Response to reviewer 3:

This study focused on the dynamics of land-based nitrogen in 50 large lakes in the Yangtze River basin over the past 40 years, and used LPJ-GUESS model to study the driving factors of lake eutrophication. Based on the principal component analysis (PCA), the authors divided the 50 lakes into three types according to two principal components. This work is interesting because the authors have identified a driving mechanism for lake eutrophication. On the whole, I find it easy to understand and interesting. However, there are several issues in this manuscript that need to be corrected.

Response: Many thanks for your positive comments and we have revised my manuscript and addressed each comment below.

In line 31: It is suggested that the introduction should be supplemented with an explanation of the current state of eutrophication-driven research. There are some relevant studies in this area. Could you explain the innovation of your research?

Response: Thanks for this valuable suggestion. Now, we have briefly described the current state of eutrophication-driven research on the Yangtze Plain (see lines 66-86): "In recent several decades, national field surveys and satellite observations have been widely used to investigate nutrient loadings (Tong et al., 2017; Li et al., 2022), chlorophyll-a concentrations (Guan et al., 2020), trophic state index (TSI) (Hu et al., 2022; Chen et al., 2020) and algal bloom occurrence (Huang et al., 2020) to assess eutrophication issues in local or regional lakes of the Yangtze Plain, all of which revealed the lakes on the Yangtze Plain experienced eutrophication and algal blooms for the past two decades. Cyanobacteria blooms were reported to frequently occur in Taihu and Chaohu lakes, with the peak expanded extent reported for 2006 (Qin et al., 2019). Since then, the magnitudes of algal blooms significantly decreased from 2006 to 2013, and slightly increased again from 2013 to 2018 (Huang et al., 2020). Satellite observations revealed widespread and serious eutrophication issues in large lakes of the Yangtze Plain for the periods of 2003-2011 and 2017-2018, although significantly decreasing trends were found in 20 out of 50 lakes throughout the periods (Guan et al., 2020). Moreover, 35-year Landsat-derived trophic state index (TSI) also indicated that hyper-eutrophic and eutrophic lakes mainly characterized the Yangtze Plain, with slight increase in TSI from 1986 to 2012 and then decrease since 2012 (Hu et al., 2022). National field surveys demonstrated that although total phosphorus concentrations overall decreased from 2006 to 2014, it still remained under high levels (i.e., > 50 μg L^{-1}) in eastern China lakes (Tong et al., 2017). Various laws and guidelines were implemented on regional and national scales to control eutrophication problems, such as the Guidelines on Strengthening Water Environmental Protection for Critical Lakes in 2008 and the Water Pollution Control Action Plan in 2015 (Huang et al., 2019). Nevertheless, the eutrophication issues are still challenging to control and improve under the scarcity of effective strategies for the whole Yangtze Plain due to unknown causes of eutrophication issues."

The innovation of our study includes 1) examining the regional scale's linkage between nutrient sources and eutrophication changes, and 2) explicit consideration of vegetation and soil nitrogen cycling as well as eco-hydrological processes on impacting terrestrial nutrient leaching. Now, we have added more descriptions about the innovation of my research (lines 87-107): "To understand the primary causes of eutrophication in the lakes of the Yangtze Plain, previous studies have attempted to determine the contributions of riverine nutrient exports and lacustrine nutrient loading to algal blooms in individual lakes, such as Taihu and Chaohu lakes (Tong et al., 2017; Tong et al., 2021; Xu et al., 2015). Based on field-measured phytoplankton biomass and nutrient concentrations, algal blooms in Taihu Lake were primarily attributed to excessive nutrient loads from 1993 to 2015 (Zhang et al., 2018). Overloaded nutrients, in combination with climatic warming, were found to regulate the seasonal variations of cyanobacteria blooms in Chaohu Lake based on the monthly nutrient monitoring at discrete points (Tong et al., 2021). However, these studies only tracked the primary drivers of algal blooms for individual hyper-eutrophic lakes (i.e., Taihu and Chaohu lakes), which is insufficient to understand spatial variations in causes of eutrophication changes on regional scales and support the design of region-specific effective management strategies to mitigate eutrophication issues. Furthermore, lacustrine nutrient loading is always associated with terrestrial nutrient sources, such synthetic fertilizers, livestock manure, and industrial sewage (Wang et al., 2019; Yu et al., 2018). For example, Wang et al. (2019) identified that diffuse sources contributed 90% to riverine exports of total dissolved nitrogen, and point sources discharged 52% of riverine phosphorus exports to Taihu Lake, where diffuse sources mainly focused on synthetic fertilizers and atmospheric deposition, while sewage and manure discharge represented point sources. It was also reported that chemical fertilizer and wastewater discharge provided primary nitrogen sources for Chaohu Lake (Yu et al., 2018). Unfortunately, all these studies did not examine the impacts of vegetation uptake and soil retention on terrestrial nutrient sources, making it insufficient to comprehensively understand the linkage between terrestrial nutrient sources and eutrophication in regional lake ecosystems.”

