Dear Editor and Reviewers,

We sincerely thank the reviewer for the thorough evaluation and for the critical comments provided in the previous round, which, although leading to the rejection of the earlier version, have been invaluable in guiding a substantial revision of this manuscript. In response to these comments, we have undertaken a comprehensive restructuring of both the analytical framework and the presentation of the results, while carefully revisiting each of the concerns raised and implementing targeted revisions accordingly.

In particular, we have clarified the modeling framework, strengthened the physical interpretation of the attribution analysis, and improved the overall coherence of the manuscript, so that the linkage between methods, results, and conclusions is now more transparent and logically consistent. We hope that the revised manuscript adequately addresses the reviewer's previous concerns and demonstrates a significantly improved level of rigor and clarity.

In the following, we provide a detailed, point-by-point response to each comment, where the reviewers' comments are presented in italics and our responses are given below each comment.

Comment 1: Section Abstract: Backflow should be well addressed when it first occurs, for example, from the lake to river? The river-lake connection should be briefly introduced.

We thank the reviewer for the careful evaluation and constructive comments. We agree that the original manuscript did not describe the backflow process and the river–lake connectivity with sufficient clarity, which may have affected readability. In the revised manuscript, we have provided a clear definition of backflow, which is described as a reverse transport process in which lake water moves toward the Yangtze River under specific hydrodynamic conditions. In addition, brief explanations of the river–lake connection have been incorporated into both the Abstract and the Introduction so that the interaction between basin inflow and mainstem hydrodynamics is more clearly framed, while the Methods section has been expanded to include a more explicit description of the event identification procedure, thereby improving the overall clarity and logical coherence of the manuscript.

Location of revisions: Lines 147–168.

2.3 Hydrological Regime Identification and Classification Framework

Because hydrological processes at Hukou are highly complex, specific patterns can occur under backflow conditions in which water levels remain high or continue to rise while discharge decreases significantly or even becomes negative. To address this, a hydrological regime identification method is developed based on the coupled variation of water level and discharge, in which automatic detection is combined with manual verification for event identification.

After applying smoothing to the water level and discharge series, the relative rate of change in discharge is calculated in order to capture abrupt variations. Criteria for identifying backflow events are then established. A backflow event is considered to begin when the water level continues to rise or remains at a high level for more than 5 consecutive days and the relative change in discharge shows an absolute decrease exceeding 100 $m^3 s^{-1}$ or a relative decrease greater than 30%. In addition, any condition in which discharge is less than zero is directly classified as a backflow state.

The termination of a backflow event is determined using a set of combined criteria in which the water level decreases by more than 2%, the discharge recovers to its level at the onset of the event, and the total duration does not exceed 30 days, while short-term fluctuations with durations of less than 4 days are excluded. Based on the results of automatic identification, the start and end times of events are further manually reviewed, with particular attention given to correcting misidentification under conditions of gradual variation in water level and discharge, and to supplementing potential backflow events.

Subsequently, non-backflow events are classified according to flood and drought water level thresholds issued by the Jiangxi Provincial Department of Water Resources, for which the flood threshold is 19.52 m and the low-flow threshold is 7.99 m. For backflow events that reach the flood water level, the corresponding periods are merged to ensure the physical consistency of the classification results.

Comment 2: Section Abstract: The model seems to be quantitatively to examine the contribution of the upstream dam on the lake hydrology, however, the author's main results come off as rather trivial. Is presenting model contribution rates to two decimal places really necessary?

We understand the reviewer's concern that an overly detailed presentation of numerical results may obscure the main scientific message. In the revised manuscript, the numerical descriptions in the Abstract have been streamlined so that excessive precision is avoided, while greater emphasis is placed on the physical meaning, overall trends, and underlying mechanisms, thereby improving the readability and coherence of the main conclusions. In addition, the interpretation of the model results has been further strengthened in the main text to provide a more integrated explanation. Location of revisions: Lines 9–31.

Abstract. Taking the Three Gorges Project–Poyang Lake system as the study case, this study develops an analytical framework that links basin inflow to the response at Hukou from the perspective of hydrological events, based on long-term time series of runoff, water level, and meteorological data since 1970. The framework is used to systematically identify the mechanisms through which large hydraulic projects influence hydrological processes in river-connected lakes. The results show that, under relatively stable meteorological conditions, changes in the hydrodynamic regime of the Yangtze River mainstream that are induced by the operation of the Three Gorges Project constitute one of the dominant drivers of a marked regime shift around 2003, which is characterized by reduced variability and increased stability in the hydrological conditions of the lake. Under this influence, the structure of hydrological events undergoes systematic reorganization, in which flood and backflow events decrease in both frequency and intensity, while low-flow events become more frequent and tend to occur toward the end of the year. As a result, the lake exhibits reduced variability and a tendency toward drier conditions. The regulation and storage responses under different hydrological events also become more stable, as the response to inflow is strengthened under both flood and low-flow conditions, whereas the extreme regulation behavior associated with backflow processes is significantly weakened. In terms of driving mechanisms, the Three Gorges Project reduces the backwater effect of the Yangtze River and alters the hydrodynamic constraints at Hukou, which weakens the control of the mainstream under backflow conditions and enhances the resistance to outflow under low-flow conditions, thereby increasing the sensitivity of the lake to basin inflow. The observation-driven counterfactual analysis proposed in this study provides a feasible approach for quantitatively identifying engineering impacts under complex river–lake interaction conditions. Overall, the hydrological regime of the river-connected lake shifts from being dominated by the mainstream to a state in which both the mainstream and the lake jointly exert influence. This transition reduces flood risk and enhances hydrological stability, while at the same time increasing the frequency of low-flow events and the degree of outflow obstruction, which reflects a pronounced scenario-dependent regulatory effect.

Comment 3: Section Introduction: The authors stated that "These processes are difficult to accurately capture using traditional one-dimensional or quasi-two-dimensional models(Wu et al., 2022)." I am profoundly skeptical of this viewpoint. Moreover, the cited literature fails to substantiate the claim.

We thank the reviewer for the careful evaluation of this statement. We agree that the original wording, which suggested that conventional one-dimensional or quasi-two-dimensional models are insufficient to accurately represent the process, was not sufficiently rigorous and was not adequately supported by references, which may have led to misunderstanding.

