Reply to Referee #1

Dear Referee,

We are grateful for your insightful comments on our manuscript. Your feedback has contributed to enhancing the quality of our work. Below, we provide a point-by-point response (in blue) to your comments (in black) and outline how we will address each suggestion in the revised manuscript.

Sincerely,

Nariman Mahmoodi, Ulrich Struck, Michael Schneider, and Christoph Merz

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The manuscript titled "Reinforce Lake Water Balance Component Estimations by Integrating Water Isotope Compositions with a Hydrological Model" has been thoroughly reviewed. It presents an interesting study with valuable practical applications. However, the reviewer has noted the following concerns for the authors' and editor's consideration:

1. In the abstract (lines 13-14), the authors suggest their approach as an alternative method for capturing the dynamic behaviour of the hydrological groundwater/surface water system, yet the study is based on only one year of sampling. Can this work truly represent the hydrological dynamics of the lake system? Additional clarification or rephrasing may be needed.

   We agree that relying on only one year of isotope analysis may not be sufficient to claim that this study fully represents the long-term hydrological dynamics of the lake system. Our intention in the original statement was to emphasize that the approach we used—integrating isotope analysis with hydrological modeling—offers an alternative to previous studies that focused solely on model outputs without incorporating direct measurements of isotope data. We acknowledge that long-term monitoring would provide a more robust representation of the system's dynamics. We will rephrase the abstract to clarify that this approach is intended as a complement to more extensive modeling efforts. The revised wording will better reflect the scope and limitations of the study to avoid misunderstandings.

2. The authors state that an isotope mass-balance model was used to quantify the evapotranspiration rate by accounting for groundwater inflow to offset evaporation losses, in the context of the lake's water balance. However, how is open water evaporation handled? Does the evapotranspiration calculated in this study include ET from groundwater? Further clarification on this point would be beneficial.

   In our model, we employed an isotope mass balance approach, which compares the isotopic composition of water between groundwater and lake water. The changes in isotope composition of lake water in comparison to the groundwater will be used to calculate the evaporation form the lake not evapotranspiration. More details of how the isotope mass balance works can be seen in Skrzypek et al. (2015). We will modify the manuscript to make that clear.

The referee has inquired about whether we accounted for direct evaporation from groundwater. Given that our mass balance model focuses on comparing isotope compositions, the specific pathway of evaporation—whether it occurs directly from groundwater or elsewhere—is not critical to the model's primary function. However, it is important to note that groundwater can influence soil moisture in the root zone and surface evaporation when the water table is near the surface, such as in wetland areas. When the groundwater table is within or close to the model's soil column, it can substantially affect soil moisture levels and evapotranspiration rate as a consequence. For further reference, see Chen and Hu (2004). In our study area, the GGS catchment, water flow in the root zone is predominantly vertical, moving downward to the groundwater table which is not connected to the root zone. The one-dimensional vertical flow, along with processes like evaporation and transpiration, has been accounted for in our hydrological model.

References:

Skrzypek, G., Mydłowski, A., Dogramaci, S., Hedley, P., Gibson, J.J. and Grierson, P.F., 2015. Estimation of evaporative loss based on the stable isotope composition of water using Hydrocalculator. Journal of Hydrology, 523, pp.781-789.

Chen, X. and Hu, Q., 2004. Groundwater influences on soil moisture and surface evaporation. Journal of Hydrology, 297(1-4), pp.285-300.

3. The authors mention a hydraulic connection between the lake and groundwater system. Additional details on the assumptions made would be valuable. For instance, is there any seepage from the lakebed to the groundwater?

