. $F_P^{(n)[j]}$ denotes the empirical cumulative distribution function for the rotated climate model projection data in the n-th dimension. $F_T^{(n)[j]^{-1}}$ and $F_S^{(n)[j]^{-1}}$ denote inverse Functions of the empirical cumulative distribution functions for the rotated historical observation data and historical climate model simulation data in the n-th dimension. This step preserves the trend of the climate model projection data throughout the correction process. The number of iterations is typically set to 10-30.

The MBCn algorithm performs multivariate joint distribution bias correction by iteratively applying the random orthogonal rotation and quantile delta mapping, while preserving the projected signals in the climate model. The rotation operation breaks dependencies between variables, enabling the quantile delta mapping of single variable to indirectly adjust multivariate correlations. The quantile delta mapping ensures the transmission of absolute or relative trends by computing quantile differences between the historical and projected periods of the climate model. The MBCn algorithm is accessible and implementable through an R package, available at: https://CRAN.R-project.org/package=MBC (last accessed at July 4, 2025).

8. Section 2.4: Why are Formula 3 and Formula 8 repeated? Can so many simple formulas be explained in the main text? The principle of reservoir allocation is suggested to be shown in a schematic diagram because these formulas are both numerous and simple.

Thanks for your comment. Eqs. (3) and (8) represent the water balance equations required during the initial phase and the normal phase of the reservoir, respectively. We exhibit both equations in order to provide a clearer and more comprehensive explanation of the operation rules for both phases. As per your suggestion, we will include a flowchart of reservoir operation in the revised version.

9. Line 145: For the complex physical mechanisms in the model, there are no formulas at all? What are the equilibrium equations, geometrical relationships, and constitutive relationships in the model? The Nash efficiency coefficient is relatively less necessary to present.

We appreciate your suggestion. In the revised version, we will provide a more comprehensive description to the THREW model to increase readers' understanding and knowledge of it.

10. Section 2.4: The GCM model is spatially distributed grid data, and the reservoir here is a lumped water distribution. How can a simple lumped water distribution be regulated regionally?

Thanks for your comment. As indicated in line 144, the THREW model performs spatial basin delineation based on Representative Elementary Watershed (REW). Within the LMR Basin, the THREW model delineates 651 REWs units and conducts runoff simulations based on these REW. The reservoir module also employs REW format for reservoir operation. For GCM data, to meet the needs of hydrological simulation in the THREW model, we downscale the GCM data from grid scale to REW scale and utilize the downscale GCM data as meteorological input for the model. We will provide the detailed explanation of this aspect in the revised version.

11. **Line 215: I thought that the five GCMs used for simulation could mutually test the reliability, but here the average value was directly used without analyzing the sensitivity of the five models. GCMs' errors are not complementary. Some may be more accurate, while others have larger errors. A simple average value is of no help to the research.**

We appreciate your comment. Since each GCM has its unique structure and assumptions, leading to varied runoff results and DFAA characteristics, conducting mutual reliability verification among the five GCMs may not be appropriate. We average multiple GCMs because a single GCM's projection of climate change involves uncertainty, which affects hydrological simulation results (Kingston et al., 2011; Thompson et al., 2014). Considering the average of GCMs helps reduce model bias, prevent outliers, minimize uncertainty, and provide more robust results (Lauri et al., 2012; Hoang et al., 2016; Wang et al., 2024; Yun et al., 2021b). This method is commonly used in existing studies (Dong et al., 2022; Li et al., 2021; Wang et al., 2022; Yun et al., 2021a). Additionally, we will improve the results by adding elaborations of the extreme value in GCM outcomes in the revised version.

12. **Line 214: According to the abstract, "Reservoir operations reduce DFAA's intensity." It should be getting the intensity of the DFAA, why there is a probability, and how to quantify intensity.**

Thanks for your comment. In this work, we assess the risk of DFAA events by calculating their probability, but don't consider their intensity. We sincerely apologize for the inaccuracy terminology used in the abstract section. We will correct it in the revised version. We sincerely appreciate your correction.

