# Author comments in reply to Referee 1

We thank the referee for the thorough review and the valuable suggestions, which we believe will improve the quality of the manuscript. Below we provide a detailed response. Referee comments are in bold, and our responses are in italics and blue.

Jose P. Teran,

On behalf of the authors

**Main comments:**

**The authors present an interesting study integrating reservoirs and lakes into the CoSWAT global hydrological model. The motivation for this work is clear, and the proposed model improvements appear promising. However, several aspects require further clarification and discussion before publication. The manuscript would benefit from additional analysis of basins where streamflow or storage deviates from observations, and the presentation of some figures could be improved for clarity. A clearer discussion of the model's limitations, including potential sources of uncertainty in representing reservoirs and lakes at the global scale, is needed.**

*We thank the referee for the positive assessment and the constructive comments. We agree that deeper discussion on poorly performing cases, improved figure clarity, and a clearer discussion of model limitations and uncertainty sources will strengthen the manuscript. We address each of these points in detail below.*

**Detailed comments:**

**Abstract**

**Line 27: Provide more specific information on how reservoirs and lakes affect streamflow and other hydrological variables, including quantitative performance metrics (e.g., stations with improved streamflow, KGE, PBIAS). Shorten the methods section to focus more on results.**

*We appreciate this suggestion. We will adjust this in the manuscript with more numerical details and shorten the methods.*

**Introduction**

**Line 49: List models like ParFlow that include explicit reservoir and lake representation. An example is the research of Benjamin, https://doi.org/10.5194/hess-29-245-2025, A scalable and modular reservoir implementation for large-scale integrated hydrologic simulations**

*We will include more models where this is the case. ParFlow is a good example and we thank the referee for the suggestion.*

**Line 44-45:"Drying and wetting trends are intensifying..., replace "as is" with "accompanied by" for clarity.**

**Line 51: The sentence includes too many pauses and should be rewritten for clarity.**

*These two suggestions are taken into account, we will modify the manuscript accordingly. We thank the reviewer for the comments.*

**2 Methodology**

### 2.1 Global Datasets

**Clarify the target resolution to which all data were resampled.**

*We thank the referee for this comment. It might not be so clear in Table 1. All spatial inputs used for creation of Hydrologic Response Units (HRUs) were resampled to 0.01° from their native resolution. While the rest (e.g., weather forcings) were not resampled. We will make sure this is clearer on the revised manuscript.*

**Line 145-157: Only highlight the nine major basins instead of listing all basins in detail. Consider merging with Section 2.3 for clarity.**

*We thank the referee for the suggestions. We believed it was important to mention this as the modelled regions do not all necessarily represent one large system or basin, but can include several independent ones. However, we do agree a detailed listing is not necessary as the point raised before is probably clear from Figure 1, so this section will be shortened in the revised manuscript.*

**Figure 1: Add the north arrow and scale bar.**

*We respectfully note that the figure already includes a labelled graticule with latitude and longitude coordinates indicating East and North directions, providing full spatial reference for the map. For a global map in geographic projection, we believed the scale bar was not ideal at this extent as it varies with latitude, and, given the graticule, a north arrow would be redundant. Similar figures in comparable studies (Müller Schmied et al., 2021; Vanderkelen et al., 2022) do not include these elements either. We are happy to adjust if the Editor feels otherwise.*

### 2.3 Reservoir/Lake integration into model network

**Figure 2: According to Section 2.3, Figure 2b represents the overall workflow and should appear first. Rename figures to ensure Figure 2b is the first (overall workflow), and 2a follows. Like Figure 2b become 2a, and 2a become 2b.**

*We appreciate this suggestion. We believe the intended message of the figure may not have been communicated clearly enough. Figure 2a represents the main CoSWAT model setup process built by the CoSWAT Framework (Chawanda et al., 2025), and Figures 2b, 2c, and 2d illustrate the new procedures contributed in this study, showing how they are integrated into that framework. Therefore, Figure 2a intentionally appears first as the overarching context, with the new contributions following. We will clarify this in the caption and surrounding text in the revised manuscript.*

**Line 168-171: Reword to describe "integration of reservoirs and lakes into the model network" rather than "a new lake/reservoir resolution procedure."**

*This is completely true and we thank the referee for noting it. The wording was not the best. We will refer to this as "integration" rather than "resolution" throughout the revised manuscript .*

