Surface Nitrogen Budgets for Cropland and Pastureland on a Global Grid – Opportunities and Challenges

Katrin Kaltenegger[1], Wilfried Winiwarter[1,2]

[1] International Institute for Applied Systems Analysis (IIASA), Vienna, Austria
[2] Institute of Environmental Engineering, University of Zielona Góra, Poland

E-mail: kalteneg@iiasa.ac.at

Abstract

To limit harmful effects of nitrogen (N) inbalance on the environment as well as on people, it is important to identify areas of N surplus as well as deficiency. Several indicators such as N balance and N use efficiency (NUE) have been developed to evaluate the application of N fertilizers in agriculture, however differing definitions and heterogeneous reference areas cause problems to compare studies and draw conclusions. We transparently develop soil surface nitrogen budgets on an 0.5-degree grid globally, based on publicly available sources, to indicate areas of N inbalance while pointing out linked challenges incentivizing further research.

Keywords: Nitrogen, Nitrogen Balance, Nitrogen Use Efficiency, Agriculture

1. Introduction

Anthropogenic activities have strongly shaped the global cycle of reactive nitrogen (Galloway et al., 2004). The exceedance of the planetary boundary calls for a global focus to resolve inefficiencies and surplus. Using indicators such as N budgets and N Use Efficiency (NUE: see e.g. Lassalletta et al., 2014) helps to understand priorities and possibilties to improve an adverse environmental situation that is the consequence of providing the global population with sufficient and adequate food. Originally based on statistical data available on a country scale, there is a need for a finer resolution to capture sub-country effects. While modelling approaches may provide consistent results across environmental media, here we strive to combine publicly available and largely independent datasets, to identify and evaluate discrepancies. The aim of this work is to develop a spatially explicit map of soil surface N budgets, globally for the year 2010, on a 0.5-degree grid, while pointing out the challenges as well as the opportunities of such a procedure.

2. Methods

We use the spatial distribution of 175 different crops (including forage crops and pastureland) found in the M3 crop map (Monfreda et al., 2007) and the spatial distribution of livestock management systems (FAO Geonetwork). Using FAOSTAT data on harvested areas and yields per crop, the original numbers of the crop map were updated from the year 2000 to the year 2010 and then used to spatially distribute fertilizer consumption (IFA data for 28 world regions and 13 crop types) as well as biological nitrogen fixation (BNF) (Herridge et al., 2008). N removals by crop type were taken from EPNB (2016); N deposition from the atmosphere from IGAC/SPARC CCMI (2016). Manure N application, was calculated by combining animal numbers with excretion rates from the GAINS model, (http://gains.iiasa.ac.at), and manure fractions managed and fractions lost during management (Herrero et al., 2013). N grazed was calculated from manure N using a formula from Kozloski et al. (2018)

3. Results and Discussion

The resulting first version of a global map indicates, for most parts of the world, N surplus (Figure 1). Regions with high surplus are East and South Asia, but also large parts of Northern Europe. Parts of North and South America show high soil surface N budgets that are largely driven by high levels of manure N input on pastureland from grazing livestock. Whereas N deficiency was discovered in Subsaharan Africa calculating soil surface N budgets only on Cropland, these deficiencies turn into N surplus when expanding the calculations to pastureland, possibly implying an unused potential in manure N as already pointed out by Ndambi et al. (2019).

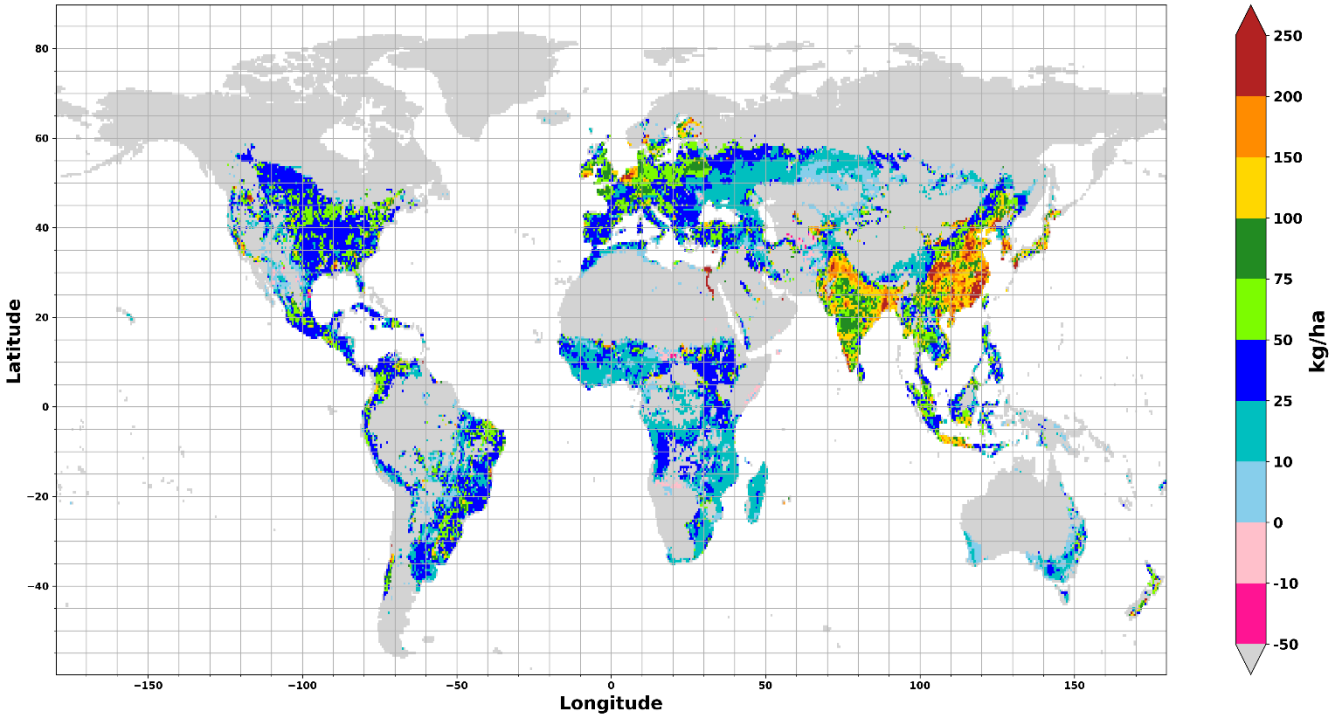

Figure 1 Global Nitrogen Soil Surface Budgets on Cropland and Pastureland

4. Conclusion

Calculating agro-environmental indicators such as N Budgets and NUE from publicly available statistical data on a global grid poses an opportunity to track developments and explore potentials fo tightening N cycles. Further efforts to explore sensitivities and uncertainties of data are required. Using independent inputs allows to identify discrepancies and further data needs.

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