13. **Please pay attention to the garbled characters that appear in lines 156, 242, and 243.**

Thank you for your reminder. We will focus on this issue and address it in the revised version.

14. **When many formulas are piled up and there are no corresponding textual descriptions, it is very difficult to know what the logic between them is. Here, it is necessary to select the most important ones from these formulas for listing and then describe the logic of the formulas. Furthermore, what's these methods' regional applicability? What are their advantages and limitations?**

Thank you for your suggestion. We will adjust the displayed equations in the revised version, , supplement their logical relationships, and emphasize their applicability and limitations.

15. **Section 3.1: Since the study originally used ERA5 for correction, it doesn't mean that being closer to ERA5 is accurate. ERA5 also has errors. It can only be said that after correction, the GCM is closer to ERA5, and this cannot be used as an accurate basis here. Even this**

subsection can be transformed into a description of the spatiotemporal distribution of climate data.

We appreciate your suggestion. In the revised version, we will modify the presentation of Section 3.1. However, we would like to note that correcting future meteorological data by reanalysis datasets or remote sensing datasets is a common practice. In the existing studies, for example, Hoang et al. (2016) utilized WATCH forcing data and APHRODITE datasets to correct the precipitation and temperature of GCM data. Ly et al. (2023) applied Global Precipitation Climatology Centre (GPCC) to correct the precipitation in the GCM data. Wang et al. (2021) employed precipitation data from the Climate Prediction Center (CPC) to correct the GCM data. Yun et al. (2021a) and (2021b) used the Global Meteorological Forcing (GMFD) dataset to correct ISMIP3b data. Therefore, we think it is reasonable to apply the ERA5 data to correct the bias of each GCM in the CMIP6 data.

16. **Section 3.2: The absence of reservoirs before 2009 and the existence of reservoirs after 2010 should be very important background. When the coupled reservoir module is used for DFAA simulation, it should be simulated in segments. For those after 2010, additional reservoirs should be added. What will the situation of reservoirs be like in future scenarios? This needs to be explained in the summary and subsequent sections of the DFAA results.**

Thanks for your comment. We would like to point out that “The statement "The absence of reservoirs before 2009 and the existence of reservoirs after 2010" is a general concept. However, in reality, reservoir construction and operation began before 2009 (Zhang et al., 2023). The earliest reservoirs in the reservoir data we utilize were constructed in 1965 and the latest in 2035. We considered the annual change of the reservoir storage in the reservoir module. For each new reservoir, its operation is initially conducted based on the operation rules during the initial phase. Once its storage reaches the minimum constraint, the new reservoir enters the normal phase and follows the rules of normal phase. The reservoir operation in future periods will also follow these patterns.

17. **Section 3.3: Shouldn't this probability be compared with the occurrence of a single disaster before? The probability can be calculated based on the time within a year.**

Thanks for your comment. Currently, there is a paucity of detailed statistics on individual flood and drought events in the LMR Basin, which presents challenges in determining the probability of DFAA events by the single disaster. Moreover, we adopt $|\mathrm{R-SDFAI}| > 1$ as the criterion for the occurrence of DFAA events, which means that we identify DFAA events that are at least a transition between a mild hydrological drought event (standard runoff index $(\mathrm{SRI}) <-1$) and a mild hydrological wet event (standard runoff index $(\mathrm{SRI}) > 1$) (Song et al., 2023). We plan to enhance this section in the revised version.

18. **Section 3.4: How will the future reservoir operation information be obtained?**

We appreciate your comment. The reservoir dataset we collected encompasses future planned reservoirs, with the latest one scheduled to begin operations in 2035. It’s noted that the reservoir storage is scheduled to increase significantly in the future period notable and the capacity of tributary reservoirs during this period is sizable, especially in downstream reservoirs, as shown in Fig. 1c.

