Response to shot comment from Dr. Lu

NISHINA et al.

January 16, 2017

Dear Dr. C. Lu

Thank you for sharing your time to review our manuscript. We'd like to respond the individual comment one by one.

> 1) How do you decide whether a region is single or double-cropping based on crop calendar data (Sacks et al., 2010)? As I know, its impossible for the US to have such large areas of double-cropping agricultural land (over half of country land shown in your figure 1). I am attaching a USDA report on the recent trend of double-cropping in the US. There are only small percentage of cropland using such practice (about 2% of total cropland in the US). If thats the case, it will substantially affect the cropland areas used in your study and the estimated fertilizer use rate. If harvested area is overestimated or nearly doubled, the fertilizer use rate would be underestimated.

Thank you for your information. Our assumption was just doubling the crop area where the crops in SAGE calendar have information about 2nd or 2 seasons transplanting date. By your comment, we have recognized that our settings of double cropping region were extremely overestimated, globally. As you mentioned, fertilizer rate was underestimated in US (and some other countries) because of our assumption (eq. 4).

So, we have changed the double crop map in the revised version. In the revised N fertilizer map, we utilized the double cropping region based on cropland use intensity (CUI) developed by Siebert et al. (2010, in Remote Sens.). In this map, we used CUI more than 1.3 to be double cropping regions. According to this map, the range of CUI in US varied from 0.9–1.1. Therefore, we avoid the underestimation of N fertilizer rate in US.

As soon as possible, we will upload the revised map in PANGAEA.

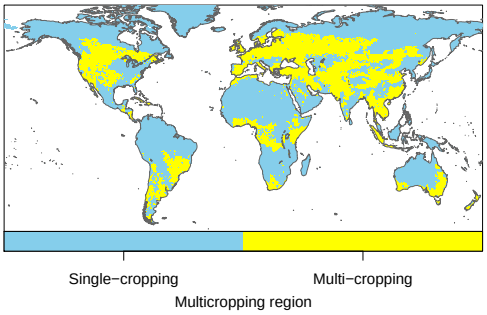

Figure 1: Original map

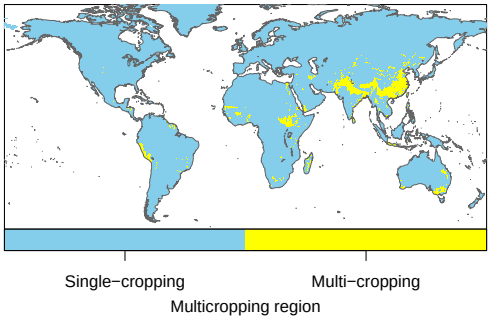

Figure 2: Revised map (Siebert et al., 2010)

2) You assume there are two fertilizer timing: the first is 7 days before sow- ing/transplanting and the second is 30 days after based fertilizer application, and the ratio of fertilizer use between these two are 7:3. Is there any supportive evidence or citation for such assumption (timing and ratio to split fertilizer)? In addition, the SAGE dataset has just one average date for each crop in a region. So the dates of N fertilizer inputs were fixed during 1960-2010. Considering the changes in crop distribution and agricultural practices, this timing should vary a lot. Could you discuss what potential consequence would yield by using the fixed application timing?

Thank you for your important comment. We confirmed the some famers in US to apply N fertilzer at fall especially in dry corn belt region with irrigated area to save their working time. And, also, we confirmed that the timing could affect reactive N gases emission (e.g., Burzaco et al., 2013 in ERL). But, Autumn fertilizer application is not best application practice for all regions even in US and not common in globally. This application methods is only applicable in dry climate region, because of N leaching in follow season. And only specific fertilizer species is recommended in autumn species (http://plantsci.missouri.edu/nutrientmanagement/nitrogen/practices.htm). In addition, we cannot reach the statistics how large proportion of US farmers do this. So, in this time, we don't consider the autumn application in the revised map.

For N fertilizer application, If I have to bring up one, the assumption (criteria) is referenced on the common Maize practice, however, there are no concrete reference.

However, in Robertson and Vitousek (2009, in Annual Review of Environment and Resources), we can see following recommendation;

> Commonly, best practice calls for two applications to field crops, such as corn, with a starter rate (30 kg N ha-1, for example) applied at planting and a side-dress rate (the remaining N to be applied) several weeks later, once the crop has germinated and entered a rapid growth phase.

This is a one of the reference to our assumption. Also, we can referred "Plant nutrition for food security -A guide for integrated nutrient management-" as general guideline for agricultural practice. (ftp://ftp.fao.org/docrep/fao/009/a0443e/a0443e.pdf)

We agreed that our assumption was not realistic to apply the various crop (and vegetable) species management. But, of course, there are no silver bullet. At least, We should excuse such backgrounds in the manuscript.

> 3) I think the fraction of NH4 in North America may be largely underestimated because the Anhydrous Ammonia and Aqua Ammonia, two important NH4 fertilizer sources in North America, were not included in FAO dataset, but present in USDA data (see table 4 in a single worksheet: http://www.ers.usda.gov/data-products/fertilizer-use-and-price/) and
>
> (http://ageconomists.com/2016/02/15/nitrogen-fertilizers-shift-happens/). Do you think if it can partially explain why NH4 fraction in North America shown in your figure 6 and 7 is the lowest across the world? I dont know if the same condition also exists in other countries or regions.

We assumed that other N include NH_3 in FAOSTAT. So, the fraction of other N was set to be 100% in NH_4^+ and this is not negligible fraction in the consumption (see table 1).

> 3) in your manuscript text, the second application is 30 days after the first application, but in figure 1, it is 45 days after.

Thanks. This is typo. "45 days" is correct. I'd like to revise it in the revision.

Reference

Siebert, S., Portmann, F. T., & Döll, P. (2010). Global patterns of cropland use intensity. Remote Sensing, 2(7), 1625-1643.

Burzaco, J. P., Smith, D. R., & Vyn, T. J. (2013). Nitrous oxide emissions in Midwest US maize production vary widely with band-injected N fertilizer rates, timing and nitrapyrin presence. Environmental Research Letters, 8(3), 035031.

Robertson, G. P., & Vitousek, P. M. (2009). Nitrogen in agriculture: balancing the cost of an essential resource. Annual Review of Environment and Resources, 34, 97-125.