We thank Reviewer 2 for the careful reading of the manuscript and for the constructive comments. Below we respond to each comment individually. Reviewer comments are shown in black, followed by our responses in blue.

Referee #2

1. Lines 55–58, are building a quantitative argument about water-storage assessment gaps and then line 58 abruptly pivot to “The specific microclimatic conditions, organic-rich soils and high-water tables within peatlands are the basis for a specific flora and fauna”. This interrupts the logical progression. Consider relocating this sentence to lines 49–53, where ecological functions and biogeochemical cycles are introduced.

Thank you for this suggestion. We agree that the sentence concerning the role of peatland-specific microclimatic conditions, organic-rich soils, and high water tables in supporting specialized flora and fauna interrupts the flow of the argument regarding water-storage dynamics. We have relocated this sentence to the earlier section discussing ecological functions and biogeochemical processes in peatlands, improving the logical progression of the Introduction.

2. Grammar of the objectives (iii): consider saying quantifying.

Thank you. The wording has been revised. Objective (iii) now reads: "quantifying the specific contributions of precipitation, evapotranspiration, inflow, outflow and water-storage change to the water balance of the peatland site."

3. instead of saying has used say used (line 94)

We agree and have revised the sentence accordingly. The text now states that Renaud et al. (2025) "used a 2D cross-sectional transect...".

4. It would be better to say: This study presents/develops a hydrologic model setup rather than "This study addresses a hydrologic model setup that can be used..." (Line 100)

Thank you. We have revised the sentence for clarity. It now reads: "This study presents a hydrologic model setup that provides a basis for assessing potential rewetting measures under given climatic and hydrological conditions in a typical degraded fen peatland in Brandenburg, Germany."

5. Line154- CO2/H2O - use proper subscripts.

We agree and have corrected the notation throughout the manuscript. CO_2 and H_2O are now consistently formatted using proper subscripts.

6. Please adopt a single convention, either sentence case or title case and apply it consistently to all figure titles, panel headings, and axis labels.

Thank you for pointing this out. We have carefully reviewed all figure captions, panel labels, and axis titles and adopted a consistent sentence-case format throughout the manuscript.

7. The title promises "insights for rewetting," the abstract states that the model "provides an initial assessment of potential management measures … that could enable effective rewetting" (lines 33–35) the introduction claims the setup allows for "a robust assessment of possible rewetting measures" (line 100). However, the results do not actually simulate any rewetting scenarios. It only models the baseline drained conditions from 2015 to 2023. I recommend that the authors to clarify this in paper. As currently written, the framing overstates what the paper delivers.

Thank you for pointing this out. We agree that the original wording could imply that explicit rewetting scenarios were simulated. The objective of this study was to develop and validate a robust hydrological model under current drained conditions and to quantify the key processes controlling water balance and storage dynamics. While these results provide a necessary basis for future evaluation of rewetting measures, no rewetting scenarios were simulated in the present study. To avoid overstating the scope of the work, we have revised the manuscript to clarify that the model establishes a baseline framework for future scenario analyses rather than directly assessing rewetting interventions. We modified several statements that previously referred to a "robust assessment of rewetting measures" to emphasize that the study provides the hydrological understanding required for future rewetting assessments. We also changed the title to: 'Integrating coupled surface-subsurface modeling and field measurements in a degraded fen: insights into water balance dynamics and a basis for developing rewetting measures'.

8. In the Discussion, it is mentioned that the Kristensen-Jensen evapotranspiration framework caps the effect of LAI at roughly 2.5, even though the actual fen grasses at the site reach an LAI of around 7 during the summer (line 234; also line 302 for summer 2018). The model overestimates AET during the 2018 drought (lines 292–294, 364–365), and the authors acknowledge the LAI cap as a limitation in the Discussion (lines 544–547), but they do not connect these two points. Please clarify whether the LAI saturation at 2.5 contributes to the 2018 overestimation, or whether the overestimation arises from another mechanism.

