Reply on RC2

Maureen Beaudor et al.

Author comment on "Global agricultural ammonia emissions simulated with the ORCHIDEE land surface model" by Maureen Beaudor et al., EGUsphere, https://doi.org/10.5194/egusphere-2022-626-AC2, 2022

We thank Reviewer2 for his comments on our manuscript and the time spent on his reviews. Please find below a detailed point-by-point reply to the comments and suggestions to reviewer #2.

Our responses to the reviews followed the arrow. The text added in the revised version of our manuscript is in italics and the line numbers correspond to the first version of the manuscript.

Reviewer2

Comments

Areas identified for major improvements in order to be accepted for publication.

- Indoor ammonia emissions. Units for equations in this section (pages 8 and 10) need to be clear, particularly TAN related. Emission factors in Table 3 (many > 1) as factor of TAN and it is hard to understand why they are great than 1 from the units provided.

  --> We thank the reviewer for this clarification. Indeed, these units need to be corrected in the table caption (done). In Table 3, EF are presented as % of TAN content in the manure. However, in the equations, we converted the EF as kgN/kgTAN which corresponds to a proportion rather than a percentage.
- Soil ammonia emissions

- It is hard to understand the Zactivityparameter in equation 13 as it is on both side of the equation. How is TAN(soil,aq) related to this parameter? I would think deposition is surface application like fertilization despite that some fertilization is applied in deep soil to avoid surface runoff.

  --> We agree with the reviewer, we should rather express the Zactivity as a function of the time since it is updated at each time step.
  It is now corrected in the manuscript as followed: Zactivity(t) = X *Zactivity(t-1) .
  The Zactivity parameter is more related to the N concentration in the liquid phase than strictly to the depth level at which N is applied. We fully agree deposition should be considered as a surface application. By default, we assume that the activity layer for N dynamic equals 0.2m. This assumes that all the TAN is located within this layer at a

given concentration depending on the soil water content. When applying fertilizer and manure, we have information on their specific N concentration that we directly use to set the pzact_surf variable. For NHx deposition, currently, we have no data regarding the specific water volume of NHx deposition and no information either on how to treat dry and wet deposition. As a consequence, we prefer not to specify any particular parametrization regarding its concentration and instead use the default parametrization.

- The ammonia flux equation (16) is bi-directional depending on the free-atmosphere concentration which changes seasonally and diurnally. It is too crude to use monthly field averaged over 11 years from the global run (LMDZ-INCA) for its 30min simulation (acknowledged in the conclusion). Although the sensitivity test on this field did not show significant change comparing the change in pH and days of fertilization probably due to averaging evaluation, it does not mean it is not important. Since this is a key parameter in flux calculation, more evaluation is needed. For instance, the paper needs to address how it treats negative and positive flux (16) (average or only count positive flux as emissions). How good is the free-atmosphere concentration – any evaluation comparing ammonia flux field measurement? Or, maybe one year simulation with the free-atmosphere concentration directly from the global run (not averaged) should be conducted to evaluate how it influences the soil emissions spatially and temporally.

  --> We know the uncertainties related to the fixed atmospheric concentration in the emissions calculation.
  In the paper's framework, ammonia emissions are estimated from an offline point of view through a surface model.
  In our current approach, N depositions are considered through the soil TAN pool, which is involved in the calculation of the gaseous NH3 concentration.
  However, no proper compensation point is implemented yet and only two resistances are represented (aerodynamical and quasi-boundary layer resistances).
  Since no coupling between the atmosphere and surface is not yet fully implemented around the N cycle, forcing ORCHIDEE by a fixed concentration is the most obvious option, as no interaction with the atmosphere exist. The monthly time-step has been chosen due to computational constraints. As a global land surface model, ORCHIDEE commonly receives monthly or annual forcing files (N fertilization, N deposition, BNF, CO_2 concentrations), except for the meteorological fields where a pre-processing work has been performed to adapt the data to the model.
  We are currently working on the coupling between LMDz-INCA and ORCHIDEE, both components of the IPSL ESM.
  In addition to the transmission of the hourly-calculated fields as N depositions and NH3 concentrations from the atmosphere to the surface, surface compensation points will be implemented to integrate more accurate bi-directional exchanges of NH3.
  Therefore, the influence of several key variables will be tested and compared against the offline mode.