In line 253: The simulated and observed responses of the nitrogen leaching to different levels of fertilizer application rates for three main crop types response in Figure 3. What do the dotted lines in Figure 3 mean? Please add the explanation.

Response: The dotted lines in Figure 3 are also the comparison between simulated (red) and observed (blue) response of leached nitrogen. In this study, we obtained two pairs of simulated and observed response of leached nitrogen for each main crop type, where two pairs were represented by the dotted and solid lines, respectively. Now, we have added more explanation into the figure caption.

In line 236：Observations of crop yields and GPP are used to assess the accuracy of the LPJ model in simulating the nitrogen leaching. Does this effectively evaluate the reliability of the model? Please explain the reason.

Response: Thanks for this comment. We think these two outputs (i.e., crop yield and GPP) are relevant for the assessed variable (i.e., leached nitrogen), although it could be more straightforward to compare with soil water nitrogen concentration or leaching if these data were available. As the model simulated crop developments in response to available nitrogen sources and environmental and soil conditions, the simulated crop yield and GPP can directly represent how well the model capture crop growth and vegetation dynamics, and indirectly evaluate the modelled nitrogen usage by plants. Therefore, we concluded that such evaluations can demonstrate the reliability of LPJ-GUESS simulations.

In line 274：In Figure 4 (b), check for missing units (%) in the vertical coordinates. Please check it.

Response: Yes, thanks for pointing out this issue. It definitely needs a units of NUE (%) that has been now added into Figure 4b.

In line 281：In Figure 6 (b) (d) and (f), the vertical coordinates lack units (Kg N/ha). Please check it.

Response: Thanks for this comment. All of these three figures should have units as kg N ha^{-1} for the vertical coordinates. Now, I have added the units into these three figures.

In Figure S3, the position of the legend coincides with the picture. Please check and adjust the position of the legend.

Response: Thanks for pointing out this issue. The legend of Figure S3 has been moved to the right side, please see it in the supplementary file.

In line 324: Figure 7 (c) is not found in the manuscripts, and I assume you mean Figure 8 (c). Please check it.

Response: This is a typo. It should be Figure 8c that has been corrected now.

In line 335: In Figures 8 (a) and 8 (b), there are only relationships for type I and II lakes are found, but there no relationships for type III lakes. Please check it.

Response: Thanks for this comment. The leached nitrogen and agricultural phosphorus sources were found to positively correlate with the eutrophication changes for type I and II lakes (Fig. 8a&b). By contrast, the anomalies of industrial wastewater showed significantly positive correlations with the PEO trends in lake class III ($R = 0.29$, $p < 0.05$ in Fig. 8c). Now, we have used the red stars to mark statistically significant correlations in Fig. 8, and also added explanations into the figure caption.

In line 327: The significantly negative correlations between the PEO and IW Anomalies were found for Class I and II (Fig. 8C) .This conclusion is very interesting and I hope the author can explain it.

Response: Thanks for this suggestion. Yes, the significantly negative correlations were found between industrial wastewater and PEO anomalies for Class I and Class II (Fig. 8c). As I mentioned above, lakes in Class I and II are mainly located in western and central regions, with intensive agriculture activities and high fertilizer applications (Chen et al., 2016). Such agriculture ecosystems provided substantial nutrient sources for eutrophication growth and development, which were greatly larger than available nutrient from industrial wastewater. In addition, agriculture nutrient sources generally increased with enhanced fertilizer applications, while industrial wastewater discharge showed overall decreasing trends (Li et al., 2013; Lyu et al., 2016). In such cases, industrial wastewater showed significantly negative correlation with PEO anomalies for Class I and II lakes. We also acknowledged that such correlation between industrial wastewater and eutrophication changes might be affected by spatial variability in examined lakes within each class. Now, we have added these explanations about the significantly negative correlations between the PEO and IW anomalies in class I and II lakes into Section 3.4 (see lines 378-387).

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