Response to Anonymous Referee #1

Overall response: We would like to thank reviewer 1 for these insightful and useful comments. These help improve the manuscript. Here we outline the point-by-point responses below in blue, and the relevant figures are attached.

Comment: The paper represents the second part of the description of the AMmonia-CLIMate (AMCLIM) model for quantifying ammonia emissions specifically from livestock production responding to environmental conditions and agricultural practices. The model which incorporates a high level of detail is well described in general and seems to perform well compared to observations and also to previous global-scale estimates. A serious and appropriate sensitivity analysis is also conducted confirming the important role of pH in the emissions.

The strength of the approach lies in the diversity of agricultural practices data and a detailed representation of ventilation scheme in the housing that are considered for ammonia emissions.

The study will likely provide a major advancement for the community especially for designing precise mitigation strategies for NH_3 losses but I have some comments before it can be considered for publication.

Reply: We appreciate that the reviewer recognizes the value of our study. We thank the reviewer for spending time reviewing the manuscript and the development of the AMCLIM model.

Comment: I believe it is crucial in the introduction to put the AMCLIM approach in the state-of-the-art modeling context for ammonia emissions from agriculture. From l.51, this part can be more developed/precise to highlight the strength of AMCLIM. For instance, global processed-based models included in Land Surface Models (LSM) such as FAN v2 in CESM (Vira et al., 2020) and CAMEO in the IPSL ESM (Beaudor et al., 2023) in which detailed soil C/N cycles are implemented with multiple interactions (vegetation, soil BGC, water, and energy budget) also incorporate agricultural practices (by livestock type) and run with dynamic environmental conditions at the global scale. However one of their weaknesses is to rely on Emission Factors (EF) for the manure management part. I think it would be helpful to mention it in the introduction because AMCLIM is an interesting trade-off between process-based models/ Earth System Models and more socio-economic models such as the Integrated Assessment Models (IAMs).

Reply: We agree with the reviewer. We improved the text to highlight the state-of-art of AMCLIM for simulating agricultural NH_3 emissions. From L61, we added

“A process-based, dynamical emission model, AMmonia–CLIMate (AMCLIM) has been specifically designed that incorporates the effect of both environmental conditions and management practice to simulate agricultural NH_3 emissions. Compared with existing process-based models, AMCLIM is thought to be the first model that simulates NH_3 emission from both synthetic fertilizer use and livestock farming using a consistent process-based modelling approach, with high levels of detail of the representation of agricultural practices. There are other process-based models, such as the ‘Flow of Agricultural Nitrogen’ model, version 2’ (FANv2; Vira et al. 2020) that simulates agricultural NH_3 emissions interactively within the Community Earth System Model (CESM) with detailed soil processes for land application of fertilizers and ruminant grazing. Another is the ‘Calculation of AMmonia Emissions’ model (CAMEO), which includes several management modules for livestock feed, manure management and agricultural handling practices within the global land surface model ORCHIDEE (Beaudor et al., 2023). While these models still largely rely on emission factors (EFs) for estimating NH_3 emissions from livestock sectors, AMCLIM explicitly models the N flows within the systems and includes several major N processes. AMCLIM uses an integrated approach to simulate how various N species are influenced by environmental factors in a sequence of the practices in the livestock sector, from livestock housing to manure management and ultimate application of manure to fields, as well as ruminant grazing. By following this sequence in AMCLIM, changes in emissions at an early stage of livestock agriculture influence the simulated N pools, and can thereby affect emission at a later stage of these activities. The simulations for global synthetic fertilizer use have been presented in the companion paper (Jiang et al, 2024).”

Comment: It is hard to get the global picture of the results of the different NH_3 volatilizations; the "per grid" unit for the emission flux distributions (Fig 7-11) is not common and it is hard to compare with other literature results (which are usually given by /m2). Since the spatial resolution of the model is also not clearly stated, it is almost impossible to compare it with any other results. I know that the Part 1 paper also presented the ammonia flux in that unit and maybe for consistency reasons, the authors would like to stick to that unit but a clear justification should be included.

