Geosci. Model Dev. Discuss.,
https://doi.org/10.5194/gmd-2019-233-RC1, 2019

Geoscientific Model Development Discussions

Open Access

GMDD

Interactive comment

Interactive comment on "An improved mechanistic model for ammonia volatilization in Earth system models: Flow of Agricultural Nitrogen, version 2 (FANv2)" *by* Julius Vira et al.

Anonymous Referee #1

Received and published: 23 September 2019

This manuscript aims to update the process model FAN to version 2 (FANv2) through including more detailed information on both physical and agricultural processes and use FANv2 to simulate ammonia volatilization from agricultural systems globally. Through modeling both fertilizer and manure application in agricultural lands, the authors provide updated numbers compared with that reported by FAN. Although this study is not innovative and with some flaws, it does make a significant contribution to the simulation of agricultural NH3 emission.

Main comments: 1. Why did not you consider plants (crop or grasses) in your model? If you have ignored the interaction between crops, does it mean NH3 emission from

Printer-friendly version

Discussion paper

different crops is only related to the fertilizer or manure application and its soil property? For different crops, do you use different parameters to calibrate your NH3 emission module? In page 2, line 29: 'FANv2 makes use of the interactive crop model included in CLM (Lawrence et al., 2019; Lombardozzi et al., 2019) to determine the timing and amounts of fertilization appropriate to each crop.' Please at least indicate the total amount of annual N fertilizer application in the main text. Also, does the timing of fertilization you mention vary with crop type? Only consider one-time fertilization? In page 3, line 20: 'Each crop type, in contrast, corresponds to a single soil column. Since the primary input variables in FANv2 are related to N cycling and hydrology in the CLM, FANv2 is introduced into the CLM sub-grid structure on the soil column level.' I cannot understand what you mean. Also, it seems that your NH3 emission module is kind of isolated even though you use existing parameters in the CLM (e.g., soil column, the timing of fertilization, etc.). In page 4, line 1: 'FANv2 does currently not interact with the base nitrogen cycle in CLM, and the effects of microbial immobilization and plant uptake of fertilizer and manure N are therefore not simulated.' If there is no interaction with crops when you apply fertilizer or manure, how can your FANv2 realistically simulate agricultural nitrogen flows? In page 9, line 1: 'FANv1 applies a 60 % reduction to the emissions to account for the NH3 captured by plant canopy; this reduction is included in the flux shown in Fig. 2a.' I expect how the updated FANv2 deals with N flows when considering the interaction with plant dynamics.

2. The authors miss the description of input datasets. In page 2, line 33: 'In this study FANv2 is run globally within the CLM for the six-year period 2010–2015 to simulate the present-day NH3 emissions, which are then compared with existing global and regional inventories.' Moreover, you mention NH3 emission is sensitive to climate change, but I did not find any information on climate conditions. The authors should add one more table listing the input datasets that were used to drive FANv2. Meanwhile, you need to mention that N input data are only for one-year. Even though you only cover 6 years' simulation, the temporal changes in N input amount, especially at the regional scale, may introduce the uncertainty when you compare your results with existing global and

regional inventories.

More specific questions: 1. Page 2, line 5: Here, you should at least cite articles to support your statement. Moreover, in Xu et al. (2019), they have considered the interaction between atmosphere and soils to investigate the effect of meteorological forcing.

2. Page 2, line 10: Please cite Xu et al. (2019) as well since they also emphasized the importance of environmental factors.

3. Page 4, line 16: Why 2.4 days? Any explanation for this assumption? You need to add citation here.

4. Page 5, line 21: Actually, it is not reasonable to use a constant Kd to deal with ammonium adsorption in soils.

5. Page 11: What is the time step for your simulation? Is it in second (s)? How did you get hourly, daily, monthly, and annual NH3 emission from s? Is there any assumption behind it? By the way, you mentioned an assumed 2.4 days for urea hydrolysis. How does the model deal with the 2.4 days reaction since your simulation is at second time step, right?

6. Page 18, line 6: Do you mean FANv2? I am confused with this sentence 'Since FAN assumes that fertilizers are applied in dry, granular form, no soil moisture perturbation is assumed for the fertilizer N pools. However, similar to urine, the formation of ammonium in urea hydrolysis increases the soil pH.' If there is no soil moisture effect, how does soil water content affect the NH3 volatilization?

