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Interactive comment on "Mechanistic representation of soil nitrogen emissions in the Community Multi-scale Air Quality (CMAQ) model v 5.1" *by* Quazi Z. Rasool et al.

Anonymous Referee #1

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General comments: This study presents the introduction of a process-based mechanistic scheme of soil N transformation into a regional photochemical model CMAQ v5.1. The implementation can help simulating the soil N emissions associated to processes like mineralization, volatilization, nitrification and denitrification. The authors then compare the simulated N emissions with the other two schemes used in previous versions of CMAQ, and evaluate the performance of schemes against a series of in-situ and remote sensing datasets. The manuscript is well written and well organized. The mechanistic scheme is clearly described, as well as the differences compared to the previous two schemes. But the model evaluation part needs some more clarification and explanation.

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Discussion paper

Specific comments: 1. The first paragraph of Sect. 1 introduces the importance of N fertilizer on agricultural land and its implication on N emissions, but neglected those from non-cultivated land. In addition, it is not clear why only NO and NO2 emissions are mentioned in this paragraph, and their relationships. Merging this part with the third paragraph might improve the logic here. 2. L79: the impacts of N2O emissions are not introduced as that for NOx, NH3, and HONO. 3. L223: it is a little confusing on the different versions of CMAQ and the schemes of NO emission in these versions. For example, is YL or BEIS used in CMAQ? In which version. This confusing issue can also be found in later of the manuscript due to too many schemes, methods, interaction systems, datasets are introduced here. A clarification of the abbreviations and the purpose of them could be useful to readers. 4. Similar to points 3, Sect. 2.2 is a little hard to follow given different land covers are used and converted in different model. 5. Sect. 2.6, the mechanisms are very well organized and presented. But it could be better whenever the factors impacting concentrations or fluxes can be referenced (e.g., fXXX in those equations). 6. The model comparison and evaluation are only conducted for two months in one year (May and July of 2011). It is crucial to explain the reasons in more detail. Readers may very curious about why. For example, why not using multi-month (e.g., for a whole year) and multi-year (e.g., 5-10 years) for evaluation? Is that due to the availability of observations? If so, it would be necessary to list the available observations. Unless using two months of a single year is well justified, it could be good to use more observations for seasonality, or even interannual variability, given that the purpose of a model (and the evaluation) is to be able to simulate spatio-temporal changes. 7. Sect. 2.8, what about the validation of N2O emissions? 8. Sect. 3.1, it is not clear what is the anthropogenic emissions. Please define it? Whether emissions caused by fertilizer application are anthropogenic? 9. L630: when exactly the peak emissions happened in site observation? Are they also in May and July? 10. L638: differences are obvious also in Canada. It may be good to explain this too. 11. Sect. 3.2, Why not directly compare it with observations like in Fig. S2-6. It should be mentioned that negative bias in difference means less bias compared

to observation. Statistics on the mean biases from different schemes are important, and should be presented. For example, the 1:1 scatter plot compared to observations, which may quantify the improvements and disadvantages. 12. Fig. 10: mechanic scheme is worse compare to that of YL in northeast US. Can it be explained? 13. L717: please explain the exact regions and locations. 14. L752-753: it could be helpful to show the general performance on the dry and wet conditions used (simulated by other models). 15. L760: it may be good to indicate from literature the importance of manure management (e.g., compared to N fertilizer) in these regions. 16. It is the first process-based scheme in a photochemical model. But authors may need to mention where this kind of mechanisms have been used before (e.g., crop models, terrestrial vegetation models, etc.), and the advantages.

Minor remarks: L346: Wang et al.: please provide the year of this publication. L457: NH4+?

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