**Line 176: how to burn-in of lake/reservoir elevations into DEM?**

*We thank the referee for raising this point. Similar to stream burning, a common approach in SWAT+ and similar models, we condition the DEM by reducing the elevation of pixels intersecting the aligned lake/reservoir area by 14 meters. This follows a similar approach to HydroSHEDS (Lehner et al., 2008) and improves the subsequent stream network delineation, ensuring better alignment with lake boundaries. This procedure was not described in sufficient detail in the manuscript and will be included in the revised version.*

**Line 186-188: Clarify why certain variables such as pvol, evol, parea, eaera, shp_col1/shp_col2, which represent reservoir information, point to hydrology.res rather than reservoir.con? Is it not more reasonable to use reservoir.con for reservoir information? Since area refers to the water body surface, is it not more consistent to use hydrology.res for water surface area? Also, why are max/min storage and outflow rates missing?**

*We thank the referee for this comment. Regarding the file structure, hydrology.res stores hydrological properties of reservoirs (such as volumes, areas, and shape parameters) used in calculations during simulations, while reservoir.con contains connectivity information (e.g., how the reservoir object connects to the channel network). This follows the SWAT+ model structure as documented in the official SWAT+ I/O documentation (https://swatplus.gitbook.io/io-docs), and is therefore the appropriate file for the variables listed. Regarding max/min storage and outflow rates, these are not set as direct parameters in the model files. Instead, they are implicitly handled for each reservoir through decision tables, as described in Section 2.4. A fixed outflow rate is a possible option within decision tables, but since CoSWAT relies on generalized simulation schemes, specific outflow rates are not prescribed and are therefore not part of the modelling framework. We will ensure that the roles of hydrology.res and reservoir.con are clearly explained in the revised manuscript.*

**2.4 New lake and reservoir simulation scheme**

**Line 207: provide more details for decision table (e.g.reference).**

**Line 208: Clarify which two parameterization methods are used (e.g., Doll et al., 2003 and H06 scheme).**

*We will make sure this is done. We appreciate the suggestion.*

**Line 208 & 735: Introducing arrays, loops, variable initialization, represents preparatory steps rather than true modifications of the source code. Only changes to formulas/functions should be considered innovations. The third and fifth item in Table A-1 representing a novel contribution.**

*We thank the referee for this comment and believe the assessment may stem from the descriptions in Table A-1 not being sufficiently clear. The introduction of arrays, loops, and variable initialization are not merely preparatory steps, but integral components of the source code modifications. Specifically, they enable a time-variant implementation of the H06 scheme (Gharari et al., 2024), which is a key contribution of this work. These structural changes are essentially part of the scheme and it would not be possible to use it without them. The innovations in Table A-1 should therefore be understood as a cohesive set of changes: the array that stores the reservoir "memory" of inflows and demands, updated continuously throughout the simulation, and the equations to calculate outflow based on this, together constitute the novel contribution. We believe the descriptions in Table A-1 may have wrongly suggested that the scheme-related modifications were limited to the res_hydro subroutine, while in fact all listed modifications are relevant and necessary. We will adjust Table A-1 and the related text to make this clearer in the revised manuscript.*

**Line 253: Combine sentences for better flow.**

*We will make sure this is done. We appreciate the suggestion.*

**Figure 3: In subplot (a), the blue area is not labeled, and the brown "Groundwater" layer appears minimal or missing. Please add a north arrow and scale bar.**

*We thank the referee for this comment. We will improve the legend to clarify the blue area (i.e., lakes and reservoirs). Indeed, the groundwater layer occupies a small area and is therefore not clearly visible specifically on this downstream section of the Nile River Basin. We will use another section of the modelled regions that is more representative of all three sources to recreate this figure on the revised manuscript. Given this is a considerably smaller extent compared to Figure 1, we agree a scale is useful, thus we shall add it on the figure in the revised manuscript.*

**2.6 Simulation setup, model comparison, and evaluation**

**Line 274 & 295: Ensure uniform resolution for the nine selected basins and all input datasets.**

*We thank the referee for this comment. We believe there may be a misunderstanding: the two resolutions mentioned refer to different datasets serving different purposes. For line 274, the 0.01° resolution refers to* *the spatial input data used for model configuration, an improvement over the 0.02° resolution of CoSWAT v1. For line 295, the 0.5° grid refers to the ISIMIP model output format, where each cell represents aggregated water storage across all lakes and reservoirs within that cell. These resolutions are therefore not inconsistent, but reflect the different nature of the datasets. We believe this is already made clear in lines 296-298:*

*"For each evaluated reservoir, the storage time series was extracted at the grid cell corresponding to the reservoir outlet. This differs from CoSWAT, whose outputs are not gridded and are produced explicitly for each water body".*