Reply: We thank the reviewer for pointing this out. The global maps of NH_3 emissions have a unit of Gg N yr^{-1} $grid^{-1}$. The resolution for all simulations is the same, that is 0.5° x 0.5°. We improved the manuscript by adding the following text from L492

“Global simulations were performed to estimate NH_3 emissions from livestock farming for the year 2010 and 2018, and had the consistent setup as simulations for synthetic fertilizer use, as described in the first part of the model (Jiang et al., 2024). AMCLIM was applied using a longitude–latitude grid at a resolution of 0.5° × 0.5°. All model inputs were regridded to the model resolution if necessary. The simulations were performed at an hourly time step, and the prognostic variables at each time step were solved by the Euler method in the model."

Comment: On the same topic, to ease the comparison with other global results, one suggestion would be to include a global map of the combined synthetic fertilizer and livestock emissions (i.e. total agricultural sources) in the common units: gN/m2/yr. This map could be shown as a final result?

Reply: To address the question of units, we have now added a final map of total NH_3 emissions from livestock in units of gN/m2/yr as requested (see below; Figure 14 in the revised manuscript). However, the synthesis of emissions from livestock and fertilizers is part of another planned publication, and we think it better to present that map there as part of a discussion of global agricultural ammonia, rather than to risk duplication.