19. The discussion section should use more literature to support the causes and reliability of the results. Here, for example, in the first part of the discussion, except for the first sentence, which is cited, the rest is all about explaining the results.

Thank you for your suggestion. We will provide additional discussions on different characteristics of DTF and FTD incorporate existing relevant studies to further substantiate our arguments.

20. The second part of the discussion talked about the reservoir's ability to respond to DFAA. Here, in addition to considering the changes in the water volume of the reservoir, it is also necessary to consider how long the reservoir operation occurred before or after the disaster. The occurrence time of reservoir operation will have a timely impact on the specific disaster.

Thanks for your comment. The second part of the discussion part centers on the role of hydrological forecasting in improving reservoirs' ability to respond to DFAA events. As highlighted in Section 4.1, the differing levels of control reservoirs exhibit over DTF and FTD risks are attributed to their constrained ability to fully harness storage when encountering completely unforeseen inflows. To address this challenge, we propose the integration of hydrological forecasting to enhance the reservoirs' mitigative capacity. The occurrence time of reservoir operation remains constant under the SOP-based module, while the inclusion of hydrological forecasting enables adaptive operation strategies informed by forecast data, which we will provide examples of in the revised manuscript.

21. The discussion in the third part also rarely cites literature, and the utilization of the resilient storage should not be the focus of the discussion in this article. The focus is on the influence of the reservoir in the process of disaster simulation.

We appreciate your comment. Given the alignment between reservoir mitigation effects and storage capacity distribution, our analysis in Section 4.3 highlights that irrigation reservoirs, alongside hydropower reservoirs, play a crucial role in diminishing the likelihood of DFAA events and mitigating flood and drought pressures in the LMR Basin. Moreover, the substantial total storage capacity of irrigation reservoirs is a key consideration. This finding is vital for policymakers and stakeholders, as it informs the development of a cohesive dispatch network that integrates both power and irrigation reservoirs, thereby fostering joint flood and drought prevention measures.

22. In addition, the bar charts and line charts from Figure 4 to Figure 6 are all numbers that can be presented in a table, and the richness of the accompanying figures should be increased.

Thanks for your comment. We plan to adjust Figs. 4 and 5 in the revised manuscript in response to your suggestion to display not only the average of five GCMs but also their maximum and minimum values, thereby enriching the figures' information and providing further clarification of DFAA events under different GCMs.

References

Dong, Z., Liu, H., Baiyinbaoligao, Hu, H., Khan, M., Wen, J., Chen, L., Tian, F.: Future projection of seasonal drought characteristics using CMIP6 in the Lancang-Mekong River Basin. J. Hydrol. 610 https://doi.org/10.1016/j.jhydrol.2022.127815, 2022.

Hoang, L. P., Lauri, H., Kummu, M., Koponen, J., van Vliet, M. T. H., Supit, I., Leemans, R., Kabat, P., and Ludwig, F.: Mekong River flow and hydrological extremes under climate change, Hydrol. Earth Syst. Sci., 20, 3027 – 3041, https://doi.org/10.5194/hess-20-3027-2016, 2016.

Kingston, D. G., Thompson, J. R., and Kite, G.: Uncertainty in climate change projections of discharge for the Mekong River Basin, Hydrol. Earth Syst. Sci., 15, 1459 – 1471, https://doi.org/10.5194/hess-15-1459-2011, 2011.

Lauri, H., de Moel, H., Ward, P. J., Räsänen, T. A., Keskinen, M., and Kummu, M.: Future changes in Mekong River hydrology: impact of climate change and reservoir operation on discharge, Hydrol. Earth Syst. Sci., 16, 4603 – 4619, https://doi.org/10.5194/hess-16-4603-2012, 2012.