*We will nonetheless ensure that the resolution of spatial inputs is stated as consistent across all modelled regions in the revised manuscript.*

**Figure 4: Add the north arrow and scale bar.**

*Similar to Figure 3, given this is a considerably smaller extent compared to Figure 1, we agree a scale is useful, thus we shall add it on the figure in the revised manuscript.*

**3.2 Reservoir and lake storage, inflow and outflow evaluation**

**Figure 5: Why do KGE histograms in the first subplot show a minimum value, but others do not?**

*As described in Section 2.6, a minimum benchmark value is only established for KGE, following Knoben et al., (2019), who define a threshold below which the model performs worse than a the mean of observations. No equivalent benchmark threshold is defined for r or PBIAS, which is why the minimum value is only shown in the KGE histogram, while all indicators have a "satisfactory" and "good" threshold.*

***Figure B-1: Why is the spatial distribution presented as a block-type map? Most of the Mississippi and South American basins show KGE values below -0.4. The authors should explain the cause of this phenomenon.***

*We thank the reviewer for this observation. The block-type appearance of the maps in Figure B-1 comes from the location of the centroid of each reservoir/lake with available data to evaluate the model. Each location is plotted as point with a square shape, as plotting each reservoir's actual shape at such scale would not allow adequate visibility. However, we note that the figure could be improved with a smaller point size and a different shape for the points to avoid confusion. We will update the figure accordingly in the revised manuscript.*

*Regarding the poor KGE values in the Mississippi and Parana river basins, the most common cause is the absence of calibration for parameters associated to the hydrological cycle, which leads to biases in main processes such as surface runoff and consequentially produces poor inflow estimates to the water bodies, affecting the storage. Moreover, alongside the uncalibrated status for general hydrology, specific parameters associated with the implemented schemes to simulate reservoir/lake outflow were also not calibrated, which can have a large influence, specially in cascading reservoirs (Shin et al., 2019; Vanderkelen et al., 2022), a configuration that happens relatively often in the mentioned regions. In that sense, the choice of fixed values for some of the scheme parameters across all water bodies, may further contribute to this. Additionally, we cannot rule out contributions from the quality of the weather input data, which could additionally have an impact on hydrological processes.*

*These aspects are broadly discussed in Section 4.2 of the manuscript. In the revised manuscript, we will expand the discussion of Figure B-1 to more explicitly highlight the spatial patterns in these regions and the most influential factors driving the poor performance observed there.*

**Line 340: Only 34% of basins achieve positive KGE values. What factors contribute to this low performance?**

*The factors contributing to the overall low proportion of basins with positive KGE are, in essence, the same as those discussed in our response to the previous comment regarding the Mississippi and Parana basins:*

*the uncalibrated state of the model leading to inaccurate estimation of key hydrological processes, uncalibrated scheme parameters for reservoir and lake outflow, the simplicity and assumptions of the reservoir/lake outflow simulation schemes, and potentially the quality of the meteorological forcing data. These aspects are broadly discussed in Section 4.2 of the manuscript. In the revised manuscript, we will state this more clearly and better establish the connection between the general performance numbers and spatial patterns described in the results section and the interpretive discussion in Section 4.2.*

**Line 368: provide more details for these explanations (e.g., figure of a few soil moisture profiles supporting the statement (Figure B-2c).**

*We acknowledge that additional supporting material would better explain the clusters found in the storage PBIAS and elevation relationship. While soil moisture profiles are not directly possible to obtain from SWAT+ as an output, we will explore the spatial distribution of water yield (i.e., the sum of surface, sub-subsurface runoff and groundwater return flows) and/or average soil water content to further clarify the mechanisms behind the observed patterns in Figure B-2c. Moreover, we will adjust this figure to better highlight those clusters. This will be integrated in the revised manuscript.*

**Line 374-375: Explain why Berryessa Lake shows underestimation from 1999-2004.**

*We thank the reviewer for this suggestion. The storage underestimation during 1999-2004 results from a combination of two factors, both visible in Figure 1 (included here to illustrate this specific period). First, inflows are underestimated during 1999-2002, which are years with relatively low precipitation, causing the model to underestimate surface runoff. Second, the outflow scheme produces an overly constant release during this period, failing to reduce outflows sufficiently during dry conditions, which causes the reservoir to lose storage at a rate higher than observed. This highlights the need for model calibration both for general hydrological processes and for the reservoir scheme: particularly the minimum storage and release coefficients, to improve the representation of reservoir behaviour during dry periods. It also highlights a broader limitation of the scheme, which may not capture operational changes made specifically in response to dry conditions, given that over the full simulation period the monthly storage performance remains satisfactory (KGE = 0.62). We will include this in the revised manuscript.*

