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Atmospheric Chemistry and Physics Discussions



# *Interactive comment on* "Impacts of climate change and emissions on atmospheric oxidized nitrogen deposition over East Asia" *by* Junxi Zhang et al.

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Comments from Reviewer 3:

General comments:

In this work, the authors used the multimodel results from the ACCMIP study to investigate the projected changes in dry and wet deposition of oxidized nitrogen compounds (NOy) in 2030–2039 and 2100–2109. This builds on the work of Lamarque et al. (2013), who used the same model results to examine changes in mean nitrogen and sulfur deposition. An important contribution over the past work is the examination of



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Discussion paper

the separate impacts of emission and climate changes on NOy deposition, as opposed to the combined effects, and how the change in NOy deposition could affect the primary productivity (PP) of the eastern China seas. However, unlike the past work, they did not examine the contributions and changes in deposition of reduced nitrogen compounds and are thus missing a significant fraction of the reactive nitrogen deposition budgets. I think this is a missed opportunity to make an important contribution to our understanding of how reactive nitrogen may change in the coming decades. Ammonia emissions have different spatial and temporal patterns from NOx emissions and are likely to increase or remain relatively constant in the coming decades. Therefore, the changes in total inorganic reactive nitrogen deposition and its causes could be quite different compared to NOy deposition and the resulting impacts on PP of China seas. While I do encourage the authors to include reduced nitrogen in their analyses at some level, I think the current work makes enough of a contribution to our understanding of these issues to warrant publication.

Response: We thank the reviewer for the constructive and insight comments. We agree that adding the analysis of reduced nitrogen is meaningful and interesting to elucidate the impact of ammonia emissions. However, the analysis of reduced nitrogen will likely form a separate study and therefore leave this part of analysis in future study. For now, we mainly focus on the oxidized reactive nitrogen deposition. Please see the detailed responses to the specific comments below.

Specific comments:

The figures are small and the text difficult to read. I suggest that column and row headings be added to the tables of maps to allow the reader to more easily follow what is being presented.

Response: We thank the reviewer for the suggestion to improve the quality of the figures. We have modified the texts in the busy figures including Figs. 1-6 and Fig. 9.

Lines 108–109. How do the shipping emissions compare to the other NOx emissions

in East Asia?

Response: The contribution of shipping NOx emission has been added in the revised introduction, and they account for nearly 9% of total NOx emissions in East Asia.

Lines 123–125. It would be interesting to know the areas where the deposition had to increase to compensate for the decreased deposition over the tropics and northern hemisphere midlatitudes.

Response: Discussion here has been revised in order to make it clearer. The deposition over ocean increases, compensating for the decreased deposition over the tropics and Northern hemisphere midlatitudes land areas (due to the decrease of large-scale precipitation) through the transport effect (Line 128-132 in the revised manuscript).

Section 3. Evaluation of the ACCMIP results. Some discussion of the variability in the results across the different models would be very interesting, which is alluded to in the first sentence of section 4.

Response: In the part for evaluation of ACCMIP precipitation, discussion of the inter-model variability has been added in the revised manuscript (before section 4) and Fig. S2 in the supporting information has also been added.

In Figure 5, what does each data point represent? If it's the changes for a grid cell in each region, then it would be informative to color the data points by region, so that the reader can see the differences in each region.

Response: Yes, each data point represents a grid cell in the BYE areas. We have adjusted the color of points in Fig. 5 with red points indicating grids in BS, blue points for grids in YS and black points for grids in ES.

In Figures 7 and 8, it is not clear what role the changes in shipping and lightning emissions play in the changes in their relative contributions to NOy deposition. Therefore, please add a discussion on the changes in shipping and lightning emissions in the future scenarios examined in this work.

Response: We have revised Fig. 7,8 (add a line for total NOy deposition) and added a table (Table S4) summarizing the shipping and lightning emissions in historical period and the future scenarios. The corresponding discussion have been added in the revised manuscript section 5, paragraph 7,8.

Lines 421–423. The Zhang et al. and Qi et al. studies examined the total inorganic nitrogen deposition and not just the NOy fraction. Please clarify this in the manuscript and adjust the comparisons as needed.

Response: Thank you for the suggestion. The difference of species used has been clarified in the revised manuscript.

It is not completely clear how the results in Figure 9 were generated. However, since by equation 6.2 PPnoy is proportional to NOy deposition, I would think that the percent changes in PP due to changes in NOy deposition should be the same as the percent change in total NOy deposition. If this is not the case, then please provide a more thorough discussion on how Figure 9 was calculated. If true, then I suggest that Figure 9 be replaced with the percent change in total NOy deposition, which could then include the changes over land. Then, note in the discussion that the percent changes in PP in the eastern China seas are the same as the change in total NOy deposition.

Response: The reviewer is correct that the percent changes in PP due to changes in NOy deposition is the same as the percent change in total NOy deposition. Therefore, based on the reviewer's suggestion, we redrew Fig. 9 with rows 2 – 7 representing change of total NOy deposition (i.e., cover both land and ocean areas). In addition, the first row remains the PPnoy over the ocean to illustrate the spatial distribution of PP as the base case.

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