

Responses to Comments from the Reviewer

(Manuscript ID: essd-2025-507)

Title: History of anthropogenic Phosphorus inputs (HaPi) to the terrestrial biosphere from 1860 to 2020

Reply to Reviewer #1

The authors well addressed most of the concerns by the two reviewers. However, one issue in the major comments (my previous Comment 1) was not well resolved or defended.

Response: We sincerely thank the editor and reviewers for their time and effort in reviewing our manuscript, as well as for their insightful and constructive comments and suggestions. We have thoroughly addressed all the concerns raised by the reviewer, providing comprehensive and detailed responses.

Comment 1: The authors argued that the reason to ignore the crop-specific fertilizer use for several periods provided by FUBC1-9 (Ludemann et al., 2024) is “the FUBC1–9 dataset (Ludemann et al., 2022) provides national-scale nutrient budget estimates rather than spatially explicit fertilizer application rates. These data offer valuable information on fertilizer use at the country level, but they do not provide spatially explicit information on fertilizer application within countries.” However, Ludemann et al. (2024) provided crop-specific fertilizer use including the area of each major crop, the total amount of fertilizer, and the fertilization rate for those crops (kg P per hectare). Such information combined with the crop distribution produced here could be used to derive a better spatially explicit fertilizer application rates. Similar has probably been done for single year (e.g., Mueller et al., 2012) that this study heavily relies on. What are the obstacles to do so? If it is not feasible or probably inappropriate, the author need to provide strong argument on this issue for not doing so and also illustrate the uncertainties and limitations. Again, it should be noted that both crop distribution and crop-specific fertilizer application rate can vary a lot along time. This may strongly affect the distribution.

Response: We thank the reviewer for this important clarification. We agree that the FUBC1–9 dataset (Ludemann et al., 2022) provides valuable crop-specific information which could potentially be combined with spatially explicit crop distribution data to derive crop-specific fertilizer application maps. However, the FUBC1-9 crop-specific country-level fertilizer information is only available for a set of discontinuous time periods (mainly concentrated in 1990s, 2010, 2014, 2018), with substantial variations in both the number of countries and the types of crops covered across different survey years. Consequently, constructing a globally consistent annual dataset from FUBC1–9

would require extensive data harmonization, interpolation, and gap-filling across countries, crops, and time periods. These additional procedures would inevitably introduce further assumptions and uncertainties.

Therefore, we selected the fertilizer application rates from Mueller et al. (2012) as the baseline spatial dataset. On one hand, Mueller et al. (2012) incorporated both national- and subnational-level information, providing relatively detailed spatial patterns of fertilizer application, particularly for countries with large and heterogeneous agricultural areas. On the other hand, the Mueller et al. (2012) dataset is already provided as a gridded, crop-specific product, which can be directly integrated with the crop distribution data used in HaPi to generate spatially explicit fertilizer inputs. Similarly, in the long-term global FAOSTAT reference database of cropland nutrient budgets, Ludemann et al. (2024) only provide fertilizer use information for cropland at the country level rather than for individual crops.

Nevertheless, we acknowledge that the HaPi may not fully capture temporal changes in the relative fertilizer use intensity among individual crops. We also recognize that integrating the crop-specific fertilizer information will be a promising approach for future improvement. We have added these statements in 4.3 Limitations in Data Development:

“HaPi may not fully capture temporal changes in relative fertilizer intensity among individual crops.”

Minor remarks

Comment 2: What is the reason for the very different variation in P fertilizer input from National Bureau of Statistics and HaPi? (Fig. S5a) This may need to be explained.

Response: Good question! The discrepancy between the HaPi dataset and the National Bureau of Statistics (NBS) arises primarily from differences in their underlying statistical sources and methodologies for estimating phosphorus (P) content in compound fertilizers.

The total P fertilizer input for China in HaPi is derived from FAOSTAT, and the overall magnitude and temporal variability of the HaPi are generally consistent with the corresponding FAOSTAT statistics. FAOSTAT directly provides the total P fertilizer use, including both P fertilizers and compound fertilizers, using default nutrient conversion factors (<https://www.fao.org/faostat/zh/#data>). In contrast, NBS separately reports nutrient-equivalent application amounts for P fertilizers and compound fertilizers. However, the publicly available NBS statistics do not disclose the P content of compound fertilizers. To estimate total P input from the NBS data, we therefore separately considered domestically produced and imported compound fertilizers according to their respective shares and estimated their P contents using the nutrient

compositions reported by Lin and Li (2002). The resulting P input from compound fertilizers was then combined with the P contained in P fertilizers reported by NBS, and all values were converted to elemental P. Thus, the two datasets differ in their underlying data sources, nutrient-conversion factors, and estimation procedures. These differences, particularly in the treatment and estimation of P contained in compound fertilizers, may lead to different interannual variations, as shown in Fig. S5a. Such discrepancies between statistical datasets are not uncommon, especially when different agencies employ distinct data collection and estimation frameworks.

References

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