

Interactive comment on “Global deposition of total reactive nitrogen oxides from 1996 to 2014 constrained with satellite observations of NO₂ columns” by Jeffrey A. Geddes and Randall V. Martin

Anonymous Referee #1

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Better quantifying the trends of atmospheric nitrogen deposition is of great importance to understand and to predict its effects on environment. This manuscript has investigated global deposition of oxidized nitrogen (NOy) using long-term (1996-2014) model simulations with emissions constrained by satellite NO₂ column observations. It presents a novel approach to estimate the long-term trends in global NOy deposition by using satellite observations as nitrogen input constraints and a chemical transport model to account for physical/chemical processes in the atmosphere. The model results show different deposition trends from 1996 to 2014 depending on regions, which are evaluated with available surface measurements of wet deposition flux. In

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particular, the manuscript points out a recent decline of NOy deposition over China since 2011.

The study is overall well conducted and fits the scope of ACP. The manuscript is well organized and presented. I recommend publish on ACP after the following comments been addressed.

Specific Comments

1) Page 5, Methods:

My first comment is that the present manuscript is missing some description and explanation of the top-down NOx emissions. First, measurements from three satellite instruments are used to estimate the long-term NOx emissions. Are there any instrumental differences among the three satellite products? If so, how do you reconcile them? Second, the three satellite instruments have some overlapping time periods (e.g. 2007-2011 for SCIAMACY and GOME-2). How do you use them for emission estimates during these periods? While these may have been presented in another study, a brief description here will help readers to better understand the method.

And third, I strongly suggest present more information and analyses on the global top-down NOx emissions and their trends during the focused period by adding more text and a figure. This is not clear at present, and will be really helpful to understand the trends in NOy deposition as presented in Figure 6 and 7.

2) Page 6, Line 15:

“Monthly mean simulated NO₂ columns are calculated using days with coincident satellite observations”. How do you select coincident days when using monthly-mean gridded satellite NO₂ observations (Line 11)? And how do you sample the model simulation? Please clarify.

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3) Page 6, Line 11-17:

Do you mean you do not change the seasonality of NOx emissions in the model? Please clarify. And what is the NOx emission seasonality in the model? This is not described in the Appendix.

4) Page 17, Line 1:

Is there any trends in the export efficiency or changes in the export fraction during the period 1996-2014 over the US and Asia? From Line 11 below, it appears that the export fractions over Europe have a decreasing trend.

5) Page 17, Line 22-24:

A recent study on atmospheric nitrogen deposition over China reported a NOy export fraction of 36% (Zhao et al., 2017), not that different from the values for Europe and the US, compared with 24% in this study. Can you explain why? different NOx emissions, inclusion of adjacent oceans, or model horizontal resolution?

Reference: Zhao, Y., Zhang, L., Chen, Y., Liu, X., Xu, W., Pan, Y., and Duan, L.: Atmospheric nitrogen deposition to China: A model analysis on nitrogen budget and critical load exceedance, *Atmospheric Environment*, 153, 32-40, 2017.

6) Page 18, Line 30:

Please explain “perturbing NH3 emissions everywhere”. Increase or decrease? Do you change all anthropogenic and natural NH3 emissions, including the oceanic NH3 emissions?

7) Page 20, Line 23, 25, 27

The unit “kg N ha⁻¹ yr⁻²” here might be confusing. Suggest add here “at a rate of ...” or use annual deposition changes during the period.

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8) Page 22, Appendix, Line 27-29:

Energy statistics are used to scale emissions between 1996 and 2010. How about emissions after 2010? Please clarify.

9) Page 44, Figure 8:

Please state in the figure caption that the sensitivity test is for the year 2012.

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