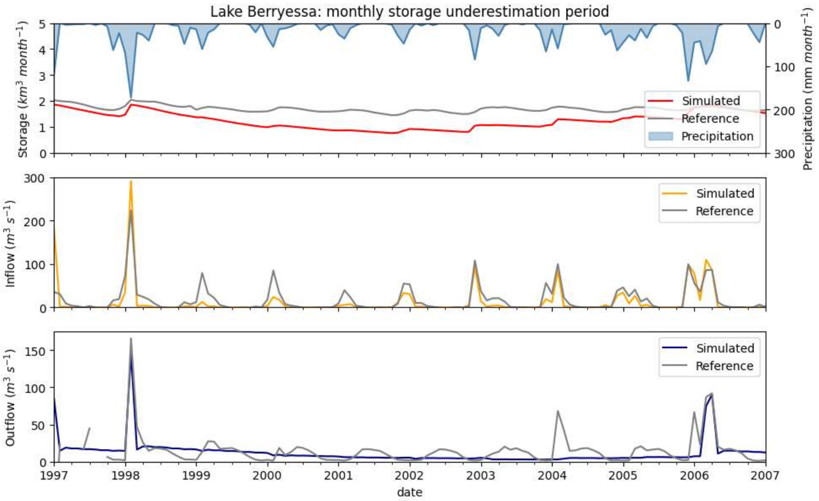

*Figure 1: Monthly storage, inflow, outflow and precipitation for Lake Berryessa.*

**Line 382: The inclusion of reservoirs in Lake Oahe–Mississippi River appears to decrease streamflow performance, particularly in 2004–2009 when storage is poorly simulated. What causes this, and why do inflow and outflow metrics show large deviations (inflow: KGE = -2.03, PBIAS = -96.9%; outflow: KGE = -1.84, PBIAS = -109.3%)?**

*We appreciate this comment, and the further analysis of this case provides useful insights. Lake Oahe is a particularly interesting case, as it is affected by phenomena similar to those observed for Lake Berryessa, including issues with scheme parameterization and poor inflow simulation, but with the added influence of an upstream reservoir: Fort Berthold, as illustrated here in Figure 2. At Fort Berthold, inflow is overestimated for much of the simulation period, driven primarily by surface runoff overestimation, which in turn leads to overestimated reservoir outflow. This propagates downstream to Lake Oahe, where inflows are also generally overestimated (Figure 6b in the manuscript), producing overestimated outflows and large storage fluctuations during several periods of the simulation (e.g., 1974–1982).*

*During the 2004–2009 period specifically, the model enters a phase of storage overestimation. Inflow overestimation persists, though at lower magnitudes than in other periods, but the simulated outflow, while still overestimated, is not of sufficient magnitude to deplete storage to observed levels, as it happens on other periods. Storage evolution during this period shows how, besides an inadequate inflow, the scheme parameterization can significantly affect storage simulations. All aspects discussed explain the particularly poor performance metrics reported for Lake Oahe in terms of inflow, outflow, and storage for the period 2004-2009.*