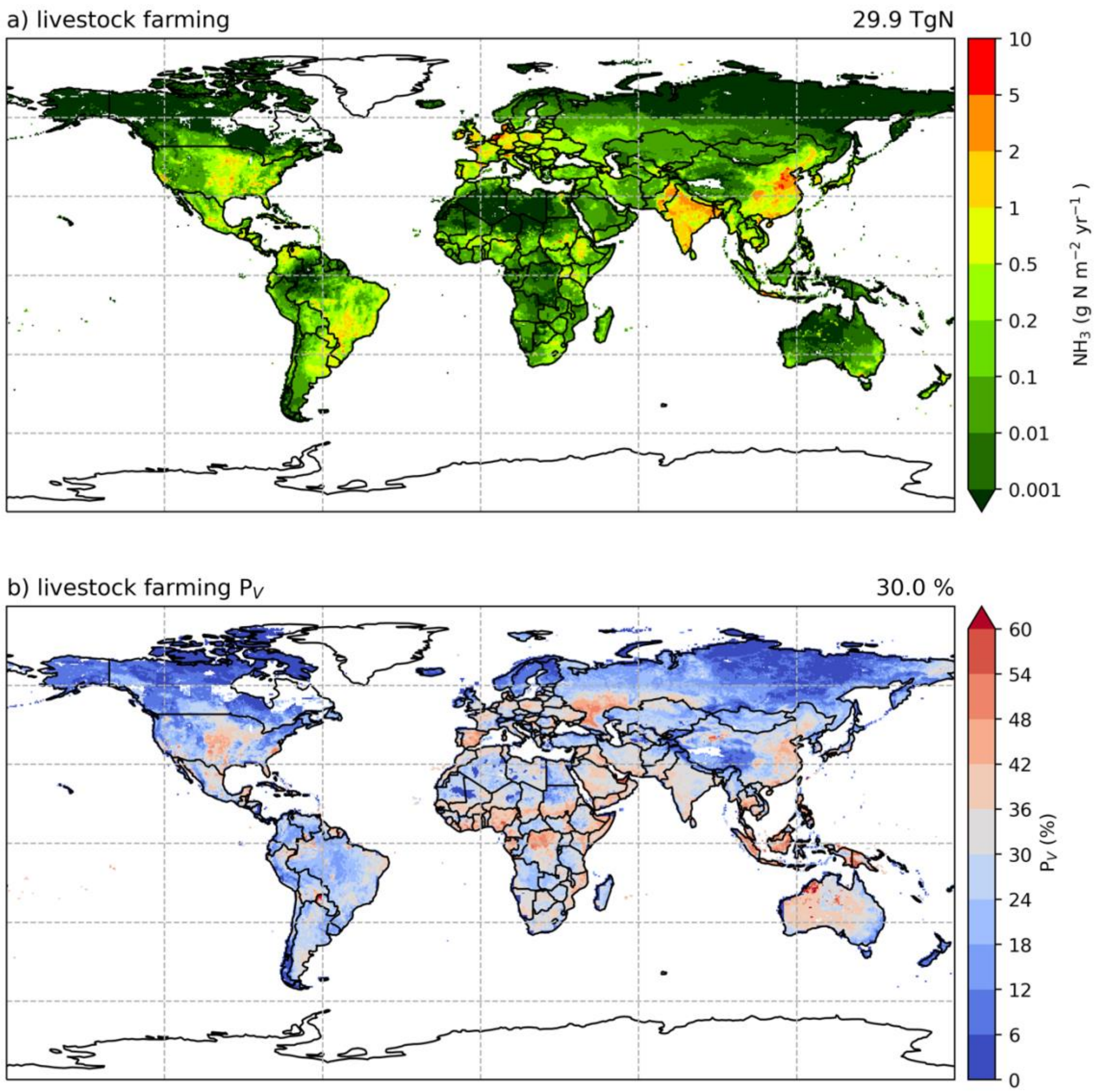


Figure R1-1. Simulated (a) annual global NH_3 emissions (gN m^{-2} yr^{-1}) from livestock farming (including housing, manure management, land application of manure and grazing) in 2010. (b) Percentage of total livestock excreted N that volatilizes (P_V) as NH_3 in 2010. The resolution is 0.5° × 0.5°.

Comment: The 2-year (2010 vs. 2018) comparison needs to be justified earlier in the manuscript and I am missing a description of the input that has been used for 2018. The setup for this experiment is not properly described in the Methods. Is the livestock distribution dataset for 2010 vs. 2018 the same? How the 2010 year inputs have been extrapolated?

If the meteorological impact is the major reason behind the 2-year comparison maybe the title of section 4.4 could be more explicit.

Please consider that 2018 results already appear in the previous sections when describing the maps of the volatilization rates.

Reply: Livestock inputs for 2010 and 2018 are different. Livestock and MMS data for the year 2010 were obtained from the FAO GLEAM model. We applied the interannual variability between 2005 to 2015 reported by Lu and Tian (2017) and extended to year 2018 by a linear interpolation. The meteorological inputs were from ERA5 reanalysis datasets for both years. To address the reviewer's comments, we made the following changes for the revised manuscript, from L455

"In the present paper, the combined AMCLIM model was applied for 2010 and 2018 to demonstrate full simulations for two different years, with activity data and meteorological variables varied between years, so that the inter-annual variability in both emissions and volatilization rates can be analysed."

