

Geosci. Model Dev. Discuss., author comment AC3  
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## Reply on RC2

Huan Fang and Greg Michalski

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Author comment on "Assessing the roles emission sources and atmospheric processes play in simulating  $\delta^{15}\text{N}$  of atmospheric  $\text{NO}_x$  and  $\text{NO}_3^-$  using CMAQ (version 5.2.1) and SMOKE (version 4.6)" by Huan Fang and Greg Michalski, Geosci. Model Dev. Discuss., <https://doi.org/10.5194/gmd-2020-415-AC3>, 2021

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1. "I agree with the first reviewer about the scope of this paper being too narrow, and I think that reviewer's suggestion of combining this work with Fang and Michalski (2020) would be appropriate ...", "I have serious concerns about the overlap in content with Fang and Michalski (2020). "

**We decided to combine the companion paper with this manuscript in order to deal with the overlapping and completeness issue.**

2. "I am not sure what we are learning from the many figures showing the seasonal variation in  $\delta^{15}\text{N}$  concentrations for transport only, transport with different emissions, transport with different meteorology, and transport with deposition on, etc ..."

**The more organized interpretation and quantification of the output have been included in the revised manuscript in section 3**

3. "The conclusion that the PBL is the "key driver for the mixture of anthropogenic and natural  $\text{NO}_x$  emission" seems odd ..."

**The more in detail interpretation and quantification of the output have been included in the revised manuscript in section 3.3**

4. "Please add quantitative metrics to the abstract to more precisely communicate the impact that adding CMAQ's process-level understanding has on the evaluations in Indiana."

**Confirmed**

5. "Page 2, Line 31: Better add the reference to the FIVE mobile emission model (McDonald et al., 2018: <https://doi.org/10.1021/acs.est.8b00778>) to these references."

**Confirmed**

6. Page 3, Line 18: Consider changing " $\text{NO}_x/\text{NO}_y$ " to " $\text{NO}_x$ " or " $\text{NO}_x$  and  $\text{NO}_y$ "

**Confirmed**

7. "Section 2.1: Why run with an extracted domain? Was this just to make the model go faster?"

**To eliminate the bias near the domain boundary**

8. "Much of section 2.3 can be moved to SI. The main manuscript can just state what models and version numbers were used for each part."

## Confirmed

9. "Page 10, Lines 3-18: It is hard to understand exactly what was accomplished in the deposition velocity tuning approach and what its limitations are. This would all be solved if the authors were able to include chemistry in the study and turn chemistry off for a transport+deposition only case."

**Including chemistry in the study and turn chemistry off is what exactly we did. The more in detail explanation of deposition have been included in the revised manuscript in section 3.7.**

10. "Section 2.6: We need some idea of how the emission datasets performed against coincident observations from routine networks for conventional pollutants like NO<sub>2</sub>, EC, O<sub>3</sub> and particulate Sulfate to check that they were processed with reasonable assumptions."

**We decide to give up this section, and explore the sensitivity of emission dataset in future work**

11. "Please consider removing Tables S1 and S2 from the supplemental information. Just refer readers to the MCIP user guide."

**Table S1 and S2 were summarized from user's guide, it is easier to understand for the reader and more relevant to the corresponding section in the manuscript.**

12. "Section 2.7: I'm not sure what is meant by the 'research area' and 'emission-free zone'. Is it just U.S. versus Canada? The term 'nested' usually refers to an area of higher resolution. Although this doesn't strictly have to be the case, I urge the authors to consider renaming their 'nested' grid..."

**We do not have emission dataset in Canada, thus when the air mass transports out of the Midwest, the atmospheric NO<sub>x</sub> is diluted. In addition, we set atmospheric NO<sub>x</sub> δ<sup>15</sup>N = 0‰ for initial condition and boundary condition, the air mass from Canada, or boundary of the domain could flattened the atmospheric δ<sup>15</sup>N(NO<sub>x</sub>). Details in section 2.2.2-2.2.4. The term 'nested' was changed to 'extracted'**

13. "Page 14: Rather than using Fig. 3 to show the expected dispersion of NO<sub>x</sub> in the model domain, why not include a figure as a barplot that quantifies the differences in weighted average δ<sup>15</sup>N values for the different categories discussed like agricultural areas, big cities, highways and EGUs?"

**Fig. S6 in the revised manuscript**

14. "Page 14, line 28: Consider adding a figure with distance from power plant on the x and δ<sup>15</sup>N on the y to show the decay along a couple of trajectories from an important facility."

**Fig. 6 in the revised manuscript**

15. "Page 18: Is there any data to evaluate the PBL heights?...", "Page 18, line 12: Why not have a figure showing the positive correlation between PBL height and δ<sup>15</sup>N ..."

**Fig. 9 and Fig. 10 in the revised manuscript**

16. Fig 7 can go to the SI.

**Confirmed**

17. "Fig. 10 is not terribly informative other than to show that the southern boundary should probably also be restricted for the nested area."

**The purpose of this analysis is showing how the simulation over the extracted domain improve the performance (by 1‰ near the southern boundary)**

18. I recommend moving Section 3.7 to the first section of the Results.

**We decide to start with the interpretation and quantification of the simulation first, then comparing with the measurements.**

19. "Strongly recommend putting Figs. 11 and 12 together so that measurements and models are on the same figure. Why not pair the model and obs in time for the figure ..."

**Fig. 11 and Fig. 12 shows the characteristic of measurements and simulations, the comparison between them are in the next figure and the associated paragraphs in the manuscript**

20. "Fig. 14: Consider normalizing both panels to remove influence of chemistry bias. It seems like there is a signal here that the CMAQ modeling is able to capture, but it is hard to tell."

**We do agree the normalization could make the figure looks more beautiful. However, the similar monthly variation and seasonal trend with the gap between the simulated  $\delta^{15}\text{N}(\text{NO}_x)$  and measured  $\delta^{15}\text{N}(\text{NO}_3^-)$  is exactly what we are expecting, since there are isotope effects associated with the photochemical transformation of  $\text{NO}_x$  into  $\text{NO}_y$ . After including the  $^{15}\text{N}$  into the chemical mechanism in our future work, this gap will be resolved.**