Li, Y., Lu, H., Yang, K., Wang, W., Tang, Q., Khem, S., Yang, F., Huang, Y.: Meteorological and hydrological droughts in Mekong river basin and surrounding areas under climate change. J. Hydrol.: Reg. Stud. 36, 100873. https://doi.org/10.1016/j.ejrh.2021.100873, 2021.

Luo, X., Luo, X., Ji, X., Ming, W., Wang, L., Xiao, X., Xu, J., Liu, Y., Li, Y.: Meteorological and hydrological droughts in the Lancang-Mekong River Basin: spatiotemporal patterns and propagation. Atmospheric Research 293, 106913. https://doi.org/10.1016/j.atmosres.2023.106913, 2023.

Ly, S., Sayama, T. & Try, S.: Integrated impact assessment of climate change and hydropower operation on streamflow and inundation in the lower Mekong Basin. Prog Earth Planet Sci 10, 55. https://doi.org/10.1186/s40645-023-00586-8, 2023.

Sabo, J. L., Puhi, A., Holtgrieve, G. W., Elliott, V., Arias, M. E., Ngor, B. P., Räsänen, T. A., Nam, S.: Designing river flows to improve food security futures in the lower Mekong Basin. Science 358 (6368). https://doi.org/10.1126/science.aao1053, 2017.

Song, X., Lei, X., Ma, R., Hou, J., & Liu, W.: Spatiotemporal variation and multivariate controls of short-cycle drought–flood abrupt alteration: A case in the Qinling-Daba Mountains of China. International Journal of Climatology, 43(10), 4756–4769. https://doi.org/10.1002/joc.8115, 2023.

Thompson, J., Green, A., & Kingston, D: Potential evapotranspiration-related uncertainty in climate change impacts on river flow: An assessment for the Mekong River basin. Journal of Hydrology, 510, 259 – 279. https://doi.org/10.1016/j.jhydrol.2013.12.010, 2014.

Van Pelt, S. C., Kabat, P., ter Maat, H. W., van den Hurk, B. J. J. M., and Weerts, A. H.: Discharge simulations performed with a hydrological model using bias corrected regional climate model input, Hydrol. Earth Syst. Sci., 13, 2387–2397, https://doi.org/10.5194/hess-13-2387-2009, 2009.

Wang, A., Miao, Y., Kong, X., & Wu, H: Future changes in global runoff and runoff coefficient from CMIP6 multi-model simulation under SSP1-2.6 and SSP5-8.5 scenarios. Earth's Future, 10(12), e2022EF002910. https://doi.org/10.1029/2022EF002910, 2022.

Wang, C., Leisz, S., Li, L., Shi, X., Mao, J., Zheng, Y., and Chen, A.: Historical and projected future runoff over the Mekong River basin, Earth Syst. Dynam., 15, 75–90. https://doi.org/10.5194/esd-15-75-2024, 2024.

Wang, S., Zhang, L., She, D., Wang, G., Zhang, Q.: Future projections of flooding characteristics in the Lancang-Mekong River Basin under climate change. J. Hydrol. 602. https://doi.org/10.1016/j.jhydrol.2021.126778, 2021.

Yun, X., Tang, Q., Li, J., Lu, H., Zhang, L., Chen, D: Can reservoir regulation mitigate future climate change induced hydrological extremes in the lancang-Mekong River Basin? Sci. Total Environ. 785. https://doi.org/10.1016/j.scitotenv.2021.147322, 2021a.

Yun, X., Tang, Q., Sun, S., & Wang, J.: Reducing climate change induced flood at the cost of hydropower in the Lancang-Mekong River Basin. Geophysical Research Letters, 48, e2021GL094243. https://doi.org/10.1029/2021GL094243, 2021b.

Zhang, K., Morovati, K., Tian, F., Yu, L., Liu, B., Olivares, M.A.: Regional contributions of climate change and human activities to altered flow of the Lancang-mekong river. J. Hydrol.: Reg. Stud. 50, 101535. https://doi.org/10.1016/j.ejrh.2023.101535, 2023.