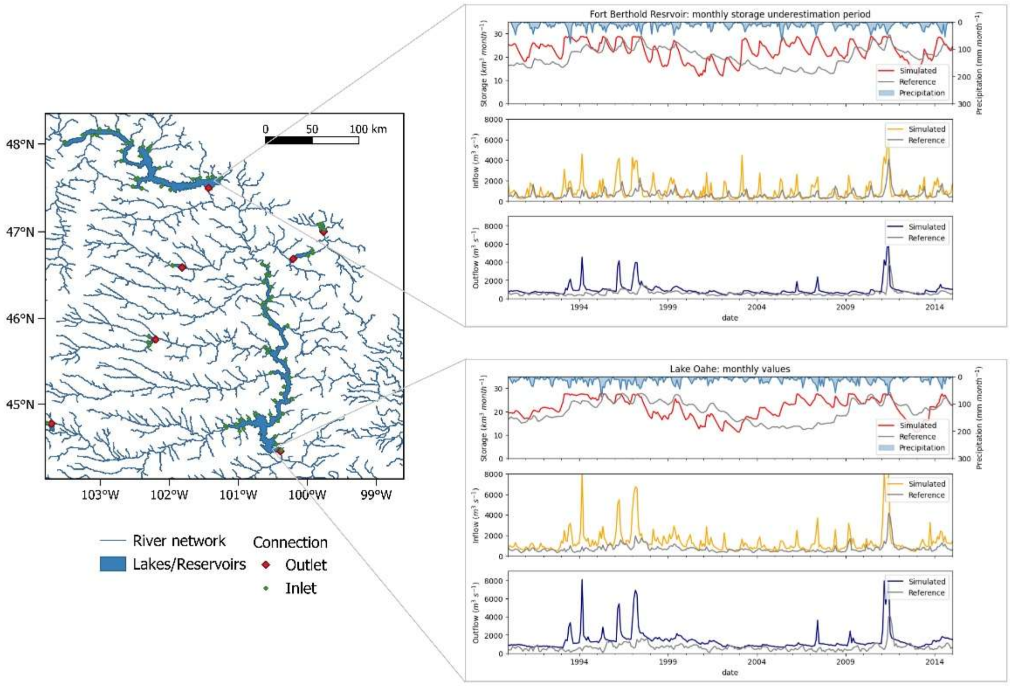

*Figure 2: Monthly storage, inflow, outflow and precipitation for Lake Oahe and Fort Berthold reservoir.*

*Overall, we see the influence of the uncalibrated state of the model for hydrological processes, the impacts of cascading reservoirs and the parameterization of the reservoir scheme. This is a valuable and important analysis that we will include in the revised manuscript.*

### 3.3 Comparison with other global models

**Figure 7: Clarify why CoSWAT's distribution is inconsistent across models. Are the violin plots comparing metrics between CoSWAT and other models or between models and observation data? Also, in subplot (b), the model colors differ. Why are dark and light colors not consistently labeled in the legend to indicate metric ranges? clarify color representations in the legend.**

*Regarding the varying CoSWAT distribution (Figure 7a), this is a consequence of the evaluation approach: as described in lines 399-403, performance distributions are computed using only the subset of water bodies simultaneously represented by CoSWAT and each respective ISIMIP model. Since the reference datasets differ in their reservoir coverage, the CoSWAT sample size varies per comparison. We will rephrase this in the revised manuscript to make it more explicit. Regarding the colours in Figure 7b we believe the legend is consistent: for each model, the darker shade represents the stricter performance threshold and the lighter shade the looser one, following the same pattern across all metrics. We will nonetheless revise the caption to make this colour scheme more explicit and easier to interpret.*

**Line 395-396: Provide references for the reservoir-related models mentioned.**

*Thank you for this suggestion, we will add their references in the revised manuscript.*

### 3.4 Streamflow evaluation

**Figure 8: Subplot (a) is redundant with Figure B-1a; Subplot (b): Distinguish categories 1-4 with colors or labels.**

*Thank you for this comment. Subplot (a) of Figure 8 presents streamflow performance, while Figure B-1a shows reservoir storage performance; these are inherently different variables and therefore the plots are not redundant. Regarding subplot (b), skill category labels are already provided on the y-axis, but we will update the colours to make the distinction between categories clearer in the revised manuscript.*

**Figure 9: Recommend indicating the area of the six sub-basins and adding inset maps showing sub-basin shapes and the locations of reservoirs and lakes in upstream/downstream positions.**

*Thank you for this recommendation. It is a great idea to have an inset map showing more spatial details to each analysed station. We will make sure to recreate Figure 9 considering that.*

**Line 451-452: Analyze the reasons for these discrepancies in the Mississippi and Central European regions and propose potential improvements? Figure 8 also seems to reflect this issue.**

*We thank the reviewer for this observation. The interpretation of these discrepancies is provided in Section 4.3, where we discuss that improvements in streamflow performance, while widespread, remain insufficient in absolute terms for a large fraction of stations due to the uncalibrated state of the model and biases in hydrological processes (e.g., surface runoff). Despite achieving relative improvements through the integration of lakes and reservoirs, the primary pathway to address poor performance in absolute terms is large-scale calibration, specifically through Hydrological Mass Balance Calibration (HMBC; Chawanda et al., 2020), as discussed in Section 4.4. In the revised manuscript, we will explicitly reference the Mississippi and Central European regions as illustrative examples of this pattern in Section 4.3, making the connection between the regional results and the broader interpretive discussion more explicit, and identifying these regions as priority targets for future HMBC application.*

**Line 482-483: Clarify whether the overestimation is caused specifically by the reservoir implementation.**

*We thank the reviewer for pointing this out. The overestimation of runoff is not caused by the reservoir implementation, as the same pattern is already present in the model configuration without reservoirs. The main reason lies in the parametrization of main hydrological processes. This will be clarified in the revised manuscript.*