In the revised manuscript, this section has been reformulated so that traditional hydrodynamic models are no longer broadly characterized as inadequate; instead, we emphasize that different modeling approaches are suited to different research scales and objectives. Specifically, while one- and two-dimensional hydrodynamic models have clear advantages in representing water levels, flow velocities, and detailed hydrodynamic processes, this study focuses on identifying the response relationship between basin inflow and outlet discharge, as well as its stage-wise evolution, under long-term and multi-scenario conditions. Therefore, an observation-driven and data-driven framework is adopted to complement the limitations of conventional physical models in long-term and comparative multi-scenario analyses. The relevant text has also been revised to adopt a more cautious and neutral tone so as to avoid any inappropriate generalization or dismissal of existing methods.

Location of revisions: Lines 60–75.

Poyang Lake is a representative case for studying the influence of mainstream changes on river-connected lake hydrology because of its ecological importance and its high sensitivity to variations in the water level of the mainstream. As the largest freshwater lake in China, Poyang Lake receives inflow from five major tributary systems within its basin and discharges into the Yangtze River at Hukou after regulation and storage. It is a typical through-flow and seasonally connected river–lake system (Jiang et al., 2024). In 2003, the Three Gorges Project was completed in the upper reaches of the Yangtze River, and its operation has significantly altered the runoff regime in the middle and lower reaches by redistributing flow within the year. As a result, runoff increases from December to May of the following year, especially during the low-flow period from January to April, whereas it decreases from June to October, with the most pronounced reductions occurring during September and October (Li et al., 2017; Wu et al., 2022). These changes have led to complex alterations in the hydrological regime of Poyang Lake and have posed new challenges to the stability of the lake ecosystem (Dai et al., 2018; He et al., 2022; Xie et al., 2021). Therefore, it is essential to systematically characterize the long-term evolution of hydrological patterns in Poyang Lake under the influence of the Three Gorges Project, as this can improve understanding of how mainstream regulation affects hydrological connectivity, storage–discharge balance, and seasonal cycles in downstream river-connected lakes, and can also provide scientific support for integrated basin management, ecohydrological regulation, and lake restoration(Tian et al., 2025; Zhang et al., 2015).

Comment 4: Section Introduction: paragraph 70-75, this part aims to highlight the importance of combined SWAT model and LightGBM model for the present work, however, this part should be moved elsewhere.

We thank the reviewer for the thoughtful suggestions regarding the manuscript structure. We agree that introducing specific modeling approaches in the Introduction was somewhat abrupt and did not support a clear logical flow. In the revised manuscript, this issue has been addressed by relocating the detailed description of the methods to Section 2.4. The Introduction now retains only a conceptual overview of the study design, in which the analytical framework is outlined from the perspective of basin inflow drivers and the outlet response relationship, without referring to specific model implementations. With these revisions, the Introduction is more clearly focused on the scientific questions and research significance, while the methodological details are presented in a dedicated section, resulting in an improved overall structure and clarity.

Location of revisions: Lines 169–209.

2.4 Basin Inflow Simulation and Quantification of Influencing Factors

To establish a unified reference for analyzing hydrological processes in the lake and to separate the effects of basin inflow from those of mainstream hydrodynamics, a sequential modeling framework is constructed, which consists of a Hukou discharge response model and a basin inflow simulation model.

(1) Hukou Discharge Response Model

In order to characterize the natural response of the lake system to basin inflow under conditions of weak mainstream influence, a Hukou discharge response model is developed using the LightGBM machine learning approach. Training data are selected from normal-flow hydrological conditions during which hydrodynamic conditions are relatively stable, the influence of the Yangtze River mainstream is weak, and no backflow occurs. Based on daily observations of inflow from the five tributaries and outflow at Hukou, a mapping relationship is established in which discharge at Hukou is controlled solely by basin inflow.

The model is trained and tested using a time series split in which 80% of the data are used for training and 20% for testing. Model performance is optimized by adjusting the number of trees, learning rate, and sampling parameters, while early stopping is introduced to prevent overfitting. In addition, segmented modeling is conducted using 2003 as a breakpoint in order to capture stage-dependent variations in the discharge response relationship. Model performance is evaluated using percentage bias (PBIAS), root mean square error (RMSE), and Nash–Sutcliffe efficiency (NSE).

After model validation, two types of applications are conducted. First, observed inflow from the five tributaries during backflow events is used as model input to reconstruct the discharge process at Hukou under the assumption of no strong mainstream influence, and the reconstructed discharge is compared with observed discharge in order to quantify the contribution of backflow effects. Second, basin inflow under different scenarios is input into the model to reconstruct discharge at Hukou under a unified reference condition, which enables comparison of hydrological processes across different scenarios.

(2) Basin Inflow Simulation Using SWAT

To quantitatively attribute the mechanisms through which basin hydrological changes influence discharge at Hukou, the SWAT model is used to generate basin inflow series under multiple scenarios, which allows assessment of how variations in basin runoff regulate hydrodynamic responses at Hukou. During model calibration and sensitivity analysis, key parameters are selected and optimized, including those at the basin scale, HRU scale, soil properties, groundwater processes, and channel characteristics. Model parameters are iteratively adjusted to ensure good agreement between simulated and observed discharge.

Since the period from 1990 to 2010 represents the most significant stage of land use change in the Poyang Lake basin, while changes become relatively stable after 2010, the years 1990 and 2010 are selected as representative scenarios for comparison. After calibration, meteorological and land use data under different scenarios are input into the model to simulate basin inflow processes, which serve as the basis for discharge simulation at Hukou.

It should be noted that SWAT produces monthly runoff series for the five tributaries, whereas the Hukou discharge response model is constructed at a daily scale. To ensure consistency between the two models, monthly runoff is uniformly distributed according to the number of days in each month under the constraint of mass conservation, thereby converting it into daily inflow series for use as model input. Although this approach may smooth short-term fluctuations at the daily scale, the primary objective of this study is to analyse relative changes and stage-dependent characteristics under different scenarios rather than to reproduce daily extremes, and therefore the impact of this temporal transformation on the results is limited.

Comment 5: S Section Introduction: paragraph 80-85, looking into the literature (e.g., backflow, Three Gorges Dam, Poyang Lake), it seems the author has missed a lot of earlier work, for example,

Zhang, Q., Li, L., Wang, Y. G., Werner, A. D., Xin, P., Jiang, T., & Barry, D. A. (2012). Has the Three-Gorges Dam made the Poyang Lake wetlands wetter and drier?. Geophysical research letters, 39(20).

Li, Y., Zhang, Q., Werner, A. D., Yao, J., & Ye, X. (2017). The influence of river-to-lake backflow on the hydrodynamics of a large floodplain lake system (Poyang Lake, China). Hydrological Processes, 31(1), 117-132.

