Responses to Anonymou Referee #1' Comments

Dear reviewer,

We appreciate you for the helpful and inspiring comments. These comments are all valuable and helpful for revising and improving our paper, as well as the important guiding significance to our research. The following texts are our point-to-point responses, all comments are in black, and the replies are in red.

The authors applied a standard SWAT model in two large basins to undertstand the impacts of Eastern Pacific (EP) and Central Pacific (CP) El Niños on water quality. They found contrasting water quality effects due to differences in precipitation and air temp annormalies between the two EI Ninos.

(1) The authors suggest that impacts of extreme climate on the load of N and P to the rivers are dominated by variability of precip and consequently runoff. They discussed very little of impacts of hydrological change on biogeochemical cycles - the basiss of water quality change. For example, how the change in temp affects N denitrification and carbon decomposition and N leaching processes, in addition to water quantity through ET? Change in climate and hydrology is not only affecting total nutrient load but also the concentration of flow chemistry. More discussion in this aspect will provide more insights on the impacts of extreme climate change.

Reply: We agree with the reviewer that temperature could also impact nitrogen and phosphorus components, such as nitrate, organic nitrogen, soluble phosphorus, mineral phosphorus, and organic phosphorus besides total nutrient loads during El

Niño events. According to the comment, we have carried out new analyses and the results showed that compared to precipitation, temperature plays a secondary role in altering nutrient levels through biogeochemical processes. We have added a new Section 4.3 about biogeochemical process variations due to temperature change as follows.

4.3 Biogeochemical process variations due to temperature change

The effect of temperature on water quality through affecting evaporation and runoff has been analyzed in Section 3.2.2. In fact, temperature can also affect water quality through some biochemical processes of nutrients (Neitsch et al., 2011). In order to analyze the biogeochemical process variations due to temperature changes during EP- and CP-El Niños, new analyses on nitrogen and phosphorus components, such as nitrate, organic nitrogen, soluble phosphorus, mineral phosphorus, and organic phosphorus had been carried out. Results from the analyses demonstrated that compared to precipitation, temperature plays a secondary role in altering nutrient levels through biogeochemical processes. Taking nitrate as an example, we showed the composite results of annual and seasonal nitrate anomalies (Figs. S6 and S7), respectively, during EP- and CP-El Niños. Figures S6 and S7 indicated that the pattern of nitrate was more similar to that of precipitation (Figs. 5a, 5c, and 6a-6h) but different from that of temperature (Figs. 7a, 7c, and 8a-8h) in the Corn Belt region during El Niños. This could be further confirmed by the pattern correlation results. The correlation coefficients of annual nitrate and precipitation were 0.47, 0.36, 0.22, and 0.39, respectively, at OTRB and UMRB during EP- and CP-El Niños. The correlation coefficients between nitrate and temperature were relatively small (the coefficients were -0.15, 0.08, 0.30, and -0.31, respectively). The coefficient values altered between positive and negative at the two basins during EP- and CP-El Niños.

The inconsistent relationships between nitrate and temperature were mainly because the nitrate content could vary through nitrification, mineralization, denitrification, and plant uptake processes (Neitsch et al., 2011). When temperature rises, the former two processes increase nitrate content, but the latter two decrease nitrate content. Thus, the final sign of the correlation coefficient between nitrate and temperature really depends on the dominant processes. Similar results were also found at seasonal scales (not shown). These results indicated that nitrate variations were dominated by precipitation variations in the two basins during EP- and CP-El Niños, instead of temperature impacts on the biogeochemical processes. Similar results were also found for other nutrient components, such as organic nitrogen, soluble phosphorus, mineral phosphorus, and organic phosphorus (not shown).

Thank you for the suggestion.

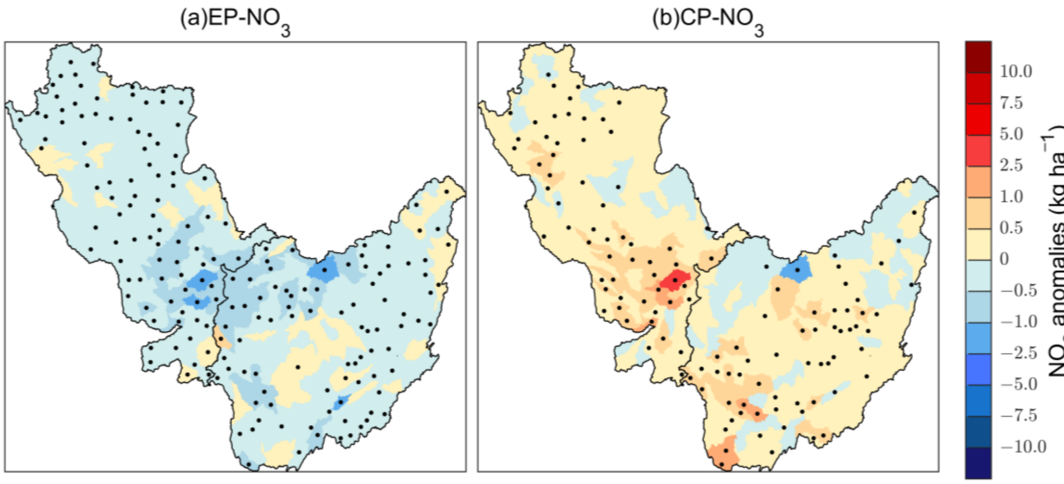

Figure S6. Composite results of annual nitrate (NO_3) anomalies (unit: kg ha^{-1}) in EP-El Niño years (a) and in CP-El Niño years (b) during the period of 1975–2016. Stippling denotes anomalies significantly different from zero at the 95% confidence level based on the Monte Carlo test.

