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Interactive comment on "Global nitrogen and phosphorus fertilizer use for agriculture production in the past half century: Shifted hot spots and nutrient imbalance" *by* Chaoqun Lu and Hanqin Tian

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Thanks for your precious comments. We summarized your points and responded as below.

1. Authors states the lack of long-term spatially explicit dataset for fertilizer use, but there are data starting from 1970, and recent paper covering the full 20th century published in PNAS in 2013 is not cited

Response: Many century-long earth system modeling studies require data set of agricultural nitrogen fertilizer use starting from the beginning of last century. And most

existing geospatial data of nitrogen fertilizer use are based on FAO or IFA country-level survey, but ignore the spatial heterogeneity and cross-crop variation in fertilizer application within country. Therefore, to generate a century-long geospatial data set by considering both cross-country and within-country heterogeneity is our motivation for this study. We are not sure if the paper you mentioned is Bouwman et al. (2013, PNAS) or not. If so, this research only provides estimates of synthetic nitrogen fertilizer use in a few historical time points (e.g., 1900, 1950, 2000). We quote the approach they used for generating these estimates, "Fertilizer use for 1950 is taken from the FAO (13). For the year 1900, we used country data on the use of fixed N (industrially produced N fertilizer, Chili nitrate, guano, coke-oven ammonium sulfate, calcium cyanamide, and electric-arc calcium nitrate) for 1913 (48) and assumed that the use in each country in 1900 is 80% of that in 1913. For the year 2000, we used country data on total synthetic fertilizer consumption and crop production and animal stocks (22) and N and P fertilizer use by crop (49)." It cannot meet the data requirement of an ecosystem/earth system modeling study. We cited this paper in the revised manuscript. The similar data development can be found in Bouwman et al. (2005) for the time points of 1970, 1995, and 2030.

2. The assumption of linear increase of N and P fertilizer use prior to 1961 is problematic.

Response: Thanks for raising this question. Since the data before 1961 is hard to found and has much divergence in its quality and reporting criteria among countries, we removed the description of this part from the manuscript and only focus on the period 1961-2013.

3. Older version of IFA data (e.g., 2003) covers more countries and fertilizer use in grassland and meadows.

Response: Thanks for your suggestion. The IFA data of fertilizer use by crop (Heffer, 2013) we are using now depicts crop-specific fertilizer use in the year of 2010-2010/11.

It is the most up-to-date country-level crop-specific fertilizer use data we can get so far. It covers over 94% of global fertilizer consumption. For the rest ∼6% fertilizer consumptions, in order to keep the data record consistent from the same data source, we used IFA-derived country-level data by assuming fertilizer use rate is uniform for all the crop types in each of these less-intensive fertilizer use countries. Since the purpose of this study is to provide long-term synthetic nitrogen fertilizer use data across global cropland, the land use data we used here only include cropland distribution and change (e.g., M3-crop, HYDE 3.2 data). We clarified this in the revised manuscript.

4. A further concern is that harvested are is used to distribute fertilizer, but perhaps a better way could have been crop yields, which combines area and biomass production.

Response: Thanks for your suggestion. We do see data development approaches of future fertilizer use scenarios that includes crop yield or biomass production (e.g., Bouwman et al., 2005, 2013), but this method ignores the changes in crop use efficiency of nitrogen and phosphorous. To facilitate modeling assessment of crop yield and agricultural production, we would like to have a set of fertilizer use data that is independent of productivity to avoid autocorrelation and problematic assumptions. Therefore, we only use harvested cropland area to spatialize country-level fertilizer use amount.

5. Synthetic fertilizer use is only part of nutrient inputs in agriculture and incomplete for biogeochemical studies

Response: We agree that there are many sources of nutrient input, such as atmospheric nitrogen deposition, biological nitrogen fixation, manure N and P application, weathering, that have important influence to biogeochemical cycling. However, the purpose of this study is to develop spatially-explicit time-series data of agricultural N and P fertilizer use across the globe, rather than to estimate all the nutrient input sources.

6. So the authors have not reviewed the literature and did not start with the knowledge already available, both approaches and statistical information, which is a pity, because

most of this data is open access and freely available. In addition, the data as published in this discussions paper in itself is not really useful, since it lacks other sources of nutrients that in many countries are more important than synthetic fertilizers.

Response: We have compared the newly-developed data in this study with other two typical similar data sets that demonstrated gridded maps of agricultural fertilizer uses (Potter et al., 2010; Mueller et al., 2012). The other data sets failed to provide similar information, either due to limited spatial extent or temporal span, or the lack of geospatial component. As we mentioned above, there are indeed many sources of nutrient input, among which synthetic fertilizer use accounts for 1/3 and half of total N and P inputs, respectively. It's of critical importance to know the spatial and temporal patterns of N and P fertilizer uses across global cropland. It could help us identify the hot spots and hot periods of anthropogenic nutrient input, and the consequent changes in food production, environmental quality, and climate change, and lead to effective nutrient management toward a sustainable world.

Reference

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