We thank the reviewer for identifying the important gaps in the literature review and for providing relevant references. In the revised manuscript, we have expanded and systematically updated the review of previous studies. In particular, the Introduction now includes a more comprehensive synthesis of (i) backflow processes and their hydrodynamic mechanisms, (ii) existing knowledge on the impacts of the Three Gorges Project on river–lake interactions, and (iii) recent advances in the study of hydrological regulation and river–lake coupling in connected lake systems.

Building on this, we have further clarified how the present study extends the existing body of work, which is mainly reflected in three aspects: first, the hydrological regime of the lake is systematically characterized from a hydrological event perspective; second, a counterfactual analysis framework is developed to separate the influences of basin inflow and mainstem hydrodynamics; and third, the stage-dependent differences in driving mechanisms are quantitatively analyzed under multiple scenarios.

These revisions provide a more complete research background and more clearly define the scope and contribution of this study. Location of revisions: Lines 35–75.

River-connected lakes represent an important hydromorphological type worldwide. These lakes are connected to major rivers through outlet channels, through which they receive regulated basin inflow and subsequently discharge into the mainstream, while they also receive water from the river. This bidirectional exchange gives rise to a distinctive hydrological regime that is characterized by large differences in water levels between wet and dry periods and by substantial fluctuations in water surface area. Through such periodic variations, river-connected lakes play an important role in regulating basin-scale hydrological processes (Yang et al., 2021). However, this regime is highly sensitive and vulnerable, and significant changes in the mainstream river can disrupt the hydrological rhythm of the lake and may further lead to regional ecological and water resource security problems (Zhang et al., 2020, 2018).

A growing body of research on river–lake interactions indicates that the hydrological processes of river-connected lakes are jointly controlled by multiple factors, among which the key mechanism lies in the complex hydrodynamic coupling between the mainstream and the lake (Liang et al., 2021). The river–lake system cannot be described as a simple water level response, but rather should be regarded as a dynamically coupled system that is influenced by hydrodynamic conditions and river–lake morphology (Huang et al., 2022; Lai et al., 2014). During this process, factors including local inflow, hydraulic gradient, and flow velocity act together to determine the intensity of water exchange, which results in distinct interaction patterns under different hydrological conditions (Zhang et al., 2012). During flood periods, the system is mainly influenced by the backwater effect of the mainstream, which can impede lake outflow and may even induce reverse flow, whereas during low-flow periods the lake predominantly supplies water to the mainstream and plays a key role in flow regulation (Li et al., 2020; Wang et al., 2009). Since the hydrological regime of the mainstream serves as one of the key boundary conditions controlling water exchange, its variation directly affects the backwater intensity and hydraulic gradient, which in turn reshapes the hydrodynamic processes and exchange patterns under different hydrological conditions (Changxin et al., 2015; Yao et al., 2019). Analyses that focus only on individual events or single characteristics are insufficient to fully capture these effects, and a systematic investigation of how mainstream changes influence river–lake interactions under different hydrological conditions is therefore essential for understanding the evolution of hydrological regimes in river-connected lakes (Li et al., 2023; Zhao et al., 2023).

Poyang Lake is a representative case for studying the influence of mainstream changes on river-connected lake hydrology because of its ecological importance and its high sensitivity to variations in the water level of the mainstream. As the largest freshwater lake in China, Poyang Lake receives inflow from five major tributary systems within its basin and discharges into the Yangtze River at Hukou after regulation and storage. It is a typical through-flow and seasonally connected river–lake system (Jiang et al., 2024). In 2003, the Three Gorges Project was completed in the upper reaches of the Yangtze River, and its operation has significantly altered the runoff regime in the middle and lower reaches by redistributing flow within the year. As a result, runoff increases from December to May of the following year, especially during the low-flow period from January to April, whereas it decreases from June to October, with the most pronounced reductions occurring during September and October (Li et al., 2017; Wu et al., 2022). These changes have led to complex alterations in the hydrological regime of Poyang Lake and have posed new challenges to the stability of the lake ecosystem (Dai et al., 2018; He et al., 2022; Xie et al., 2021). Therefore, it is essential to systematically characterize the long-term evolution of hydrological patterns in Poyang Lake under the influence of the Three Gorges Project, as this can improve understanding of how mainstream regulation affects hydrological connectivity, storage–discharge balance, and seasonal cycles in downstream river-connected lakes, and can also provide scientific support for integrated basin management, ecohydrological regulation, and lake restoration(Tian et al., 2025; Zhang et al., 2015).

Comment 6: Section 2.1, Poyang Lake, located on the southern bank of the middle–lower Yangtze River. Perhaps the location is wrong. It locates in the middle steam of the River? Please check it.

We thank the reviewer for the careful examination of the geographical description of the study area. We agree that the original wording, "located on the southern bank of the middle–lower Yangtze River," was not sufficiently precise and could lead to ambiguity regarding the exact location of Lake Poyang.

In the revised manuscript, this description has been clarified and refined so that it now explicitly states that Lake Poyang is situated on the southern bank of the middle–lower reaches of the Yangtze River and is connected to the mainstem through the Hukou outlet. This revision more accurately reflects its geographical position within the transition zone of the middle–lower Yangtze and its hydrological linkage with the main channel. In addition, we have further emphasized the hydrological significance of Hukou as the sole outlet of the lake, thereby improving the scientific accuracy and completeness of the study area description. Location of revisions: Lines 90–95.

Poyang Lake is located on the southern bank of the middle and lower reaches of the Yangtze River in China and is the largest freshwater lake in the country. The lake is connected to the Yangtze River mainstream through its only outlet at Hukou, and its hydrological processes are jointly regulated by basin inflow and the water level of the Yangtze River. It serves as the final receiving body for runoff from five major tributary systems within the basin and represents a typical river-connected lake in the middle and lower Yangtze River region(Fischer and Knutti, 2015; Xu et al., 2019).

Comment 7: Section 2.1, the authors used two hydrological stations Jiujiang and Hukou (Fig.1), however, these two stations are so close to each other. What are their respective purposes, then? I'm not sure if the author has taken into account the possible joint impact from the lake and the upper Yangtze River on the station hydrology.

We thank the reviewer for raising this important point regarding the rationale for station selection. We understand the concern that the relatively short distance between the Jiujiang and Hukou stations may lead to functional overlap or ambiguity in interpretation.

To address this, we have added a dedicated clarification in Section 2.2 (Data sources) of the revised manuscript. Specifically, Hukou Station is defined as the sole outlet control section of Lake Poyang, which directly reflects the lake outflow process and serves as the key node for characterizing the lake's hydrological response. In contrast, Jiujiang Station is located on the Yangtze River mainstem approximately 19 km upstream of the lake–river junction and is largely unaffected by the direct outflow from the lake; its water level variations primarily represent the hydrodynamic conditions of the Yangtze River. Compared with more distant mainstem stations, Jiujiang is spatially closer to the Hukou section and therefore provides a more appropriate proxy for the backwater influence exerted by the mainstem on the lake outlet.