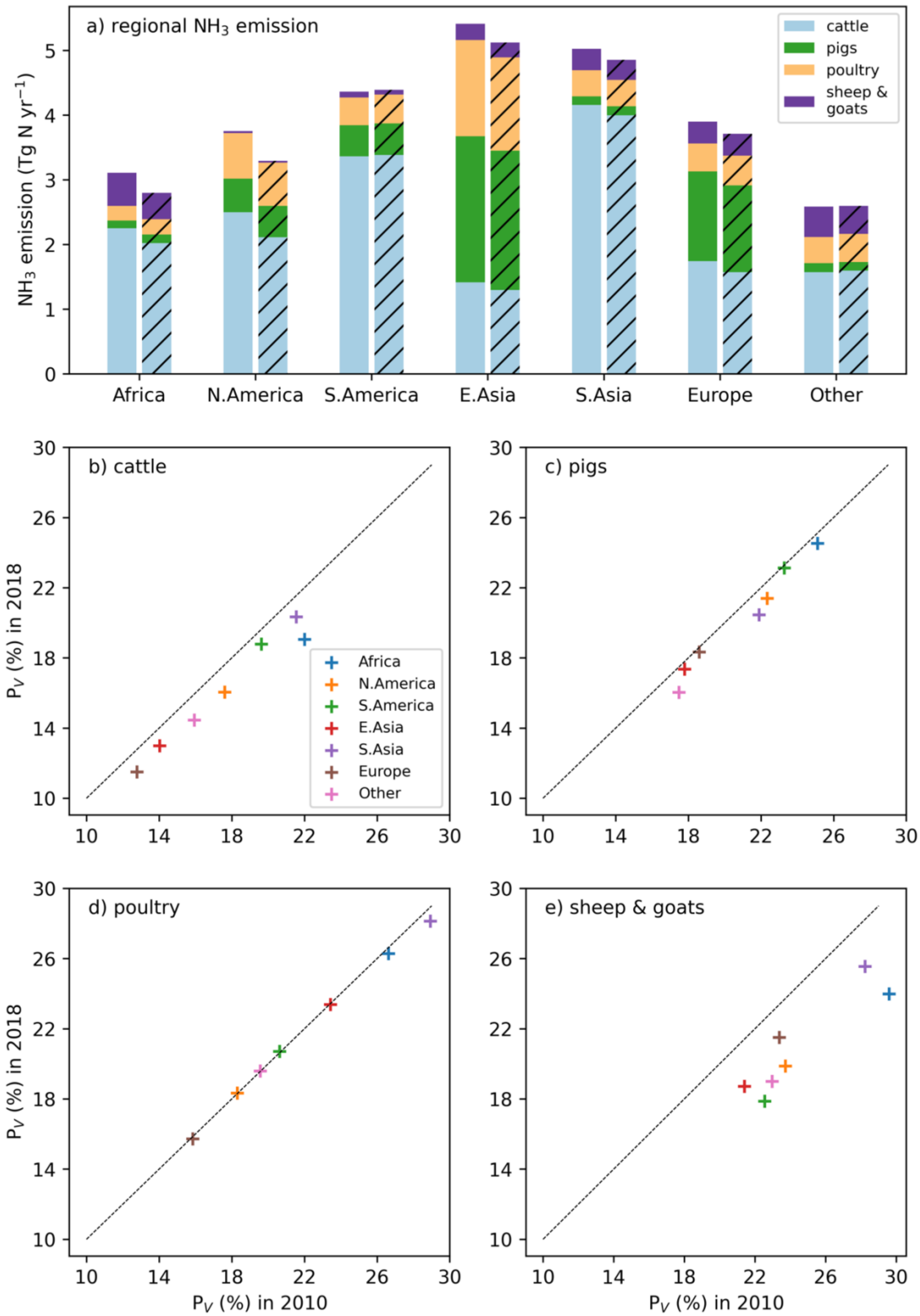
and from L466

"…The reference year of these data is 2010. For simulations for the year 2018, livestock population and N excretion rates were extended by a linear interpolation based on the inter-annual variations between 2005 and 2015 suggested by Lu and Tian (2017). The MMS data that determines the fraction of a manure management system are assumed to be constant through the year."

Comment: The maps related to 2018 are in the Appendix, this makes the manuscript somehow very heavy for the reader to do this back and forth (especially for 6 maps x 3 animal types). Is there any way to combine these results maybe in a histoplot by region instead of multiple maps?

Reply: Here we provide a histogram as suggested by the reviewer to show the yearly difference of NH_3 emissions from the livestock sectors across different geographical regions, together with simulated volatilization rates for all livestock groups. We have added this as a new Figure 15 to the main text of the paper. We added the following texts from L901

"As shown in Fig. 15, NH_3 emissions and volatilization rates vary across different geographical regions and between two simulated years. The highest NH_3 emissions from livestock agriculture are estimated to occur in East and South Asia. In general, the volatilization rates for livestock are lower in 2018 than 2010, except for poultry. This is because a large fraction of poultry which are broiler and layer production systems are assumed in the model to be kept in houses with controlled temperature and ventilation, so the P_V rates were less impacted by the differences in environmental conditions between years. By comparison, the P_V rates from sheep and goats show the largest inter-annual variability among all livestock groups because sheep and goats typically graze outside and are housed in naturally ventilated barns. As a result, NH_3 volatilization from sheep and goats is more dependent on the environmental conditions than poultry. The differences in housing and grazing management also explain why P_V rates from pigs showed the second smallest difference and cattle showed the second largest difference between the two simulated years."



a) regional NH_3 emission
NH_3 emission (Tg N yr^{-1})
cattle
pigs
poultry
sheep & goats
Africa
N.America
S.America
E.Asia
S.Asia
Europe
Other
b) cattle
c) pigs
d) poultry
e) sheep & goats
P_V (%) in 2018
P_V (%) in 2010

Figure R1-2. Estimated (a) NH_3 emissions from livestock farming in seven geographical regions for the two studied years, 2010 (left) and 2018 (right, hashed), and comparisons of volatilization rates P_V between the two years for (b) cattle, (c) pigs, (d) poultry and (e) sheep and goats.

Minor comments:

Comment: Fig 1: I think representing the NH_3 losses on that schematic would be useful

Reply: We would like to keep Fig. 1 the same as the companion paper (Jiang et al., 2024).

Comment: L. 174 : Is there any difference between $F_{NH3\ volatilization}$ and F_{NH3} throughout the equations?

Reply: No, $F_{NH3\ volatilization}$ and F_{NH3} are the same. We removed $F_{NH3\ volatilization}$ in the revised manuscript.

