

General comments

This manuscript presents a valuable year-long observational study of ammonia concentrations around three Swedish livestock farms representing poultry, pig, and dairy production systems. The study addresses an important topic, as agricultural ammonia emissions are a major contributor to nitrogen deposition, ecosystem impacts, and secondary aerosol formation, while long-term near-source concentration measurements around individual livestock facilities remain comparatively limited.

The manuscript is clearly within the scope of ACP as a measurement report. A particular strength is the combination of spatially distributed sampling around different farm types with a full annual cycle, allowing the authors to examine both spatial gradients and seasonal/management-related variability. The finding that NH₃ concentrations decline strongly with distance from livestock housing, remain elevated above regional background levels, and vary with temperature and management practices is useful for interpreting near-source NH₃ exposure and for improving the representation of agricultural NH₃ sources in inventories and local-scale assessments.

Overall, I find the manuscript suitable for publication after minor to moderate revisions. The core dataset is valuable and the main conclusions are generally well supported. However, several aspects would benefit from clarification, particularly the treatment of uncertainty, the statistical interpretation of temperature relationships, the representativeness of one farm per production system, and the use of “distance to nearest housing” as a proxy for source influence in complex multi-building farms. I also suggest broadening the introduction slightly to better connect the local measurements to the wider atmospheric relevance of anthropogenic NH₃ emissions.

Specific comments

1. Broader atmospheric context of NH₃ emissions

The introduction clearly explains the relevance of NH₃ for nitrogen deposition, ecosystem impacts, and PM_{2.5} formation. Around Line 50, where the manuscript states that ammonia contributes to fine particulate matter formation, the authors could slightly broaden this discussion by mentioning that NH₃ can also influence aerosol formation and aerosol–climate-relevant properties in the upper troposphere (you can cite this paper: <https://doi.org/10.1073/pnas.2506658122>). This would connect the near-source farm measurements more clearly to the wider atmospheric implications of agricultural NH₃ emissions.

Suggested text after Line 50:

“Surface ammonia emissions may also be transported to the upper troposphere, where they can enhance aerosol formation and influence climate-relevant aerosol properties (Xenofontos et al., 2025).”

Suggested citation:

Xenofontos, C., Kohl, M., Ruhl, S., Almeida, J., et al.: Global impact of anthropogenic NH₃ emissions on upper tropospheric aerosol formation, *Proceedings of the National Academy of Sciences*, 122, e2506658122, <https://doi.org/10.1073/pnas.2506658122>, 2025.

2. Representativeness of the three farms

The study includes one poultry farm, one pig farm, and one dairy farm. This is appropriate for a measurement report, but the manuscript should be careful not to generalize too strongly from one example of each production system. In several places, statements such as “poultry farms tend to...” or “dairy farms typically...” could be interpreted as broad conclusions about production systems in general. I recommend consistently distinguishing between findings from the specific farms studied and broader interpretations supported by previous literature.

For example, phrases such as “At the poultry farm investigated here...” or “In this study, the dairy farm showed...” would make the interpretation more precise.

3. Distance to nearest housing as a source proxy

The analysis uses distance to the nearest livestock housing as a proxy for source distance. This is practical and understandable, but each farm contains multiple housing units, likely with different livestock numbers, ventilation systems, and emission strengths. The manuscript notes this issue, but the implications could be discussed more clearly.

I suggest adding a short paragraph explaining how this simplification may influence the fitted distance–concentration relationships. For example, sites farther from the nearest building may still be influenced by another housing unit, manure storage, slurry spreading, or prevailing wind direction. If possible, the authors could also test whether using distance to the dominant housing unit, or excluding ambiguous sites, changes the main conclusions.

4. New calf housing at the dairy farm

The manuscript states that a new housing facility for approximately 400 calves became operational during the measurement period, but that the original distance to housing was retained for analysis. This choice should be justified more clearly. Since this change may alter the source configuration during the study, I recommend adding either a sensitivity test or a more explicit discussion of its possible influence, especially for the affected site.

5. Treatment of values below detection limit

The manuscript states that for some valid samples below detection limits, the detection limit value, or assumed values of 1 or 2 $\mu\text{g m}^{-3}$, were used. This approach may bias monthly or annual means upward, particularly at lower-concentration sites. Please clarify how many samples were treated this way for each farm and site, and consider including a sensitivity analysis using, for example, LOD/2 or excluding those samples. Even a brief statement that the conclusions are insensitive to this choice would strengthen the analysis.