- Constant pH. Giving the importance of pH in soil ammonia flux modeling – demonstrated in many publication (e.g. Pleim et al., 2019, JAMES), it seems that there is no reason to use a fixed pH in this global-scale modeling. Using the soil pH map directly would be a better sensitivity test than just changing it to another constant higher (7 to 7.5) – clearly high emissions expected.

  --> We thank the reviewer for this remark. We are aware of the simplification done by taking a fixed pH to calculate the NH3 volatilization.

Our understanding of the influence of the pH is linked to the modification of the soil pH after the application of N input and thus through the pH of the manure or fertilizer, as indicated in Massad et al., (2010).
In their paper, they also mention that depending on the fertilizer type, the pH of the solution might not be impacted by the soil pH (e.g, ammonium nitrate).
Despite the fact that ORCHIDEE is forced by annual soil pH maps, there is no update of the soil pH related to N input, and the soil pH can be much lower than in reality.
To be more realistic we should consider the perturbations in pH since the N addition passes, and their magnitudes depend on the type of manure or fertilizer as described in Vira et al., (2019).
However, this implementation is complex and is not part of the N cycle that we aimed to improve in this paper.

- Figure maps are too small and have color scales difficult to see the regional differences (figures 2, 4, 5, 6, 8, 11, 13 and those in the supplement). --> done

More specific minor comments are listed below:

- Spell out acronyms in the abstract (e.g., ORCHIDEE, USA, CTM, CEDS). --> done
- Spell out acronyms in the main text (e.g., CEDS and EDGAR in line 59, FAN in line 74…, and many others). --> done
- Not all grassland is for grazing or hay production. How does the system differentiate grassland in the grid cell to be natural grassland or for agricultural production? This is related to whether all grassland in the grid cell receive fertilization – both manure and synthetic.
ORCHIDEE does not differentiate natural from managed grassland.

  --> It is exact, only grid cells either with the presence of livestock or fertilizer application are considered for the emission calculation, so we can assume that the pixel is managed.
  Following sentence is added L.183:
  Please note that ORCHIDEE does not differentiate natural from managed grassland.
  Only grid cells either with the presence of livestock or fertilizer application are considered for the emission calculation, so we can assume that the pixel is managed.
- How does the system constrain each grid-cell's effective crop biomass by the global crop harvested NPP – explain more (lines 175-176)?

  --> We compute the ratio between the global effective crop biomass and the global crop harvested NPP (HI) at a yearly time-step. When HI >1, we impose the same constraint to the global effective crop biomass at each grid cell by dividing to HI. However, this condition never occurs in this simulation and it is rather considered as an indicator, especially for future scenarios where the biomass simulated by ORCHIDEE can be a constraint to support future livestock.
  The following sentences has been added to lines 177-178 :
  To do so, we compute the ratio between the global effective crop biomass and the global crop harvested NPP (HI) at a yearly time-step.
  When HI>1, we impose locally the same constraint by dividing the effective crop biomass by HI.

- N by plant uptake in the agricultural land is the biggest out pathway for N leaving the field (e.g., Ran et al., 2019, JAMES). The paper needs to address how N uptake is handled for fertilized cropland and grassland.

  --> We thank the reviewer for suggesting information about plant N uptake. Plant N uptake is modeled based on the work of Zaehle et Friend (2010). Plant N uptake is modeled as a function of N available in soil but also of root biomass. The more N in

soils or the more root biomass, the higher the plant N uptake. The plant N uptake modeling accounts for also information regarding the plant N status leading to higher N uptake for N starvation conditions.
Following sentence is added line 110:
TAN pool is also updated according to plant uptake as described in Zaehle et Friend (2010)

- N fixation is associated with specific grassland (e.g. alfalfa) and cropland (e.g. soybean). Does the data used in the system target the N fixation grassland or cropland (lines 343-344)?

  --> Thanks for the comment. Indeed, in our modeling framework, BNF is only considered for natural ecosystems, not for managed ones. Consequently, BNF implied in leguminous systems such as alfalfa or soybean are not considered. This potentially may limit plant productivity for regions with no use of synthetic fertilizers and where leguminous species are important.
- Many question marks in the text (e.g., lines 415, 417, 613, 618…) – correct them. --> done