With this clarification, the distinct roles of the two stations are explicitly defined, with Hukou representing the lake response and Jiujiang representing the mainstem boundary condition, thereby avoiding potential confusion. We further emphasize in the analysis that the combined use of these two stations is intended to characterize the modulation of river–lake interactions, rather than to imply direct substitution or simple aggregation. Location of revisions: Lines 106–115.

The Hukou section, which functions as the only outlet of Poyang Lake, serves as the key hydrological connection between the lake and the Yangtze River mainstream (Li and Zhang, 2015). Variations in water level and discharge at Hukou directly reflect the water exchange between the lake and the river. When the water level of the Yangtze River is higher than or close to that of the lake, the outflow capacity at Hukou is significantly reduced, which causes attenuation in the discharge process and may even induce short-term reverse flow from the river into the lake. Since the operation of the Three Gorges Project in 2003, the reservoir, which has a maximum storage capacity of 39.3 billion cubic meters, has substantially altered the water level and runoff regime of the Yangtze River along the reach that connects to Hukou, which is located approximately 1000 km downstream. These changes have further influenced the hydrological processes of Poyang Lake and have led to an increase in the instability of its hydrological regime (Yuan et al., 2019).

Comment 8: Section 2.2.2, the authors only used 1970 as the reference year, the reason should be well explained and a one-year timeframe lacks representativeness. In addition, the MK test method is very simple, but it still requires citation of the original literature.

We thank the reviewer for the valuable comments regarding the selection of the temporal reference and the methodological rigor.

With respect to the use of 1970 as a reference, we have clarified in the revised manuscript that this year is not used to represent a single-year condition, but rather serves as the starting point of the long-term time series for constructing the cumulative anomaly analysis framework. Specifically, the interannual variations (ΔH and ΔQ) are calculated relative to the multi-year mean, rather than with respect to the value of 1970 alone. Therefore, the method fundamentally reflects the cumulative deviation from the long-term mean, rather than relying on the representativeness of any single year. To avoid potential misunderstanding, the physical meaning of this approach has been further clarified in the revised text.

In addition, with regard to the Mann–Kendall test, we have added appropriate references to its original sources and provided a more standardized description of its applicability and statistical interpretation, thereby improving the completeness and rigor of the methodological presentation. Location of revisions: Lines 106–115.

The Hukou section, which functions as the only outlet of Poyang Lake, serves as the key hydrological connection between the lake and the Yangtze River mainstream (Li and Zhang, 2015). Variations in water level and discharge at Hukou directly reflect the water exchange between the lake and the river. When the water level of the Yangtze River is higher than or close to that of the lake, the outflow capacity at Hukou is significantly reduced, which causes attenuation in the discharge process and may even induce short-term reverse flow from the river into the lake. Since the operation of the Three Gorges Project in 2003, the reservoir, which has a maximum storage capacity of 39.3 billion cubic meters, has substantially altered the water level and runoff regime of the Yangtze River along the reach that connects to Hukou, which is located approximately 1000 km downstream. These changes have further influenced the hydrological processes of Poyang Lake and have led to an increase in the instability of its hydrological regime (Yuan et al., 2019).

Comment 9: Section 2.2.3, the authors stated that the LightGBM has the ability to reproduce the lake–river confluences exhibiting backflow phenomena. I am uncertain how the authors' understanding of the model's nonlinear capture capability leads to the conclusion that it can accurately represent a specific hydrological phenomenon like backflow.

2.4 Basin Inflow Simulation and Quantification of Influencing Factors

To establish a unified reference for analyzing hydrological processes in the lake and to separate the effects of basin inflow from those of mainstream hydrodynamics, a sequential modeling framework is constructed, which consists of a Hukou discharge response model and a basin inflow simulation model.

(1) Hukou Discharge Response Model

In order to characterize the natural response of the lake system to basin inflow under conditions of weak mainstream influence, a Hukou discharge response model is developed using the LightGBM machine learning approach. Training data are selected from normal-flow hydrological conditions during which hydrodynamic conditions are relatively stable, the influence of the Yangtze River mainstream is weak, and no backflow occurs. Based on daily observations of inflow from the five tributaries and outflow at Hukou, a mapping relationship is established in which discharge at Hukou is controlled solely by basin inflow.

The model is trained and tested using a time series split in which 80% of the data are used for training and 20% for testing. Model performance is optimized by adjusting the number of trees, learning rate, and sampling parameters, while early stopping is introduced to prevent overfitting. In addition, segmented modeling is conducted using 2003 as a breakpoint in order to capture stage-dependent variations in the discharge response relationship. Model performance is evaluated using percentage bias (PBIAS), root mean square error (RMSE), and Nash–Sutcliffe efficiency (NSE).

After model validation, two types of applications are conducted. First, observed inflow from the five tributaries during backflow events is used as model input to reconstruct the discharge process at Hukou under the assumption of no strong mainstream influence, and the reconstructed discharge is compared with observed discharge in order to quantify the contribution of backflow effects. Second, basin inflow under different scenarios is input into the model to reconstruct discharge at Hukou under a unified reference condition, which enables comparison of hydrological processes across different scenarios.

(2) Basin Inflow Simulation Using SWAT

To quantitatively attribute the mechanisms through which basin hydrological changes influence discharge at Hukou, the SWAT model is used to generate basin inflow series under multiple scenarios, which allows assessment of how variations in basin runoff regulate hydrodynamic responses at Hukou. During model calibration and sensitivity analysis, key parameters are selected and optimized, including those at the basin scale, HRU scale, soil properties, groundwater processes, and channel characteristics. Model parameters are iteratively adjusted to ensure good agreement between simulated and observed discharge.

Since the period from 1990 to 2010 represents the most significant stage of land use change in the Poyang Lake basin, while changes become relatively stable after 2010, the years 1990 and 2010 are selected as representative scenarios for comparison. After calibration, meteorological and land use data under different scenarios are input into the model to simulate basin inflow processes, which serve as the basis for discharge simulation at Hukou.

It should be noted that SWAT produces monthly runoff series for the five tributaries, whereas the Hukou discharge response model is constructed at a daily scale. To ensure consistency between the two models, monthly runoff is uniformly distributed according to the number of days in each month under the constraint of mass conservation, thereby converting it into daily inflow series for use as model input. Although this approach may smooth short-term fluctuations at the daily scale, the primary objective of this study is to analyse relative changes and stage-dependent characteristics under different scenarios rather than to reproduce daily extremes, and therefore the impact of this temporal transformation on the results is limited.