**Line 485: Justify the choice of the six representative basins.**

*The six representative cases were selected based on the largest change in KGE (with vs without reservoirs/lakes) within each skill category. We will ensure this selection criterion is clearly stated in the revised manuscript.*

**Line 495-496: Add figures showing reservoir configurations in the six basins with and without reservoirs for better comparison. *What is the basis for this observed phenomenon (e.g., which figure or data)? provide a deeper analysis of the reason (eg. the modeling mechanisms, the formulation and parameterization choices)***

*We appreciate this suggestion. Figure 9 already presents the comparison between simulations with and without new implementations alongside observed GRDC data for each of the six stations, which is the direct basis for the statements made. Following suggestions from other comments, the figure will be updated to also include the upstream reservoir configuration for each station, including information about the main use of the reservoir, providing better spatial and operational context. Regarding the deeper analysis, in cases where the inclusion of reservoirs degrades performance relative to the simulation without them (i.e., Benamariel and Na-Kae), the primary cause is the parametrization of the outflow scheme, which leads to inaccurate release estimates. In these cases, the issue cannot be attributed to poorly represented upstream hydrology, given that the model without reservoirs and lakes actually produces better results. We will ensure this is further expanded and explicitly linked to these examples in Section 4.3 of the revised manuscript.*

**Line 499-500: Clarify the basis for the statement in Figure 9.**

*We thank you for this suggestion. The basis for these statements is the direct comparison between the "With" and "Without" simulations in Figure 9. For Benamariel, the model already showed reasonable seasonal values without reservoirs, and adding them exaggerates the effect of upstream water bodies, leading to overestimated flows. For Na-Kae, the opposite occurs: the model already underestimates streamflow without reservoirs, and the addition of lakes and reservoirs with low outflows further amplifies this underestimation. We will recreate Figure 9 with additional details on the basin configuration and upstream reservoirs, which will provide better context for this statements.*

**4 Discussion**

**4.1 Integration of lakes, reservoirs, and irrigation**

**Line 518-521: If the irrigation module is included, validation should be provided, or remove the discussion of irrigation and focus on reservoirs and lakes.**

*We thank the reviewer for this suggestion. We will focus the discussion on lakes and reservoirs and remove the irrigation component.*

**4.2 Model performance of simulated reservoirs and lakes**

**Line 549-550: Discuss why Nasser Lake and Lake Oahe show overestimation and underestimation in certain years.**

*We appreciate this comment. Based on previous comments above, we will expand the discussion for the selected cases such as Lake Oahe and Nasser lake. Which are greatly influenced by a combination of aspects; scheme parameter values, and uncalibrated status of the model for main hydrological processes. The revised manuscript will include a deeper discussion on this.*

**Line 565-568: Given that the model performance does not improve in some cases after introducing reservoirs and lakes, can the authors suggest potential improvements? For example, could the number of reservoirs be adjusted based on basin characteristics (hydropower, flood control, irrigation)? In basins not dominated by**

**hydropower, could some reservoirs or lakes be reduced? Additionally, have the authors considered evaluating the impact of reservoirs and lakes on other hydrological variables beyond streamflow (e.g., soil moisture, ET)?**

*We thank the reviewer for this comment. Overall we believe the main pathways to improve model performance are Hydrological Mass Balance Calibration (HMBC; Chawanda et al., 2020), a localized, standalone calibration of reservoir scheme parameters, calibration of lake evaporation parameters (which can greatly affect the water balance in lakes with large surface area), which is mentioned in both section 4.2 and section 4.4. In principle, we believe that while the introduction of reservoirs could lead to a worse streamflow performance downstream in some cases, this could be corrected by following the steps mentioned before. Nonetheless, it is also a good suggestion that we appreciate and will mention, to reduce the number of reservoirs represented in the model to balance streamflow performance and representation of freshwater bodies. While the aim of the CoSWAT global model, beyond adequately representing streamflow, is to represent freshwater storage robustly, meaning to retain as many water bodies with significant storage as possible, thus, we must balance streamflow performance with storage representation. This discussion will be added to the manuscript.*

*Regarding other variables, although it would be interesting to explore them, we find streamflow and reservoir water budget the most influential related to new implementations, as we specifically aim to see how the model is able to represent freshwater body storage. But exploring other variables, specifically in applications of the model, is an endeavour that we will sure include as future work.*

**Also, following the suggestions provided for Section 3.4, add the discussion about these issues.**

*We thank the referee for the comment and the suggestion. We will extend the discussion about those issues in this section.*

### 4.3 Impacts on streamflow representation

**Line 575: Clarify the origin of the 70% and 42% values. Are they based on the sum of categories described in Section 3.4?**