Thank you for highlighting this. We agree that the Discussion should more clearly distinguish between the limitation associated with LAI saturation and the causes of the AET overestimation observed during the extreme drought of 2018. We do not believe that the overestimation is primarily caused by the LAI saturation in the Kristensen–Jensen framework. In this parameterization, LAI values above approximately 2.5 already result in maximum transpiration demand, meaning that increasing the measured LAI from 2.5 to about 7 would not further increase simulated transpiration. Therefore, the LAI limitation itself cannot explain the positive bias in AET during 2018. A more plausible explanation is that the model

overestimated plant water availability under extreme drought conditions. During summer 2018, groundwater levels declined substantially and the peat profile became unusually dry. Under these conditions, actual evapotranspiration was limited by insufficient water supply, as plant roots were no longer able to access enough water to sustain potential transpiration rates. Similar behavior was observed and discussed by Dietrich et al. (2021), who interpreted the reduced evapotranspiration during 2018 as a consequence of drought-induced water limitation at a site that normally benefits from shallow groundwater conditions. Such conditions are atypical for these fen grasslands but may become more frequent under future climate change. We therefore interpret the 2018 overestimation as being more closely related to limitations in the representation of soil hydraulic properties and plant water availability than to the LAI parameterization itself. The current model likely maintained a greater amount of plant-accessible water than was available under actual drought conditions. We have clarified this point in the Discussion and explicitly noted that future work should investigate improved parameterization of drought-induced water stress and peat hydraulic properties under extreme drying conditions.

We modified the Discussion paragraph around lines 544–547. Instead of ending with:

'*the Kristensen–Jensen framework used for evapotranspiration captured LAI effects well, but its saturation at LAI ≈ 2.5 may oversimplify canopy effects at higher densities.*'

We wrote:

'Although the observed LAI of the fen grassland reached values of approximately 7 during peak growing seasons, the Kristensen–Jensen evapotranspiration formulation assumes that transpiration demand reaches its maximum at LAI values of about 2.3–2.5. Consequently, increases in canopy density above this threshold do not lead to further increases in simulated transpiration. This simplification may reduce the sensitivity of the model to interannual variations in vegetation development and canopy structure. However, under the climatic conditions of the study site, evapotranspiration appears to be constrained more strongly by water availability than by canopy density during extreme drought periods. For example, during the summer drought of 2018, groundwater levels declined substantially and the peat profile dried out, limiting root water uptake despite high vegetation productivity. Similar observations were reported by Dietrich et al. (2021), who found that actual evapotranspiration remained below atmospheric demand because of insufficient water availability. Therefore, the overestimation of AET in 2018 is more likely related to limitations in the representation of drought-induced water stress and plant-accessible water than to the LAI parameterization itself. Future studies could investigate alternative canopy-resistance formulations that maintain sensitivity to high LAI values while also improving the representation of drought stress under extreme conditions. This issue may become increasingly important under future climate conditions. While shallow groundwater currently supports high evapotranspiration rates in many fen systems, more frequent and prolonged droughts could result in deeper groundwater tables and stronger soil moisture limitations. Under such conditions, accurate representation of plant-accessible water and drought-induced transpiration reduction may become more important than the representation of canopy density alone. Consequently, future rewetting and climate-change scenario analyses would benefit from improved coupling between vegetation dynamics, root water uptake, and evolving peat hydraulic properties.'

9. Section 2.4 (lines 195–197) states that observed ditch water levels were imposed as a Dirichlet boundary, but it does not explain how missing observations were handled. This becomes important because the Results (lines 331–335) attribute simulated–observed groundwater deviations in 2018 and 2021 specifically to missing ditch data. Please add 1–2 sentences in Section 2.4 describing the gap-filling approach.

Thank you for highlighting this. We have added a description to Section 2.4 explaining the treatment of missing ditch-water-level data. Specifically, gaps in the ditch-water-level records were filled by linear interpolation between the nearest available observations.

10. The Discussion currently reads as a single, continuous block of text that jumps between different themes. For example, it discusses ET performance, shifts to fen grass physiology, moves to the two-layer peat system, returns to ET and ditch gradients, discusses long-term storage, jumps to mesh quality and subsidence, and then goes back to ET LAI saturation. Lack of organization makes it hard for the reader to follow your core arguments. I recommend organizing the Discussion into clear subsections.

To improve readability and strengthen the scientific narrative, we have reorganized the Discussion into thematic subsections.