6. Measurement uncertainty and replicate samplers

Two of the nine sites at each farm had triplicate samplers, which is useful for assessing measurement uncertainty. However, the manuscript would benefit from a clearer quantitative summary of replicate precision. For example, the authors could report the mean relative standard deviation or absolute difference among replicates, and indicate whether uncertainty varies with concentration level or site type. This would help the reader assess the robustness of observed gradients and monthly variability.

7. Statistical interpretation of temperature relationships

The temperature relationships are interesting, but the regression analysis appears to be based on a relatively small number of monthly values. The authors should report the number of points used, p-values and/or confidence intervals for slopes, and clarify whether the regressions are intended as statistical inference or as descriptive relationships. The exclusion of the April pig-farm point is reasonable if linked to slurry spreading, but the manuscript should show how strongly this exclusion affects the regression slope and R^2 .

8. Role of wind direction and wind speed

Wind direction is considered in the site selection and shown in the figures, but the analysis mainly focuses on distance and temperature. Since NH_3 gradients near point sources are strongly wind-dependent, the authors should discuss more explicitly how the monthly wind conditions during sampling periods may have influenced the observed concentrations. If the available meteorological data allow, a simple wind-sector analysis could be helpful, even if only qualitative. For example, were the highest monthly values generally observed at sites downwind of housing during that month?

9. Regional background and agricultural context

The manuscript notes that the pig farm may have higher concentrations at intermediate to far distances because it is located in a more agriculturally intensive region. This is plausible, but it would be useful to support this interpretation with additional information, such as regional livestock density, local emission inventory data, or land-use information. The background stations are 24–45 km away, and their representativeness for each farm should be discussed more explicitly.

10. Policy and inventory implications

The conclusions state that the measurements provide a basis for refining agricultural NH_3 emission inventories and supporting mitigation efforts. This is reasonable, but the manuscript should be more specific about how the dataset could be used for inventory improvement. Since the study measures concentrations rather than deriving emission fluxes, I suggest slightly moderating the wording or clarifying that the results mainly constrain near-source concentration gradients, temporal variability, and management-related emission signatures, rather than directly providing emission factors.

11. Figures

The figures are useful but could be improved for readability. In particular, the legends in the map figures are small, and the colours in the monthly time-series figure are difficult to distinguish. Please consider increasing font sizes, using a clearer colour scale, and ensuring that site numbers, distances, and farm types are easily readable. Figure 5 could also benefit from a more intuitive colourbar rather than many individual legend entries. Figure 3 caption can also outline exactly what the boxplot components mean i.e. horizontal line is the mean, the points are the outliers etc.

12. Conclusions

The conclusion is generally well aligned with the results. I recommend adding one sentence explicitly stating the main limitation: the study provides strong evidence for the three investigated farms over one

annual cycle, but interannual variability and broader representativeness across Swedish or European livestock systems remain open questions.

Technical corrections

- Line 37: “van Damme at al.” should be “van Damme et al.”
- Line 47: The sentence beginning “The quantitative threshold of nitrogen levels, critical levels...” is awkward. Consider rephrasing as: “The critical levels, below which no long-term harmful effects on ecosystems are expected, are...”
- Line 55: “have difficulties to achieve” should be “have difficulties achieving” or “struggle to achieve”.
- Line 56: Remove the comma after “IED 2.0”.
- Line 60: “Skiba et al., 2006: Jones et al., 2013” should use a semicolon rather than a colon.
- Line 67: “Pedersen et al., 2021: Kelleghan et al., 2021a” should use a semicolon.
- Line 80: Remove the period before the citation: “ecosystems (Sutton et al., 2009).”
- Line 83: “agricultural intensive area” should be “agriculturally intensive area”.
- Line 93: “offers possibility” should be “offers the possibility”.
- Line 94–95: “impacting” is repeated; consider rephrasing.
- Line 95: “the results offers” should be “the results offer”.
- Line 125: “Environmental Research institute” should be “Environmental Research Institute”.
- Line 175: “relative the source” should be “relative to the source”.
- Figure 2 caption: “Läntmetriet” appears to be a typo; use “Lantmäteriet”.
- Line 235: “Irland” should be “Ireland”.
- Please ensure consistent formatting of NH_3 , $\text{PM}_{2.5}$, $\mu\text{g m}^{-3}$, and m throughout the manuscript.
- Please use either British or American spelling consistently, e.g. “metres/meters”, “characterised/characterized”, “volatilisation/volatilization”.