310-345:

3.2. Variations in Lake Response to Basin Inflow under Different Hydrological Conditions

Under backflow conditions, no significant correlation is observed between basin inflow and storage intensity, which indicates that lake regulation behavior is primarily controlled by external hydrodynamic forcing. The scatter distribution exhibits a fan-shaped pattern, in which variability is large under low inflow conditions and gradually converges as inflow increases. A comparison before and after 2003 shows that extreme storage events are substantially reduced, while the overall relationship shifts from a weak positive correlation to a weak negative correlation, which suggests that anomalous regulation behavior during backflow processes is weakened, as shown in Fig. 9.

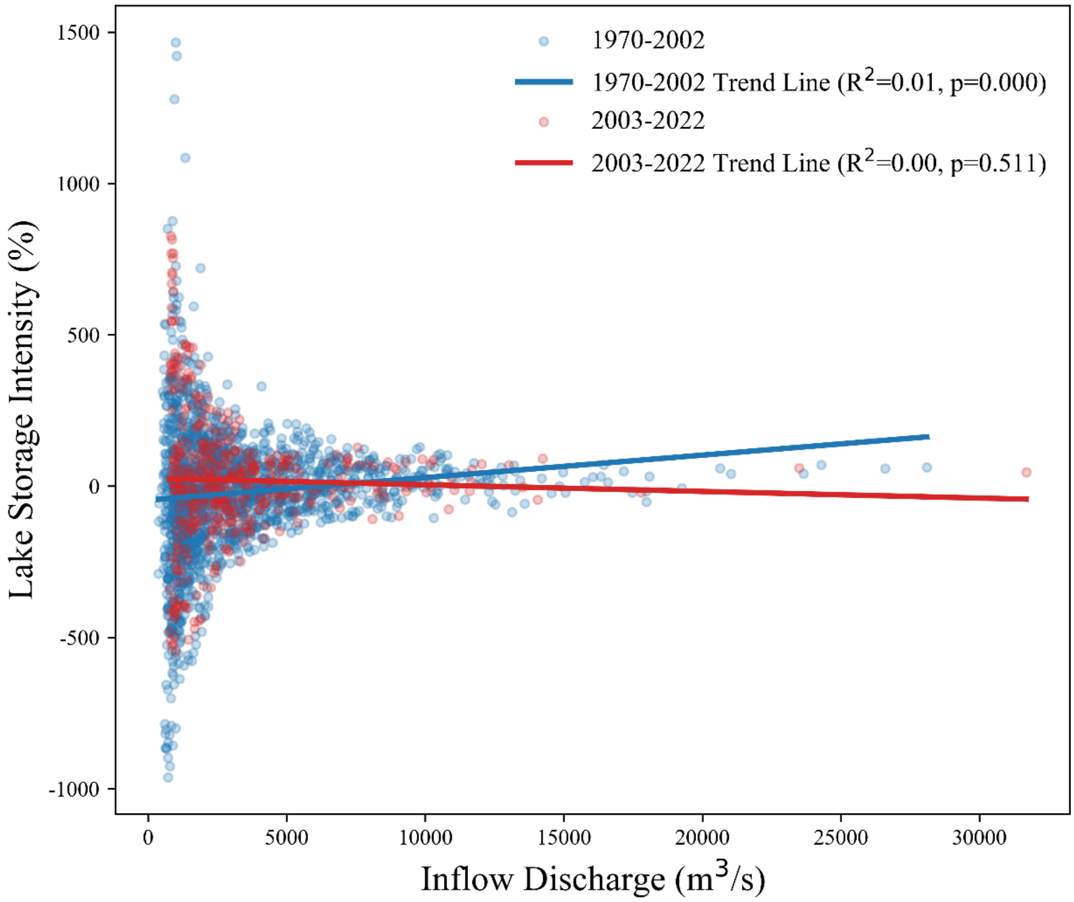

Figure 9 Relationship between Flood Magnitude and Storage Intensity at Different Stages during Backflow Events

Under flood conditions, storage intensity exhibits an overall positive correlation with basin inflow, although clear differentiation is observed across different flow ranges, as illustrated in Fig. 10. Under low inflow conditions, which are less than 5000 m³ s⁻¹, storage intensity shows strong variability and high dispersion, which reflects unstable responses at Hukou. After 2003, extreme negative values in this range are markedly reduced, which indicates that anomalous storage behavior becomes less pronounced. As inflow increases, the scatter points gradually converge, and storage intensity becomes more stable under medium to high flow conditions. Under large flood conditions, which exceed 15000 m³ s⁻¹, differences between the two periods are negligible.

