

I read the manuscript titled “Performance and methodological evaluation of a quantum-cascade-laser photoacoustic aerodynamic gradient system for field-scale NH₃ flux measurements” with great interest. The work is highly relevant, as ammonia (NH₃) exchange plays an important role in public health due to particulate matter formation, represents a direct financial loss of fertilizer nitrogen for farmers, and contributes indirectly to global warming. I kindly ask the authors to consider the following comments and revise the manuscript accordingly.

General Comments

1. **Confidence in emission rate quantification:** Although the measurement setup successfully captured the expected diurnal cycle (higher emissions during daytime), it remains unclear how confident the authors are in the absolute emission rates derived from their measurements. The quantification performance of the QCL-based system is not explicitly validated against a known reference. Therefore, I recommend that the authors either (I) design an experimental verification of the system against a controlled, known ammonia loss, or (II) explicitly state in the manuscript that the reported values represent measurement-based quantifications rather than true emission rates, acknowledging this limitation.
2. **Inclusion of uncertainty ranges:** It would be highly beneficial to include uncertainty ranges for all quantified nitrogen loss values throughout the manuscript, including the abstract. This would greatly improve the interpretability and reliability of the reported results.
3. **Indirect climate impact:** The authors should briefly mention the indirect but important pathway by which ammonia volatilization contributes to global warming, namely through the subsequent formation of nitrous oxide (N₂O), a potent greenhouse gas with a global warming potential approximately 273 times that of CO₂ over a 100-year horizon.
4. **Financial loss context:** Quantifying the financial loss associated with fertilizer nitrogen volatilization would be highly valuable for readers from both scientific and applied agricultural backgrounds. Expressing the nitrogen loss in economic terms (e.g., USD or EUR per hectare) would strengthen the practical relevance of the study.

5. **Operational range of the measurement system:** The study reports a nitrogen loss of 4% due to volatilization under the specific experimental conditions. However, it is well established that this loss ratio can be substantially higher depending on farming practices, soil properties, climate, and fertilizer type. It would be valuable for the authors to discuss the measurable range of the QCL system, specifically, what is the lowest and highest ammonia volatilization rate that the system can reliably quantify?

Detailed Comments

L33: Uncertainty ranges are missing here. Please include a summary uncertainty analysis and report the range for all key quantifications (e.g., cumulative nitrogen loss, mean emission rates).

L62: In this paragraph, the authors could briefly discuss the indirect influence of ammonia volatilization on global warming via nitrous oxide formation. Additionally, consider adding a separate paragraph or extending the existing text to address the financial loss associated with nitrogen volatilization, preferably expressed in monetary terms per hectare, while acknowledging the key parameters that influence this loss (e.g., fertilizer price, application rate, soil conditions).

L119: How would the performance of the system be affected under conditions of low soil clay content? Such soils typically exhibit higher ammonia volatilization rates due to reduced cation exchange capacity. Does the system maintain the same sensitivity and reliability under higher ambient ammonia concentrations?

L123: The study applied 30 kg N ha⁻¹ as a single fertilization event. However, as noted by Adalibieke et al. (2023) and others, typical annual nitrogen application rates can be substantially higher, often reaching 200–300 kg N ha⁻¹ for high-demand crops. A key question arises: if the application rate were increased to, say, 300 kg N ha⁻¹, resulting in much higher ambient ammonia mixing ratios, would the current measurement system still perform reliably? Please discuss the dynamic range of the instrument and its suitability for measuring elevated ammonia concentrations.

L208: I would like to see an experimental validation of the system's performance against a controlled, known ammonia loss (e.g., in a laboratory chamber or a field release experiment). If such validation was not performed, please state this clearly as a limitation and, if possible, outline a proposed validation approach for future work.

L435: Please translate the reported nitrogen loss ($1.21 \text{ kg N ha}^{-1}$, 4.0% of applied N) into a financial loss, using current fertilizer prices. If appropriate, include this economic estimate in the abstract. Additionally, the measured 4% loss falls on the lower side of typical volatilization ranges reported in the literature, See other studies, e.g. Sommer et al. (2004). Please discuss whether the system would function properly under conditions that promote higher volatilization losses (e.g., 15–30%) and whether any saturation or non-linearity effects are expected.

Figure 1: Consider converting the x-axis from "half-hourly time steps (1–48)" to a more intuitive representation, such as "Hour of day (UTC)" or local time. Additionally, if possible, add additional panels showing other key measured parameters that influence volatilization (e.g., soil temperature, wind speed, relative humidity) to facilitate direct comparison with the diurnal flux pattern.

References

- Adalibieke, W., Cui, X., Cai, H., You, L., Zhou, F.: Global crop-specific nitrogen fertilization dataset in 1961–2020. *Sci Data* 10, 617. <https://doi.org/10.1038/s41597-023-02526-z>, 2023.
- Sommer, S. G., Schjoerring, J. K., Denmeard, O. T.: Ammonia Emission from Mineral Fertilizers and Fertilized Crops, *Advances in Agronomy*, Academic Press, Volume 82, [https://doi.org/10.1016/S0065-2113\(03\)82008-4](https://doi.org/10.1016/S0065-2113(03)82008-4), 2004.