*We thank you for this suggestions. Indeed the figures are based on the categories. The 70% figure the sum of the categories where improvements exist, and the 42% figure indicates the number of stations that were poor before implementations and improve. We will make this clear on the revised manuscript by indicating that the 70% value is the sum of both category 1 and 2, while 42% accounts for those cases where stations performed poorly on the model without reservoirs and saw an improvement.*

### 4.4 Implications and future work

**Line 599-600: Provide examples of dedicated lake models for coupling with CoSWAT.**

*Thank you for this suggestion. One of the limitations of the ISIMIP Lake Sector is the difficulty of obtaining boundary conditions from global simulations, namely water budget and pollutant loading, as inputs to lake models (Golub et al., 2022). This is why efforts such as those in Ayala et al., (2026) have been made to better link the Global Water Sector with the Lake Sector. Here, we stress the potential of CoSWAT to explicitly produce those boundary conditions for lake models, thanks to the semi-distributed structure of SWAT+, which represents individual lakes and reservoirs rather than gridded cells. From the ISIMIP Lake Sector, models that account for the water balance in their formulation, such as GOTM (Peng et al., 2025), LAKE (Heiskanen et al., 2015), GLM (Hipsey et al., 2019), and VIC-LAKE (Bowling & Lettenmaier, 2010), will be mentioned in the revised manuscript. We will also mention examples where SWAT+ has been coupled with lake models such as GPLake-M (Nkwasa et al., 2025), GOTM (Jiménez-Navarro et al., 2023).*

**Line 613: Consider adjusting reservoir numbers based on basin characteristics in future work.**

*Thank you for this suggestion. As mentioned on a comment above, we will include this as a potential avenue to improve model performance in the revised manuscript.*

**5 Conclusion**

**The model should not be called a "network-resolution approach" since it integrates reservoir and lake areas rather than changing network resolution.**

*Thank you for noting this. As mentioned before, we will adjust the manuscript overall in relation to this to change the term as "integration" rather than "resolution".*

**Line 625-627: Add quantitative indicators (e.g., performance metrics) to the conclusion.**

*We appreciate this suggestion. We will definitely add significant indicators to the conclusion on the revised manuscript.*

**Line 628: The statement about improved low-flow control is not supported by the results, as some representative basins (Section 3.2, Figure 6b) still show significant low-flow underestimation. Discuss potential causes.**

*We appreciate this comment. What we meant was that, compared to a model without reservoirs and lakes, low-flow conditions are generally better represented, particularly for rivers where streamflow performance falls within categories 1 or 2. Nonetheless, there are still cases where low-flow performance relative to observations is poor, but this does not contradict the improvement observed in other cases, as shown in Figure 9. The statement will be clarified to explicitly state that the improvement is in relation to a model without reservoirs (supported by Figure 9), while acknowledging that low-flow seasons remain over- or underestimated in some cases, as seen in Figure 6 and also Figure 9. The main causes of these remaining discrepancies are biases in simulated inflows and the parametrization of the outflow scheme, and the simplicity of the outflow scheme as such. Addressing these through parameter calibration will be an important direction for future improvement. That will also be more explicitly mentioned on the revised manuscript.*

## References

Ayala, A. I., Hinostroza, J. L., Mercado-Bettín, D., Marcé, R., Gosling, S. N., Pierson, D. C., & Sobek, S. (2026). Integration of the Global Water and Lake Sectors within the ISIMIP framework through scaling of streamflow inputs to lakes. *Geoscientific Model Development*, *19*(1), 41–56. https://doi.org/10.5194/gmd-19-41-2026

Bowling, L. C., & Lettenmaier, D. P. (2010). Modeling the Effects of Lakes and Wetlands on the Water Balance of Arctic Environments. *Journal of Hydrometeorology*, *11*(2), 276–295. https://doi.org/10.1175/2009JHM1084.1

Chawanda, C. J., Arnold, J., Thiery, W., & Van Griensven, A. (2020). Mass balance calibration and reservoir representations for large-scale hydrological impact studies using SWAT+. *Climatic Change*, *163*(3), 1307–1327. https://doi.org/10.1007/s10584-020-02924-x

Chawanda, C. J., Van Griensven, A., Nkwasa, A., Teran Orsini, J. P., Jeong, J., Choi, S.-K., Srinivasan, R., & Arnold, J. G. (2025). CoSWAT Model v1: A high-resolution global SWAT+ hydrological model. *Hydrology and Earth System Sciences*, *29*(23), 6901–6916. https://doi.org/10.5194/hess-29-6901-2025