Comment: L.190 : I think the pH variation with the different processes would be interesting to describe. Perhaps a little paragraph explaining its drivers would be beneficial since it is a critical parameter admitted by the authors and known by the community.

Reply: We added the following paragraph to the revised manuscript from L219

"As discussed in the companion paper (Jiang et al., 2024), substrate pH is a critical factor that impacts the NH_3 emission. The dynamic equilibrium between gaseous NH_3 and aqueous ammonium is dependent on pH. On the other hand, pH affects the rates of uric acid hydrolysis and nitrification, which together control the TAN pool. In AMCLIM, the pH of the livestock excretion is used for determining the decomposition rates of N species and chemical equilibria in housing simulations."

Comment: L.343 : I am not sure this reference is well placed in the context

Reply: We updated the revised manuscript from L382

"In AMCLIM–Land, ruminants in the grassland production system are assumed to graze year-round, whereas those in the mixed production system graze seasonally. This assumption has been made in the FANv2 model (Vira et al., 2020) and was used here."

Comment: Section 2.52 : I think a table gathering information on the different inputs used for the global scale (for both 2010 and 2018) and site simulations would be useful

Reply: Here we added a new table that summarises the input data used for both the site and global simulations.

Table A4 Model inputs for site simulations and global simulations. *The reference year of these data is 2010, and changes in livestock population and N excretion rates over time are based on the variations suggested by Lu and Tian (2017) to derive livestock data in year 2018.

	Environmental variables	Activity and management data
Site simulations	indoor and outdoor temperature, relative humidity and ventilation from US EPA AFO datasets (Lim et al., 2010a; Wang et al., 2010)	animal number, biomaterial information, animal house information and management events from US EPA AFO datasets (Lim et al., 2010a; Wang et al., 2010)
Global simulations	ERA5 reanalysis meteorological variables and soil data from HWSD v1.2 as described in Jiang et al. (2024)	*livestock population, distribution, N excretion, production systems and manure management systems from FAO GLEAM model, FAOSTAT and GLW model.

Comment: L. 408: What are the spatial and temporal resolutions of the model?

Reply: For global simulations, AMCLIM was applied using a longitude–latitude grid at a resolution of 0.5° × 0.5°. All model inputs were regridded to the model resolution if necessary. The simulations were performed at an hourly time step, and the prognostic variables at each time step were solved by the Euler method in the model.

We have clarified this in the manuscript at the end of Section 2.5 from L492, as follows:

"Global simulations were performed to estimate NH_3 emissions from livestock farming for the year 2010 and 2018, and had the consistent setup as simulations for synthetic fertilizer use, as described in the first part of the model (Jiang et al., 2024). AMCLIM was applied using a longitude–latitude grid at a resolution of 0.5° × 0.5°. All model inputs were regridded to the model resolution if necessary. The simulations were performed at an hourly time step, and the prognostic variables at each time step were solved by the Euler method in the model."

Comment: L. 486: What could be a reasonable explanation for these discrepancies?

Reply: There are a few possible explanations for these differences. First, modelled NH_3 emissions were higher than the measurements for summer months in both 2008 and

2009, corresponding to higher simulated TAN (and total N) concentrations of the slatted floor and the pit (as shown in Fig. 4e) than the measured values. This is possibly due to underestimated evaporation in the animal house by AMCLIM. The underestimation of NH_3 emissions in Jan 2009 might be caused by a different reason because the modelled TAN concentrations were comparable to the measurements (as shown in Fig. 4e). This indicates that the calculated indoor resistances that constrain the volatilization of NH_3 in AMCLIM may be overestimated.

We have clarified these points by updating the following in Section 3.1.1 from L559

"…However, it underestimates the winter emissions (January 2009) by 30 %, which might be caused by overestimated resistances because the simulated TAN concentrations were comparable to the measurements (Fig. 4e). AMCLIM overestimates the summer emissions (June 2009 and July 2009) by a factor of two (Fig. 4c), corresponding to higher simulated TAN and total N concentrations of the slatted floor and the pit than those of measurements (Fig. 4e). This is possibly due to underestimations of indoor evaporation in AMCLIM."

Comment: Section 3.2: Is there any logic behind the order of the animal types that are presented? I wonder why cattle are not presented first since they are responsible for the highest emissions.