Based on lake level records and groundwater data monitored in piezometers, the groundwater fluctuations on both sides of the lake closely mirror the lake level fluctuations (Fig. 1). This indicates a strong hydraulic connection between the lake and the surrounding groundwater, supporting the conclusion that the lake is a flow-through system, as also confirmed by the isotope composition analysis, where E/I ratio is around 40% which is typical for flowthrough systems. Additionally, there is no surface water inflow to the lake. To clarify, determining the precise nature of the connection between the lake and groundwater through the lakebed would require specialized sediment sampling and laboratory analysis, which falls outside the scope of this study. In opposite, the isotopic composition analysis includes the horizontal and vertical exchange between groundwater and lake water body. The inflow to the lake has been calculated for the whole lake domain (including lakebed influence) and therefore can be used to validate the results of the hydraulic modeling.

4. The authors used the HydroGeoSphere (HGS) modelling code (Aquanty Inc., 2023) to simulate hydrological processes in the study area. Could the authors clarify why the HGS model was selected over other 3D models, such as MODFLOW, and discuss any comparative advantages?

   We selected HydroGeoSphere (HGS) for this study because it provides a fully integrated simulation of both surface and subsurface hydrological processes, which was crucial for capturing the dynamics of the study area. Unlike MODFLOW, which is primarily a groundwater flow model, HGS offers a comprehensive approach by coupling surface water, groundwater, and soil moisture interactions. This allows us to simulate processes such as evaporation from the lake (or other land use- land covers), overland flow (if any), and the interaction between surface water and groundwater, all of which are key to understanding the hydrological balance in our study area. Another advantage of HGS is its ability to model unsaturated and saturated flow, which is a basic prerequisiteto calculate the groundwater recharge directly. Additionally, HGS's ability to simulate evaporation from the lake—an essential process in this case—would be difficult to achieve with MODFLOW without significant customization or the use of third-party extensions. Therefore, the use of HGS provided a more comprehensive approach to simulating the entire hydrological system, allowing us to capture the multi-dimensional water flow pathways and interactions with greater accuracy. This uniqueness of the HGS model will be added to the manuscript.

5. It would be helpful to provide more information about the HGS model setup, including the number of aquifer layers, initial boundary conditions, and model parameters used in this study.

   The HydroGeoSphere (HGS) model used in this study integrates both surface and subsurface flow components to simulate groundwater-surface water interactions. The model setup includes multiple subsurface layers of aquifers and aquitards, the characteristics of which have already been detailed in the manuscript. The hydraulic properties and parameters of these layers will be provided in the supplementary material.

   The initial conditions for subsurface and surface flows were established by running the HGS model under steady-state conditions. Predefined groundwater and surface heads were used as the starting point for the transient simulation. Lateral boundaries were defined with specific node sets along the Havel River (constant head boundary), representing flow exchange across these boundaries.

Different land use and land cover types (forest, grassland, urban, and agriculture) were assigned distinct properties for overland flow simulations, including obstruction storage height, rill storage height, and coupling length. Evapotranspiration (ET) parameters—such as leaf area index (LAI), root depth, and evaporation depth—were specified for each land cover type. In the HGS model, ET combines plant transpiration and evaporation, affecting both surface and subsurface flows. Plant transpiration within the root zone depends on LAI, nodal moisture content (θ), and a root distribution function (RDF) applied to a defined extinction depth. Depth-dependant evaporation is modeled using quadratic depth decay function.

LAI data was measured for different land types and compared to the MODIS dataset to provide time-varying LAI inputs for the model. In the HGS model, potential evapotranspiration (PET) is set as a boundary condition, representing the (highest) amount of water that would evaporate and transpire if the water table were at the surface. PET was calculated based on energy balance methods, particularly applied to Lake GGS.

This setup allows for a detailed simulation of surface and subsurface processes, capturing complex interactions such as lateral flow, groundwater abstraction, evapotranspiration, and overland flow. Further explanations and details on the model setup and parameters will be included in the manuscript, with additional information provided in the supplementary material.

General comment: The manuscript is engaging, though minor grammatical and punctuation errors are present. Addressing these would improve clarity and readability.

Thank you for bringing this to our attention. To ensure clarity, minor grammatical errors, typos, and sentence rephrasing will be addressed in the revised manuscript.