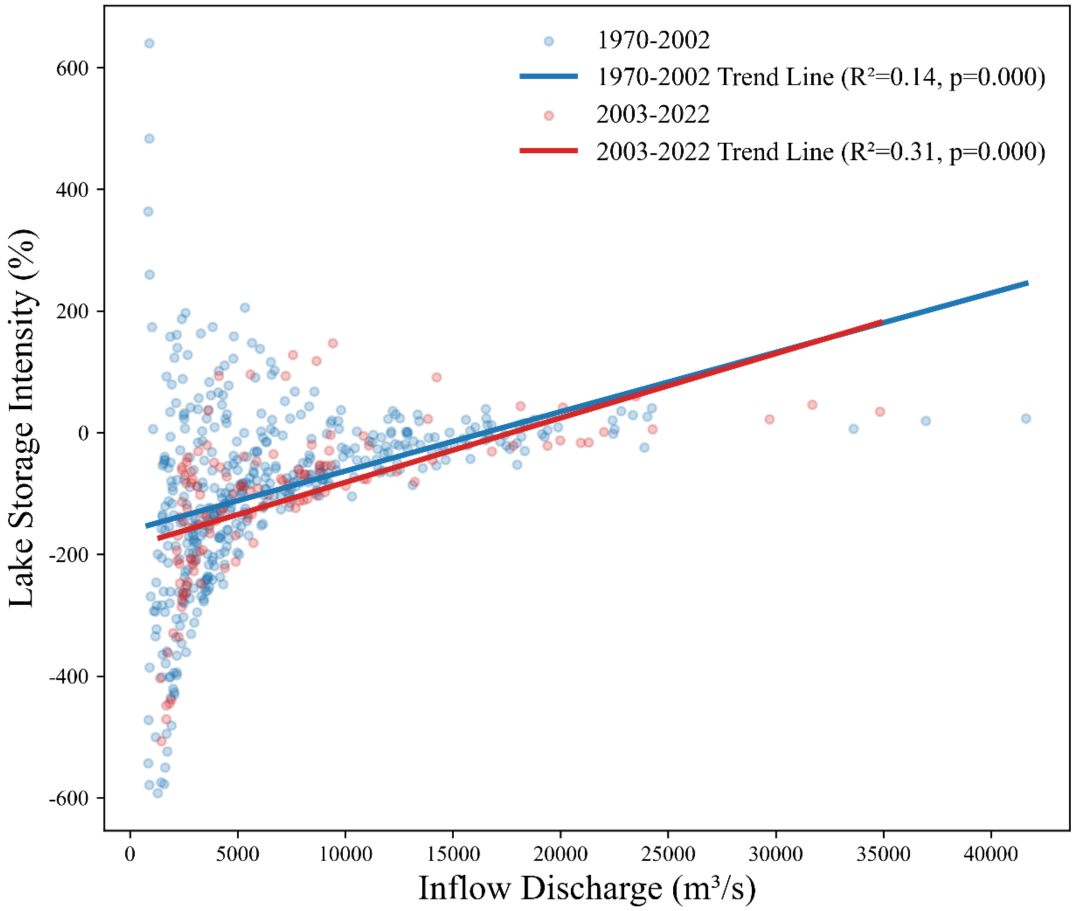

Figure 10 Relationship between Flood Magnitude and Storage Intensity at Different Stages during Flood Events

After 2003, the correlation between storage intensity and basin inflow is strengthened, as the coefficient of determination increases from 0.14 to 0.31, which indicates that the regulation response of the lake becomes more stable. However, differences between the two periods are not statistically significant in the high-flow range, with $p=0.692$, which suggests that the regulation mechanism under extreme flood conditions does not undergo substantial change. Overall, lake regulation under flood conditions shifts from a highly dispersed pattern to a relatively stable state after 2003.

Under low-flow conditions, storage intensity shows a positive correlation with basin inflow, and this relationship becomes stronger after 2003, which indicates that the lake responds more sensitively to variations in inflow. Under low inflow conditions, the range of negative storage values expands after 2003, which reflects enhanced water retention characteristics. As inflow increases, storage intensity rises rapidly, and the transition from a storage-dominated state to a discharge-dominated state becomes more pronounced. Overall, both the sensitivity and the regulation capacity of the lake under low-flow conditions are enhanced after 2003, as shown in Fig. 11.

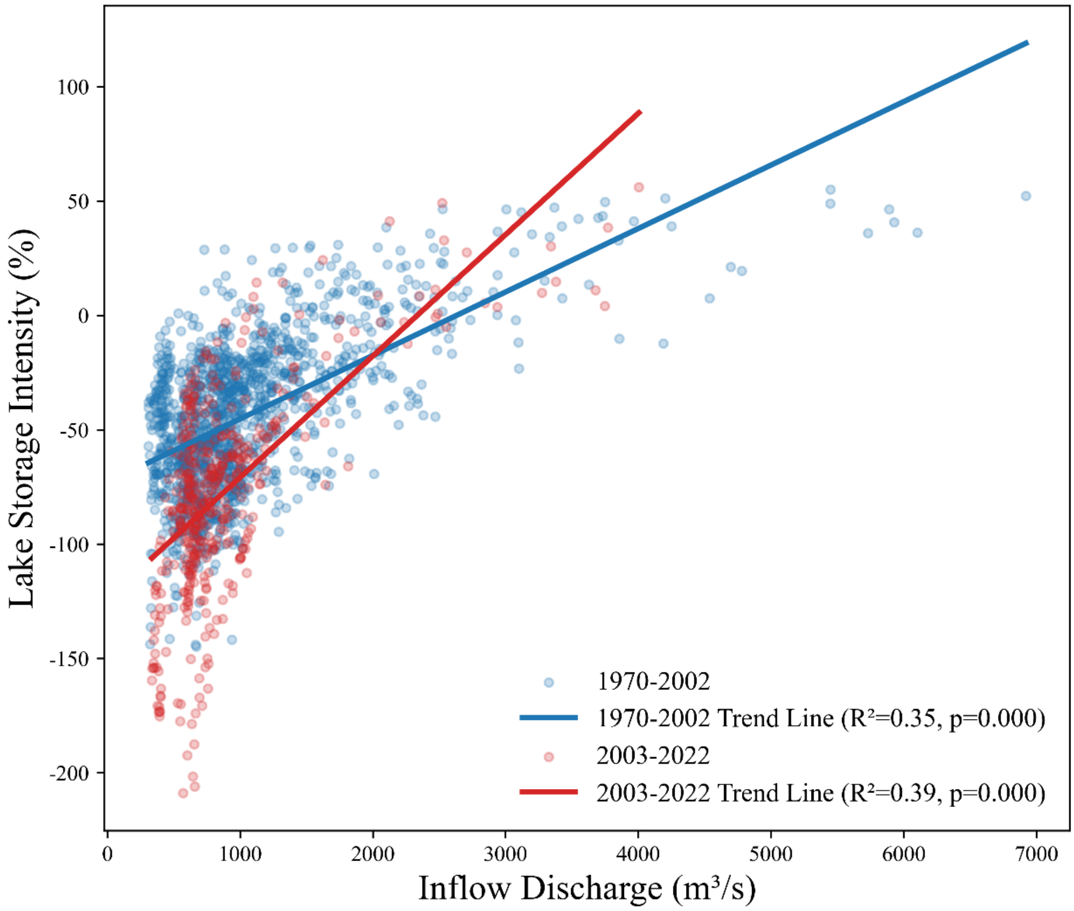

Figure 11 Relationship between Flood Magnitude and Storage Intensity at Different Stages during Low-flow Events

Comment 10: Section 2.2.3, the model seems to use discharge data from the basin river inflows, but these key stations were not shown in Fig. 1

We thank the reviewer for pointing out the incomplete presentation of the figure. In the revised manuscript, Figure 1 has been improved by adding the locations of the five major inflow control stations, including those of the Ganjiang, Fuhe, Xinjiang, Raohe, and Xiushui rivers, so that the spatial sources of the model input data are clearly indicated. In addition, the figure caption and the main text have been revised to clarify the role of each station in the study, thereby enhancing the consistency between the figure and the methodological description, as well as improving overall readability. Location of revisions: Lines 116–117.