Reply: The results for cattle (and sheep and goats) include NH_3 emissions from grazing, which has been described in the methods section after housing, manure management and land spread of manure. We would like to keep the same order in the results description. There is no specific logic behind the order of animals. We agree that cattle are responsible for the largest emissions from the livestock sector, but pigs and poultry farming also represent two major components.

We have addressed this in the manuscript by adding to the start of Section 3. From L649

"In the following sections, emissions are presented in the order of livestock housing, manure management and application of manure, while emissions from grazing are considered in section 3.3. As with the previous sections, pigs are presented first, followed by poultry, as representing a systems dominated by all-year animal housing. Then ruminants including cattle, sheep and goats are presented, as systems which are complicated by the widespread practice of partial-year housing."

Comment: Section 3.2.2: I would add a reference to the section where the new poultry emissions are compared to the older version. This would help the reader to understand that there is a dedicated section for that comparison.

Reply: We added a reference to Section 4.5 that discusses the comparison between new and old model version at the end of Section 3.2.2 from L695

"… Since the current model version has updated processes for simulating NH_3 emissions from poultry agriculture, a comparison of results between the current model version as described in this section and the previous model version by Jiang et al. (2021) is discussed in Section 4.5."

Comment: The title of Section 3.3.2 could be a bit more precise: "Comparison of grazing NH_3 emissions with observations" ?

Reply: We changed the title of Section 3.3.2 to "Comparison of estimated grazing NH_3 emissions using AMCLIM with observations"

Comment: Section 3.4: For the N budget, I wonder if other N species were also taken into account. N_2O, N_2 and NO_2 emissions can also originate from manure. Even though these EFs are relatively small compared to NH_3, I think it is important to mention them for a consistent N budget. I invite the authors to have a look at studies from Sommer et al., 2019 and EMEP/EEA 2019 for more information.

Reply: The N budget shown in this manuscript does not include N_2O, N_2 and NO_2 emissions because the present version of AMCLIM does not simulate denitrification process (and N_2O from nitrification), as presented in Fig. 2 in the companion pager (Jiang et al., 2024). These fluxes are considered to be implicitly represented by the total nitrification term. We clarified this in the revised manuscript. Here we made the following changes from L857

"Figure 13 summarizes the simulated N flows of global livestock farming for the reference year 2010 by AMCLIM, which are allocated to housing, manure management, and application to land, with a focus on NH_3 emissions. Other simulated nitrogen pathways include surface runoff, nitrification, leaching and diffusion to deeper soils, uptake by plants and amount left in soils. As specified in the description of soil processes in AMCLIM (Jiang et al., 2024), denitrification and emission of NO, N_2O and N_2 are not explicitly included in this study. The flux of "nitrification" in the N budget simulated in this study can be seen as a sum of both nitrified and denitrified N, with the amount of all relevant species (NO, N_2O and N_2) being included."

We agree that the studies of Sommer et al. and EMEP/EEA 2019 are useful on how to consider such interactions further.

Comment: L. 806: Please explain what is the GUANO model.

Reply: GUANO model is a process-based model designed for simulating and predicting NH_3 emissions from a source of seabird-derived uric acid (Riddick et al., 2017).

Accordingly, we have now revised the text to note, with new text added from L930:

"AMCLIM has been developed based on prior testing for chicken houses (Jiang et al., 2021), with the model principles building on the earlier simulation approach of the GUANO model (Generalisation of Uric Acid Nitrogen emissions), a process-based model designed for simulating and predicting NH_3 emissions from a source of seabird-derived uric acid, which has been tested in relation to measurements from seabird colonies (Riddick et al., 2017)"

Comment: Section 4.2: The GLEAM model and estimated EF from Yang et al would benefit from a little description. I wonder how the AMCLIM EF also compares with EFs from EMEP/EEA or Sommer et al., 2019 both specific to Europe and sometimes applied to the whole globe in several process-based models (Vira et al., Beaudor et al.,). In the study from Sommer et al., 2019, they also analyzed the EFs of the ALFAM2 process-based model (given as % of TAN content in the manure applied) by season and livestock type which could be interesting to compare.

Reply: As suggested by the reviewer, we present a new table (Table R.1.2 shown below, that is now included as new Table 4 in the revised manuscript. This table compares the simulated EF (expressed as % of TAN) by AMCLIM with EFs reported by EMEP/EEA and Sommer et al. (2019).