7. Page 20, line 31: One time only for each crop?

8. Page 21, line 12: 'The CLM simulations were run in the satellite phenology mode and forced with the Global Soil Wetness Project Phase 3 (GSWP3) meteorological data set (http://hydro.iis.u-tokyo.ac.jp/GSWP3).' The model comparison project covers the time period of 1850-2010; however, this study focuses on the period of 2010-2015. Did

you use climate data in 2010 to run the model for 2010-2015? Please clarify it.

9. Page 23, figure 5: Did you check the effect of different levels of fertilizer or manure? Why did you only include one site in China? What is the unit in this figure?

10. Page 27, figure 9: Can you explain why the fraction volatilized in urea is highest in Southern Africa as well as Northern Africa?

11. Page 27, figure 10a: Why is it shown the highest fraction of NH3 volatilization in the desert Africa? As I see, it seems there is little manure there in Figure 1 in the supplement. Why is it shown the highest fraction of NH3 volatilization in Africa and South America in figure 10b? Moreover, it seems the fraction is fixed for most of land areas. Please explain it.

12. Page 30, figure 11: Please indicate the time period. Also, please indicate the version of EDGAR that you used for comparison and add the citation here.

13. Page 30, line 9: 'mainly due to increased emissions from manure management and grazing'. Please check it carefully. Is there any data to support it?

14. Page 30, line 13: 'Also losses for fertilizers differ between the versions. FANv1 treated all fertilizers as urea, resulting in a higher total volatilization rate (19 %) for synthetic fertilizers than FANv2 (13 %). However, the mean volatilization rate for urea in FANv2 is 19 %, which is similar to FANv1.' You described how FANv1 deals with no crop interaction. In page 9, line 1: 'FANv1 applies a 60 % reduction to the emissions to account for the NH3 captured by plant canopy; this reduction is included in the flux shown in Fig. 2a.' Did you consider this percentage (60%) when you compared your current results with that from FANv1? If no, why yours are similar to that in FANv1 for NH3 emission from urea? Please clarify.

15. Page 31, line 10: Your higher emission is from manure. The canopy capture may be not the explanation.

16. Page 32, line 5-8: In this study, you simulated NH3 volatilization only covering 6

years. Climate change refers to a long-term change in weather. Thus, the author needs to put this into your future research even though you have conducted the sensitivity analysis to show how temperature and soil moisture can affect the NH3 volatilization processes. Please reorganize this sentence to describe what your model has done at the current stage.

17. Page 32, line 12: You mentioned that you used the local meteorological conditions to parameterize your model. Where did these data come from? It is necessary to add this information in Appendix B. Please add more detailed information on each site, such as longitude/latitude, soil type, crop type, annual temperature, annual precipitation, etc.

18. Page 32, line 17: 'In particular, livestock manure is treated everywhere as a slurry, which is likely to lead to uncertainties in developing countries where handling manure as slurry is uncommon'. Any citation?

19. Page 33, line 3: 'It is difficult to isolate any particular factor that causes FANv2 to underestimate the Chinese emission factors compared to the other inventories'. First, you only include one site in China, which may cause the underestimate. Second, did you check fertilizer and manure data and compare them with the previous study? It is possible that the amount of N inputs to Chinese agricultural soils differ a lot in different studies. Please at least state this here.

20. Page 33, line 10: Omission of rice paddies may lead to the underestimate. It has been reported that 90% of rice is cultivated in East, South, and Southeast Asia. Xu et al. (2019) claims that rice cultivation has become the largest source for NH3 emission due to its high rate of fertilization and warm temperature. Please at least discuss the important role of rice here.

21. Page 35, line 8-9: 'The model evaluates ammonia emissions interactively with the simulated atmosphere, and responds to both short and long-term variations in the meteorological forcing.' Throughout the main text, I did not see any long-term estimates of NH3 volatilization. You only reported the average annual amount for the period of

2010-2015. Also, the author did not report intra-annual estimates of NH3 volatilization. Please carefully state ‘both short and long-term variations in the meteorological forcing’ since these were not fully reported in the current study. By the way, I am curious about the intra-annual results. Is it possible to present your intra-annual results in the main text?

22. Page 35, line 23: It is odd to mention ‘This sensitivity includes the effect of increasing grazing and earlier crop planting dates in warmer climates.’ What is the relationship between this sentence and the sensitivity analysis? You did not consider these factors in the sensitivity test, right? Please reorganize it.

Reference Xu, R., Tian, H., Pan, S., Prior, S.A., Feng, Y., Batchelor, W.D., Chen, J., Yang, J. (2019) Global ammonia emissions from synthetic nitrogen fertilizer applications in agricultural systems: Empirical and processâĂŘbased estimates and uncertainty. Global Change Biology 25, 314-326.

Interactive comment on Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2019-233, 2019.