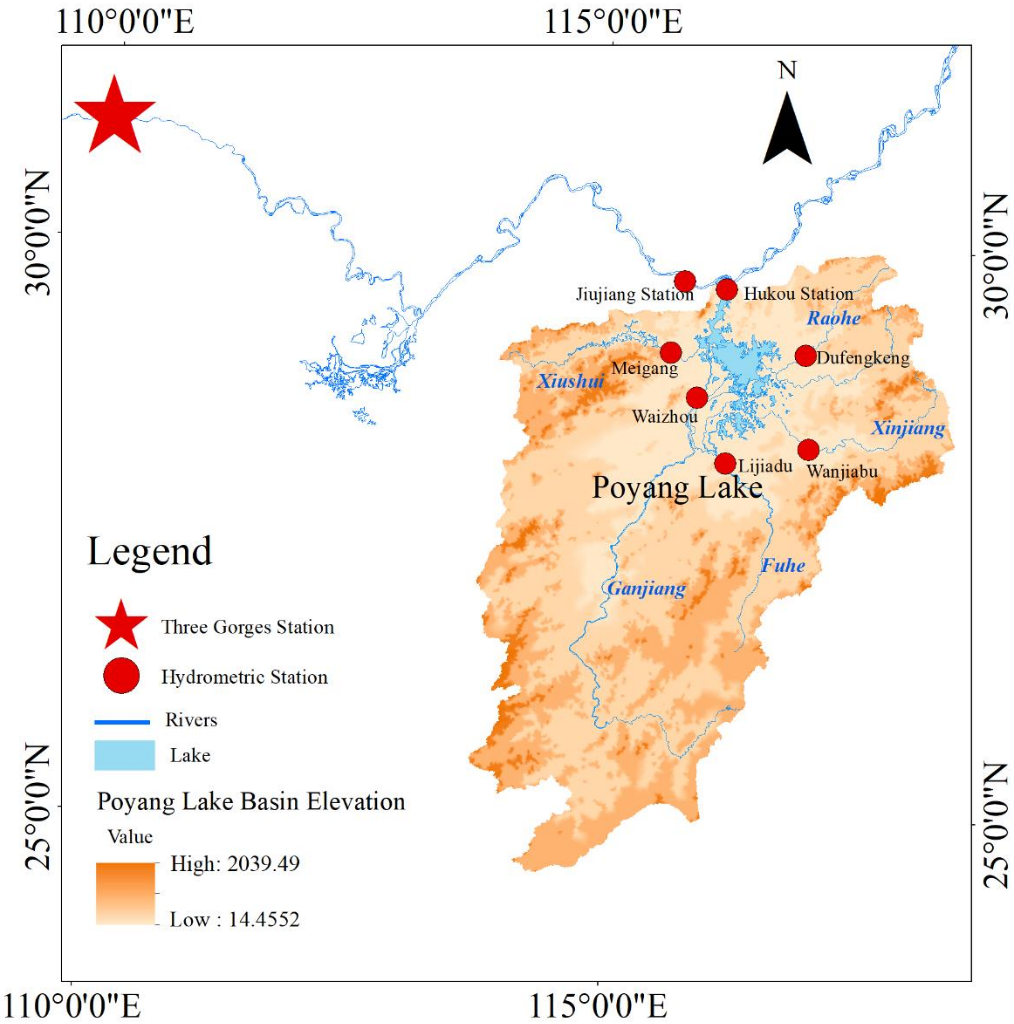

Figure 1 Study area

Comment 11: The construction for the SWAT model of the Poyang Lake basin should be very complex, involving the data collection, many hydrological parameters, and basin reservoirs. The model construction process is described inadequately, and a complete presentation of the calibration and validation procedures is lacking. This is an issue that cannot be overlooked. The absence of these critical components significantly undermines my confidence in the subsequent results..

We thank the reviewer for the rigorous comments regarding the construction and validation of the SWAT model. We agree that the original manuscript did not provide sufficient detail on model setup, calibration, and validation, which may have affected the assessment of model reliability.

In the revised manuscript, this section has been substantially expanded and clarified.

Specifically, we have (i) provided a more explicit description of the input data used for model construction, including meteorological data, land use, soil properties, and DEM; (ii) added supplementary information detailing the main categories of parameters involved in the calibration process, such as soil, groundwater, and channel parameters; (iii) improved the evaluation framework by including multiple performance metrics and reporting simulation accuracy for the major tributaries, including NSE and PBIAS; and (iv) further discussed the differences in simulation performance among tributaries and their potential implications for subsequent analyses.

It should also be noted that, in this study, the primary role of the SWAT model is to generate basin inflow series under different scenarios for the purpose of analyzing the relative influence of inflow variations on the outlet response, rather than to provide highly detailed predictions for individual river discharge processes. At the current level of accuracy, the model results are therefore sufficient to support the analysis of relative changes and stage-wise characteristics that are central to this study.

Through these revisions, the completeness and transparency of the methodological description have been significantly improved, and the credibility of the modeling results has been further strengthened. Location of revisions 346–357.

3.3 Hydrological Regulation Mechanisms at Hukou under Different Hydrological Conditions

The Hukou discharge response model shows good performance in fitting historical observations and can therefore be applied to simulate discharge responses to basin inflow under different scenarios, as shown in Fig. 12. The SWAT model also performs well, as it is able to consistently reproduce the variation trends and relative differences in basin inflow, as summarized in Table 3. The simulation results indicate that runoff from the five tributaries exhibits consistent seasonal patterns under different land use scenarios, whereas the overall magnitude of runoff is higher under the 2010 scenario, particularly during high-flow periods. Statistical analysis further shows that runoff increases by approximately 33% under the 2010 land use condition compared with the 1990 scenario, as illustrated in Fig. 13.

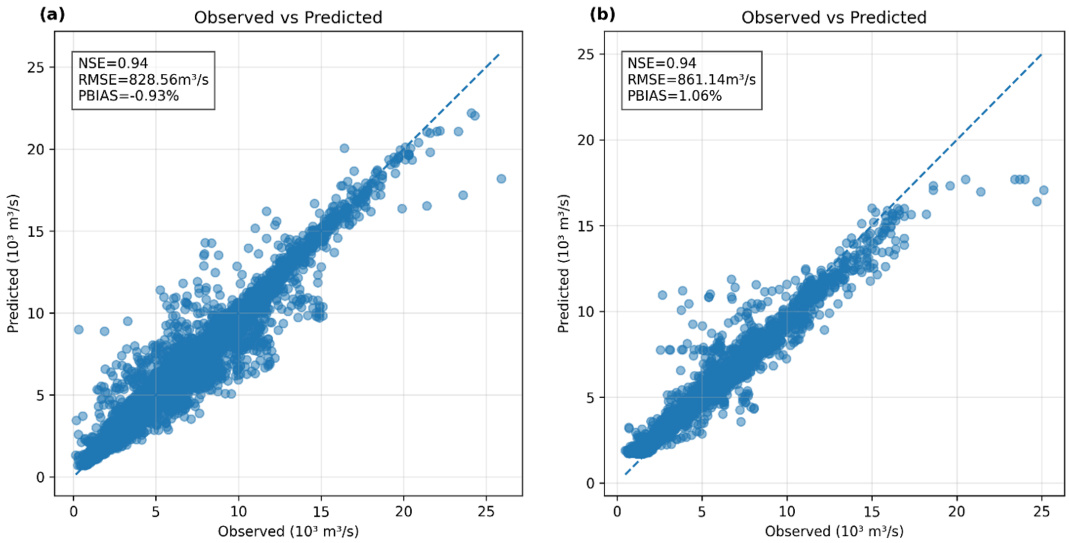

Figure 12 Validation of Simulated vs. Observed Values for the Normal-Flow Training Model. (a) befor 2003 (b) after 2003