Golub, M., Thiery, W., Marcé, R., Pierson, D., Vanderkelen, I., Mercado-Bettin, D., Woolway, R. I., Grant, L., Jennings, E., Kraemer, B. M., Schewe, J., Zhao, F., Frieler, K., Mengel, M., Bogomolov, V. Y., Bouffard, D., Côté, M., Couture, R.-M., Debolskiy, A. V., … Zdorovennova, G. (2022). A framework for ensemble modelling of climate change impacts on lakes worldwide: The ISIMIP Lake Sector. *Geoscientific Model Development*, *15*(11), 4597–4623. https://doi.org/10.5194/gmd-15-4597-2022

Heiskanen, J. J., Mammarella, I., Ojala, A., Stepanenko, V., Erkkilä, K., Miettinen, H., Sandström, H., Eugster, W., Leppäranta, M., Järvinen, H., Vesala, T., & Nordbo, A. (2015). Effects of water clarity on lake stratification and lake-atmosphere heat exchange. *Journal of Geophysical Research: Atmospheres*, *120*(15), 7412–7428. https://doi.org/10.1002/2014JD022938

Hipsey, M. R., Bruce, L. C., Boon, C., Busch, B., Carey, C. C., Hamilton, D. P., Hanson, P. C., Read, J. S., De Sousa, E., Weber, M., & Winslow, L. A. (2019). A General Lake Model (GLM 3.0) for linking with high-frequency sensor data from the Global Lake Ecological Observatory Network (GLEON). *Geoscientific Model Development*, *12*(1), 473–523. https://doi.org/10.5194/gmd-12-473-2019

Jiménez-Navarro, I. C., Mesman, J. P., Pierson, D., Trolle, D., Nielsen, A., & Senent-Aparicio, J. (2023). Application of an integrated catchment-lake model approach for simulating effects of climate change on lake inputs and biogeochemistry. *Science of The Total Environment*, *885*, 163946. https://doi.org/10.1016/j.scitotenv.2023.163946

Knoben, W. J. M., Freer, J. E., & Woods, R. A. (2019). Technical note: Inherent benchmark or not? Comparing Nash–Sutcliffe and Kling–Gupta efficiency scores. *Hydrology and Earth System Sciences*, *23*(10), 4323–4331. https://doi.org/10.5194/hess-23-4323-2019

Lehner, B., Verdin, K., & Jarvis, A. (2008). New Global Hydrography Derived From Spaceborne Elevation Data. *Eos, Transactions American Geophysical Union*, *89*(10), 93–94. https://doi.org/10.1029/2008EO100001

Müller Schmied, H., Cáceres, D., Eisner, S., Flörke, M., Herbert, C., Niemann, C., Peiris, T. A., Popat, E., Portmann, F. T., Reinecke, R., Schumacher, M., Shadkam, S., Telteu, C.-E., Trautmann, T., & Döll, P. (2021). The global water resources and use model WaterGAP v2.2d: Model description and evaluation. *Geoscientific Model Development*, *14*(2), 1037–1079. https://doi.org/10.5194/gmd-14-1037-2021

Nkwasa, A., Pelorosso, R., Nicolina Ripa, M., Nilca, M., Puiu, I., & Kahil, T. (2025, March 18). *Nutrient mitigation pathways for sustainable lake ecosystems in Europe*. https://doi.org/10.5194/egusphere-egu25-5193

Peng, J., Jones, N. L., Rayson, M. D., Schmitt, M., Umlauf, L., Whitwell, C., Keating, S. R., Shakespeare, C. J., & Ivey, G. N. (2025). Interactions Between Diurnal Warm Layers and Surface-Layer Fronts. *Journal of Geophysical Research: Oceans*, *130*(1), e2024JC021380. https://doi.org/10.1029/2024JC021380

Shin, S., Pokhrel, Y., & Miguez-Macho, G. (2019). High-Resolution Modeling of Reservoir Release and Storage Dynamics at the Continental Scale. *Water Resources Research*, *55*(1), 787–810. https://doi.org/10.1029/2018WR023025

Vanderkelen, I., Gharari, S., Mizukami, N., Clark, M. P., Lawrence, D. M., Swenson, S., Pokhrel, Y., Hanasaki, N., Van Griensven, A., & Thiery, W. (2022). Evaluating a reservoir parametrization in the vector-based global routing model mizuRoute (v2.0.1) for Earth system model coupling. *Geoscientific Model Development*, *15*(10), 4163–4192. https://doi.org/10.5194/gmd-15-4163-2022