Response to reviewer 1:

Using a process-based LPJ-GUESS model, this paper investigated the linkage between the dynamics of terrestrial nitrogen in the Yangtze Plain and eutrophication changes in fifty large lakes for the past four decades. Overall, the paper is well organized and the results answer the questions mentioned by the authors, although some uncertainties exist. But some details regarding the innovation and the method need to add before publication. The specific issues are as follows:

Response: Thank you for your constructive comments on improving our manuscript. Here, we have revised the manuscript according to these comments one by one.

Specific comments:

1. Introduction

Suggest to strengthen the innovation of the study.

Response: Thanks for this insightful suggestion. The innovation of this 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. We have now added more descriptions about the innovation of this study as the text in 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 regional variations in terms of the causes of eutrophication and support the design of effective management strategies to mitigate eutrophication issues across different eutrophic states of lakes. Furthermore, lacustrine nutrient loading is always associated with terrestrial nutrient sources, such as 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 are synthetic fertilizers and atmospheric deposition, and point sources are sewage and manure discharge. It was also reported that chemical fertilizer and wastewater discharge provided primary nitrogen sources for the 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."

2 Materials and Methods

2.1 briefly introduce the agricultural cultivation types and management patterns in the study area.

Response: Thanks for this suggestion. Now, we have added a brief introduction about agricultural cultivation and management on the Yangtze Plain (lines 122-132): "Generally, rice-sown area contributed dominantly to agriculture areas associated with climate conditions and human diet (Piao et al., 2010; Tilman et al., 2011). To enhance crop production, double-cropping strategy has been widely implemented on the Yangtze Plain, such as the rotation of early- and late-season rice (Chen et al., 2017), and the rotation of summer maize and winter wheat (Xiao et al., 2021). Several common management practices were adopted by millions of smallholders (Cui et al., 2018). For example, straw return, organic manure applications, and suitable planting density were also recommended in recent years (Cui et al., 2018). Significantly increased fertilizer applications to cropland were expected to stimulate crop yield over the past half century (Yu et al., 2019; Zhang et al., 2015). Such management practice can certainly enhance agriculture productivity, but also cause negative consequences to soil and aquatic environment (Liu et al., 2016; Shi et al., 2020)."

2.2 How the fertilization process is represented in the model needs to be described

Response: Thanks for this comment. We agree with you that the fertilization process deserves more detailed descriptions due to its importance to agricultural nitrogen leaching on the Yangtze Plain. The China Statistical Yearbook reported that chemical fertilizer applications increased from 55 kg N ha^{-1} in 1980 to 137 kg N ha^{-1} in 2014 to stimulate crop production over the Yangtze Plain (Chen et al., 2016). According to local farmers' practice (Shi et al., 2020), chemical fertilizer and livestock manure are often applied at three different stages: sowing, tillering, and heading stages for improving nitrogen use efficiency and nitrogen loss. Such fertilization schemes are represented in the LPJ-GUESS model (Olin et al., 2015), where nitrogen fertilizer is applied at crop development stages of 0, 0.5, and 0.9 which corresponds to the abovementioned three stages, and the relative fertilization rate for each stage are empirical parameters in LPJ-GUESS model. Now, these details about fertilization processes in the LPJ-GUESS simulation have been added to Section 2.2 (lines 162-167).

2.5.1 The remote sensing data of Guan, such as spatial and temporal resolution, should be briefly introduced.

Response: We agree with you that more details about remote sensing data used in Guan et al. (2020) should be added in the manuscript. We have added the following text on lines 249-252: "All full-resolution (300 m) MERIS and OLCI images were used to derive chlorophyll-a concentrations by using a SVR-based piecewise retrieval algorithm, and also detect algal bloom through two indices. High temporal resolutions for MERIS (i.e., 3 days) and OLCI (i.e., 1-2 days) ensure to provide sufficient observations on rapidly dynamic lake ecosystems."

4 Discussions and conclusions

(1) Lines 343-348 add a discussion of the reason for the decrease in NUE.

Response: Thanks for this comment. Now, we have added some discussion about the reasons for the decrease in NUE as lines 401-413: "The overall low mean NUE (27 %) and declining trends in NUE (-0.55 % yr^{-1}) characterized agricultural ecosystems on the Yangtze Plain for the past four decades, which are consistent with the previous studies using statistical datasets and numerical modelling (Zhang et al., 2015; Yu et al., 2019). Over-fertilization was primarily responsible for decline in NUE from 1979 to 2018 (Shi et al., 2020; Zhang et al., 2015). Nitrogen fertilizer applications significantly increased by 2.5 times for past four decades, greatly exceeding the increase magnitudes in crop production (+26.3%), which potentially contributed to markedly decreasing NUE over the Yangtze Plain. Moreover, fertilization-induced increases of crop yield always decrease with the increase in fertilizer applications, and eventually disappear when crop yield reaches the upper limits (Zhang et al., 2015), suggesting that high fertilization rates are more likely to generate the further decline in NUE over the Yangtze Plain. Over-fertilization might potentially enhance nitrogen accumulation in soil that can be available for crop growth and development in next years (Yang et al., 2006), thereby indicating that temporally increasing fertilization rates are generally accompanied by declining NUE in agriculture ecosystems"

(2) add an outlook for future studies regarding the uncertainties of current results.

Response: Thanks for this suggestion. The uncertainties related to the current results include unrepresented phosphorus cycling in terrestrial ecosystems, the contributions of aquaculture-related nutrient sources, the regulation of transport processes to the amount of nutrient discharge to freshwater, and uneven distributions of satellite observations. We have some perspectives about future studies that can overcome these uncertainties as the text in lines 471-474: "Nevertheless, we also acknowledge that the use of phosphorus application data can generate uncertainties in our analysis, and thus processes related to phosphorus cycles are needed to add into LPJ-GUESS in the future to study the interactions of leached N&P on lake ecosystems", lines 477-480: "Lateral transport rates of runoff and dissolved matter depend on soil properties, topography, and hydrological conditions over the drainage area (Solomon et al., 2015; Tang et al., 2014; Tang et al., 2018), is required to further consider at regional scales to link to the dynamics of terrestrial nutrient exports for lake ecosystems on the Yangtze Plain", lines 486-489: "These associated drivers are required to draw a complete picture of accessible nutrient sources for phytoplankton communities and then specify the anthropogenic impacts on water quality and eutrophication deterioration on the Yangtze Plain.", and lines 495-497: "Nevertheless, more frequent satellite observations (e.g., MODIS observations) will still be required to obtain a more accurate assessment of eutrophication changes in lake ecosystems."

Reference

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