Table 3. SWAT model performance

Performance	Ganjing		Raohe		Xiushui		Fuhe		Xinjiang	
metrics	R^2	NSE	R^2	NSE	R^2	NSE	R^2	NSE	R^2	NSE
1990	0.75	0.75	0.63	0.60	0.75	0.72	0.75	0.74	0.66	0.63
2010	0.79	0.79	0.64	0.62	0.67	0.65	0.66	0.66	0.60	0.60

Comment 12: The author has made some revisions and improvements in response to the previous comments. However, overall, the research depth and novelty of the paper remain insufficient. Backflow is a long-standing issue between the Yangtze River and Lake Poyang, and there is a substantial body of research on this topic. This study merely extends the time series by combining different models, and the findings regarding the contribution of the Three Gorges Reservoir do not represent entirely new insights. In fact, such quantification could also be achieved through statistical methods using existing data. The paper analyzes basic indicators such as the frequency and duration of backflow events. However, it remains unclear whether the combination of SWAT and GBM adequately validates the long-term backflow sequence. Regarding the SWAT model, the author has provided supplementary explanations, but it appears that this model may have been constructed previously. Based on several accuracy evaluation metrics, the simulation performance is suboptimal—for instance, the NSE values are generally low, indicating unsatisfactory simulation of flow dynamics. The author mentions that monthly runoff was used as the model driver. Why was monthly data chosen instead of a daily time series? To carry out this research using a model coupling approach, it is first necessary to ensure the high simulation accuracy of the SWAT model, and second, to guarantee the reliability of the backflow simulation or reproduction. At present, it seems that neither of these requirements has been effectively met.

We thank the reviewer for the thorough evaluation and for raising these important concerns. We fully understand the reviewer's emphasis on the novelty of the study and the reliability of the modeling framework, and we have carefully revised the manuscript to address these issues. Our detailed responses are provided as follows:

(1) Concerning the perceived lack of novelty**

We agree that the backflow phenomenon in the Poyang Lake–Yangtze River system has been extensively studied. However, the novelty of this study does not lie in re-describing the backflow phenomenon itself, but in the development of a methodological framework and an attribution pathway for mechanism identification.

Unlike previous studies that primarily rely on statistical analysis or hydrodynamic simulations, this study develops an observation-driven counterfactual analysis framework, in which a reference state representing the lake outlet response under conditions without strong mainstem interference is first established. The systematic deviation between this reference state and the observed system is then quantified, allowing the influence of mainstem hydrodynamic processes to be indirectly identified. This approach makes it possible to perform quantitative attribution of river–lake interactions even in the absence of high-resolution hydrodynamic boundary conditions, thereby providing a new analytical perspective for complex connected water systems.

In addition, rather than focusing on a single indicator, this study systematically examines the evolution of hydrological event structures, including flood, drought, and backflow events, together with their regulation and storage responses, thereby revealing the stage-wise reorganization of river–lake interactions following the operation of the Three Gorges Project. These aspects have been further clarified and emphasized in the revised Introduction and Discussion.

(2) Concerning SWAT model performance and temporal scale selection**

Regarding the accuracy of the SWAT simulations, we have expanded the description of model calibration and validation in the revised manuscript. It should be noted that the primary role of the SWAT model in this study is to represent the relative magnitude and stage-wise variation of basin inflow under different scenarios, rather than to reproduce daily discharge processes with high precision. Accordingly, its suitability is evaluated in terms of its ability to capture long-term trends and scenario-based differences.

With respect to the temporal scale, the use of monthly SWAT outputs is based on several considerations. First, the study aims to assess the influence of basin inflow variations under different climate and land-use scenarios, rather than to simulate short-term extreme events. Second, the monthly scale reduces the influence of uncertainties in meteorological inputs and improves the robustness of scenario comparisons. Third, during model integration, monthly runoff is disaggregated into daily series under a water balance constraint, which ensures consistency between the SWAT outputs and the daily-scale outlet response model. We have also clarified that, although this transformation may smooth short-term variability, it has a limited impact on the analysis of stage-wise changes and relative differences that are central to this study.

(3) Concerning model coupling and the reliability of backflow representation**

We would like to clarify that neither the SWAT model nor the LightGBM model is used to directly simulate or reproduce backflow processes. Backflow events are identified solely from observational data, based on the joint variation characteristics of water level and discharge.

The LightGBM model is used only to establish the natural response relationship at the lake outlet under normal-flow conditions with weak mainstem influence, thereby defining a reference state without strong mainstem interference. The analysis of backflow and drought conditions is then conducted by comparing this reference state with observed discharge, with the systematic deviation interpreted as the effect of external hydrodynamic forcing. In this sense, the model serves to construct a baseline rather than to simulate complex hydrodynamic processes.

Furthermore, to reduce the influence of potential model errors, this study introduces the outflow resistance index (BI) and analyzes its statistical relationship with basin inflow, thereby extracting systematic deviation patterns rather than relying on point-wise differences. The methodological framework and associated uncertainties have been further clarified in the revised manuscript.

(4) Overall response regarding result reliability and interpretation**

We fully acknowledge the reviewer's concerns regarding model accuracy and methodological rigor. In the revised manuscript, we emphasize that the conclusions are supported by multiple lines of consistent evidence, including observational statistics, the structure of model-derived deviations, the evolution of hydrological events, and comparisons with previous studies. The primary objective of this study is to identify the directional characteristics and driving mechanisms of hydrological regime reorganization, rather than to provide high-precision, time-resolved simulations.

At the same time, we have explicitly discussed the limitations associated with model simplifications in the Discussion and uncertainty analysis, and we have suggested that future work could integrate hydrodynamic models to further improve the representation of underlying processes.

We hope that these revisions adequately address the reviewer's concerns.