Potential limitations of ammonia flux data beyond 72h after field application of slurry

Albrecht Neftel[1], Christoph Häni[2], Thomas Kupper[2], **Alex Valach**[2], and Sasha Hafner[3]

[1]Neftel Research Expertise, Switzerland
[2]School of Agricultural, Forest and Food Sciences, Bern University of Applied Sciences, Switzerland
[3]Department of Biological and Chemical Engineering, Aarhus University, Denmark

Summary

- The time horizon of the ALFAM2 model[1] for ammonia (NH_3) emissions is to be extended from 72h to 168h[2].
- Data show that emission rates after 72h strongly diminish (typically drop below the detection limit, LoD), which requires higher instrument sensitivity.
- Inspection of the database (v2.45) highlighted potential limitations for the validity of modelled emissions after 72h.
- Further quality control of the data is needed before modelled NH_3 emissions after 72h can be considered reliable.
- Datasets must provide details on detection limits, inflow concentrations, and post-processing, especially after 72h when fluxes are expected to be low.

Background and methods

- The ALFAM2 model[3] is widely used for emission inventory and regulatory modelling of NH_3 emissions.
- New model versions[4] (spreadsheet >v2.0) extend the modelled time horizon from 72h to 168h after slurry spreading.
- Existing data and instrument setups originally focussed on capturing high emission periods after application.
- Poor sensitivity of low fluxes after 72h could produce positive biases leading to overestimation of the total cumulative emissions up to 168h.
- We investigated the datasets beyond 72h used for parameter estimation and the accompanying publications to evaluate data robustness and suitability.

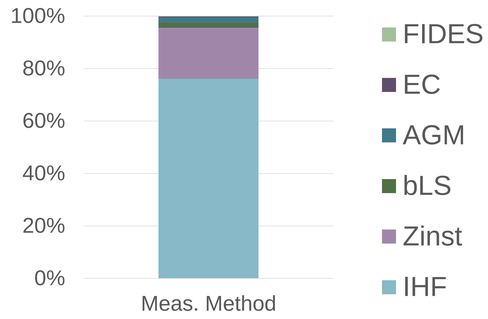

Figure 1. Bar chart showing the percent contribution of different measurement methods *with data >72h to the records used to estimate parameters for the ALFAM2 model. Measurement methods included integrated horizonal flux (IHF), theoretical profile shape (Zinst), aerodynamic gradient method (AGM), eddy covariance (EC), and dispersion models (bLS, FIDES).*

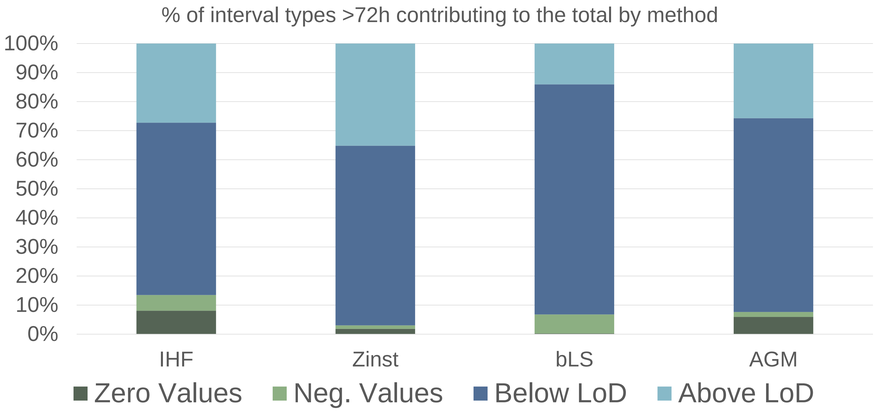

Figure 2. Bar chart with the percent contribution of different interval categories *to the total intervals beyond 72h by measurement method, including numbers of intervals above or below a detection limit (LoD) of 0.05 kg N ha^{-1} h^{-1}, and zero, or negative values.*

Results

- Half of the records extended beyond 72h.
- Simpler methods with longer time integrations such as IHF and Zinst contributed the most datasets (ca. 70%, Figure 1).
- Few inflow concentrations were provided, with some very high or unrealistic values (Table 1).
- None reported LoDs of the measurement systems.
- The majority of intervals and all medians >72h were below a reasonable estimate of the LoD (<0.05 kg N ha^{-1} h^{-1}, Figure 2).
- Many records lacked the expected negative fluxes.
- High reporting of zero values.

Table 1. Summary of key datasets with high contributions to the parameter estimation data*. Only measurements of typical slurry without treatments but including all application methods were selected and separated by experimental (purple shading) and field-scale plots (blue shading).*

Institute label	*N records*	*N intervals*	*Avg interval length (h)*	*Avg meas. duration (h)*	*N zero values*	*N neg. values*	*N below LoD[a]*	*Median (kg N ha^{-1} h^{-1})*	*% of total emissions >72h*	*Inflow conc. (y/n)*	*Meas. method*
202	109	241	45.1	154.6	7	37	208	0.013	11	No	IHF
203	7	15	124.7	335.8	7	0	15	0.002	4	No	IHF
204	17	48	55.3	244.6	1	2	41	0.016	19	No	Zinst
205	66	112	54.5	149.6	2	0	66	0.029	15	Yes[b]	Zinst
214	210	243	24.4	95.4	39	0	203	0.014	4	No	IHF
207	3	10	6.7	107.1	2	0	10	0.006	1	Yes	bLS
208	9	4163	0.7	405.4	267	76	3348	0.009	29	Yes[c]	AGM
209	4	704	0.5	170.6	0	64	630	0.017	12	Yes[c]	bLS
209	1	78	0.5	111	1	18	78	0	1	Yes[c]	EC
205	1	234	0.5	189	0	3	234	0.005	28	No	bLS
208	1	152	0.5	148.5	0	40	152	0.002	1	Yes	FIDES

[a] LoD: Estimated Limit of Detection: <0.05 kg N ha^{-1} h^{-1} (1.4 µg N m^{-2} s^{-1}), [b] Unrealistic values due to a unit error, [c] Very high inflow concentrations (>50 µg/m^3)

Outcomes

- Most of the methods were optimised to correctly track short-term high emissions following slurry application.
- These methods provide long integration periods and are less reliant on detailed quantification of instrument sensitivity and accuracy.
- Fluxes beyond 72h after application are likely to be very low (<0.05 kg N ha^{-1} h^{-1}), thus often below the instrument detection limit.
- The observed absence of negative fluxes and reporting of zero values suggest a positive bias and probable overestimation of modelled total cumulative emissions.
- Current metadata are insufficient to fully evaluate data reliability >72h.

Recommendations

- When measuring small fluxes in- and outflow concentrations converge, which requires additional instrument testing and sensitivity analysis that are currently missing.
- Existing datasets after 72h require detailed plausibility assessments which is currently limited based on the available metadata.
- To model reliable emissions beyond 72h, new datasets must report detection limits, inflow concentrations, and details on post-processing, i.e. filtering and gap-filling.
- We recommend that measurements and model predictions beyond 72h be interpreted cautiously until data quality can be verified.

Bern University of Applied Sciences

AARHUS UNIVERSITY

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Acknowledgements
We would like to thank all the groups who have contributed data to the ALFAM2 database over the years and the people involved in developing the ALFAM models. We hope that this analysis will advance the conversation on data submission guidelines and model development within the community.

Contact

SCAN ME

Länggasse 85 | CH-3052 Zollikofen
www.bfh.ch | alex.valach@bfh.ch