We have added the following text to the manuscript to clarify the main messages of this table from L975

"Table 4 compares the simulated EF (expressed as % of TAN) by AMCLIM with EFs reported by EMEP/EEA (2019) and Sommer et al. (2019). The table summarizes both global mean and EU mean EFs, with range of EFs between the 10^{th} and 90^{th} percentile of both spatial scales. As shown in Table 4, estimated EFs for livestock housing and manure application to land by this study are generally comparable to the values from literature and reports. The EFs of manure storage derived from AMCLIM simulation are often lower than EMEP/EEA (2019) and Sommer et al. (2019), while the grazing EFs are higher than previous studies. As noted in Sect.3.3.2, the simulated volatilization rates of AMCLIM may be higher than other studies, since AMCLIM estimates gross emission, without accounting for canopy recapture, that can be significant for grassland contexts, especially in wet climates (Massad et al., 2010; Sutton et al., 2013). For housing, AMCLIM did not differentiate slurry from solid manure for ruminants. The largest difference is from broiler housing, the EF of which is as two times as reported. Although estimated EFs for manure storage in this study are low, the AMCLIM model showed that slurry storage typically had lower EFs than solid manure, which is consistent with EMEP/EEA. Both this study and EMEP/EEA (2019) agreed that the highest EFs are from manure application among the four practices. However, AMCLIM also takes other organic N other than urea into account. The organic N from dung can be a slow but significant source to the TAN pool as a result of mineralization. In all AMCLIM simulations, NH_3 emissions volatilized from the TAN pool were not differentiated from urea N or other organic N. In order to include this effect for the comparison, a set of correction factors were applied to the total N to obtain the amount of TAN. It is assumed that the TAN amount is the sum of urea fraction and half of the organic N fraction (the "available organic nitrogen compound" assumed in the model, which accounts for 50 % of organic nitrogen other than urea; see Supplementary Materials Sect.S2) of livestock excreta. As a consequence, estimated EFs are more robust for housing and grazing in terms of NH_3 lost as percentage of TAN compared with manure storage and application to field because the quantities of different N forms in latter stages are more uncertain and difficult to estimate. On the one hand, it has been argued that the EF method is not ideal for calculating NH_3 emissions due to its limitations in excluding the climate-dependence of NH_3. On the other hand, the EFs given as the percentage of TAN do not explicitly include the organic N input from manure, which might result in either overestimation or underestimation in NH_3 emissions, depending on the activity data used."

Table R1-1. Averaged simulated NH_3 emission factors expressed as percentage of TAN for livestock based on the global simulations of AMCLIM compared with EMEP/EEA (2019) and Sommer et al. (2019). [*]Global mean EF. [**]Mean EF for Europe. Values in the brackets represent the 10th and 90th percentile of the 0.5°×0.5° resolution values, respectively.

	Livestock	AMCLIM	EMEP/EEA (2019) & Sommer et al. (2019)
Housing	Dairy	$19^{*,b}$(8 – 36); $13^{**,b}$(8 – 20)	24^{a}, 8^{b}, $9^{a,c}$, $19^{b,c}$
	Non-dairy	$15^{*,b}$(5 – 29); $8^{**,b}$(5 – 13)	24^{a}, 8^{b}
	Buffalo	$24^{*,b}$(7 – 39); $21^{**,b}$(8 – 25)	20^{b}
	Sheep & Goat	$28^{*,b}$(12 – 58); $25^{**,b}$(12 – 36)	22^{b}
	Pigs	$40^{*,a}$(21 – 68); $34^{**,a}$(25 – 48) $15^{*,b}$ (5 – 31); $13^{**,b}$(7 – 22)	$27^{a,d}$, $23^{b,d}$, $24^{a,e}$, $35^{b,e}$