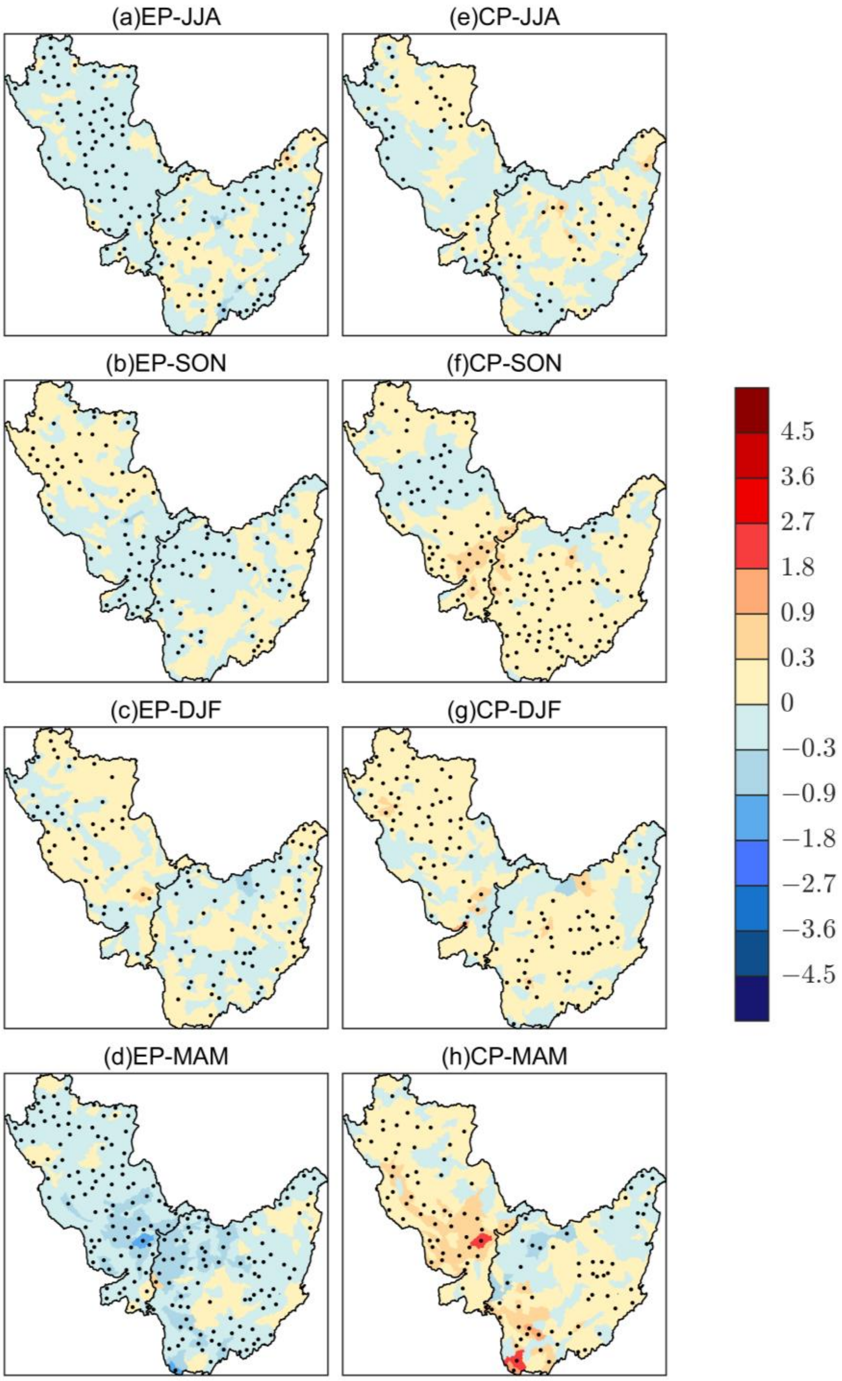

Figure S7. Seasonal composite of nitrate (NO_3) anomalies (unit: kg ha^{-1}) in summer (JJA) (a), autumn (SON) (b), winter (DJF) (c), and spring (MAM) (d) in EP-El Niño years during the period of 1975–2016; (e-h) are the same as (a-d) but for CP-El Niño years. Stippling denotes anomalies significantly different from zero at the 95% confidence level based on the Monte Carlo test.

References

Neitsch, S. L., Arnold, J. G., Kiniry, J. R. and Williams, J. R.: Soil and Water Assessment Tool Theoretical Documentation Version 2009, Available online: http://hdl.handle.net/1969.1/128050., 2011.