	Chicken	45[*,b,f](32 – 58); 41[**,b,f](34 – 44) 36[*,b,g](19 – 55); 24[**,b,g](13 – 39)	41[a,f], 20[b,f], 21[b,g]
Storage	Dairy	12[*,a](4 – 26), 8[**,a](5 – 17) 25[*,b](5 – 55), 15[**,b](6 – 26)	25[a], 32[b]
	Non-dairy	6[*,a](3 – 47), 5[**,a](3 – 10) 24[*,b](3 – 52), 13[**,b](4 – 20)	25[a], 32[b]
	Buffalo	8[*,a](4 – 16), 8[**,a](6 – 13) 39[*,b](3 – 58), 31[**,b](4 – 25)	17[b]
	Sheep & Goat	23[*,a](18 – 20), 23[**,a](28 – 28) 36[*,b](15 – 47), 39[**,b](16 – 53)	32[b], 28[b]
	Pigs	14[*,a](3 – 40), 9[**,a](4 – 21) 27[*,b](4 – 66), 15[**,b](8 – 36)	11[a], 29[b]
	Chicken	27[*,b,f](4 – 64); 19[**,b,f](6 – 44) 8[*,b,g](<1 – 17); 5[**,b,g](2 – 10)	14[a,f], 8[b,f], 30[b,g]
Manure application	Dairy	51[*,a](31 – 75), 47[**,a](25 – 63) 56[*,b](29 – 69), 51[**,b](27 – 64)	55[a], 68[b]
	Non-dairy	48[*,a](25 – 70), 46[**,a](24 – 60) 50[*,b](25 – 65), 47[**,b](25 – 61)	55[a], 68[b]
	Buffalo	43[*,a](28 – 66), 43[**,a](36 – 66) 48[*,b](31 – 67), 47[**,b](39 – 68)	55[b]
	Sheep & Goat	43[*,a](32 – 55), 43[**,a](34 – 55) 49[*,b](21 – 62), 41[**,b](25 – 55)	90[b]
	Pigs	51[*,a](17 – 84), 43[**,a](20 – 67) 47[*,b](16 – 77), 45[**,b](21 – 63)	40[a,d], 45[b], 29[a,e]
	Chicken	61[*,b,f](19 – 95); 50[**,b,f](23 – 78) 50[*,b,g](17 – 93); 49[**,b,g](18 – 63)	69[a,f], 45[b,f], 38[b,g]
Grazing	Dairy	25[*](2 – 44); 16[**](<1 – 45)	14[EMEP/EEA], 9[Sommer]
	Non-dairy	26[*](2 – 44); 17[**](<1 – 43)	14 [EMEP/EEA], 9 [Sommer]
	Buffalo	37[*](2 – 42); 36[**](7 – 46)	14 [EMEP/EEA]
	Sheep & Goat	33[*](<1 – 46); 31[**](<1 – 45)	9 [EMEP/EEA]

[a]slurry
[b]solid manure
[c]tied housing
[d]finishing pigs (8-110 kg)
[e]sows and piglets (up to 8 kg)
[f]laying hens
[g]broilers

Comment: L.833: For the animal EFs taken from Yang et al., study, would you have any references for the data presented? I don’t see any precise reference in their paper but instead this description: “NH_3 EFs from different animal types were collected by keyword searches of above several databases, including “animal ammonia/NH_3 emission", "cattle", "buffaloes", "chickens", "ducks", "goats", "sheep", "livestock production" and "animal husbandry operations". "

Reply: We also do not have detailed references for the animal EFs as they were not provided by Yang et al. (2022). Only a summary of all collected EFs has been reported by the paper.

Comment: L.918: Please define FAN v2. In addition, a little description would be beneficial for the reader maybe in the introduction as suggested earlier.

Reply: We added the following text in the manuscript to briefly introduce both FANv2 and CAMEO model.

"…There are other process-based models, such as the 'Flow of Agricultural Nitrogen' model, version 2' (FANv2; Vira et al. 2020) that simulates agricultural NH_3 emissions interactively within the Community Earth System Model (CESM) with detailed soil processes for land application of fertilizers and ruminant grazing. Another is the 'Calculation of AMmonia Emissions' model (CAMEO) that includes several management modules for livestock feed, manure management and agricultural handling practices within the global land surface model ORCHIDEE (Beaudor et al., 2023)…"

Comment: L. 978: Please correct for "database".

Reply: We corrected the word "database".

Comment: L.982: I believe the sentence in parenthesis should not be there.

Reply: We removed the unnecessary sentence in the parenthesis and updated the text from L1232

"Other uncertainties in the land application have been discussed in the companion paper (Jiang et al., 2024), which also influence the grazing simulations, including: input data for soil characteristics (soil texture, pH and organic matter content), the representation of soil pH dynamic after urea deposition during grazing, and linear relationships used for calculating diffusive and drainage fluxes of N species."