Surface/atmosphere exchange of NH_3 above managed grassland

Long term low-cost monitoring and short-term intensive campaigns

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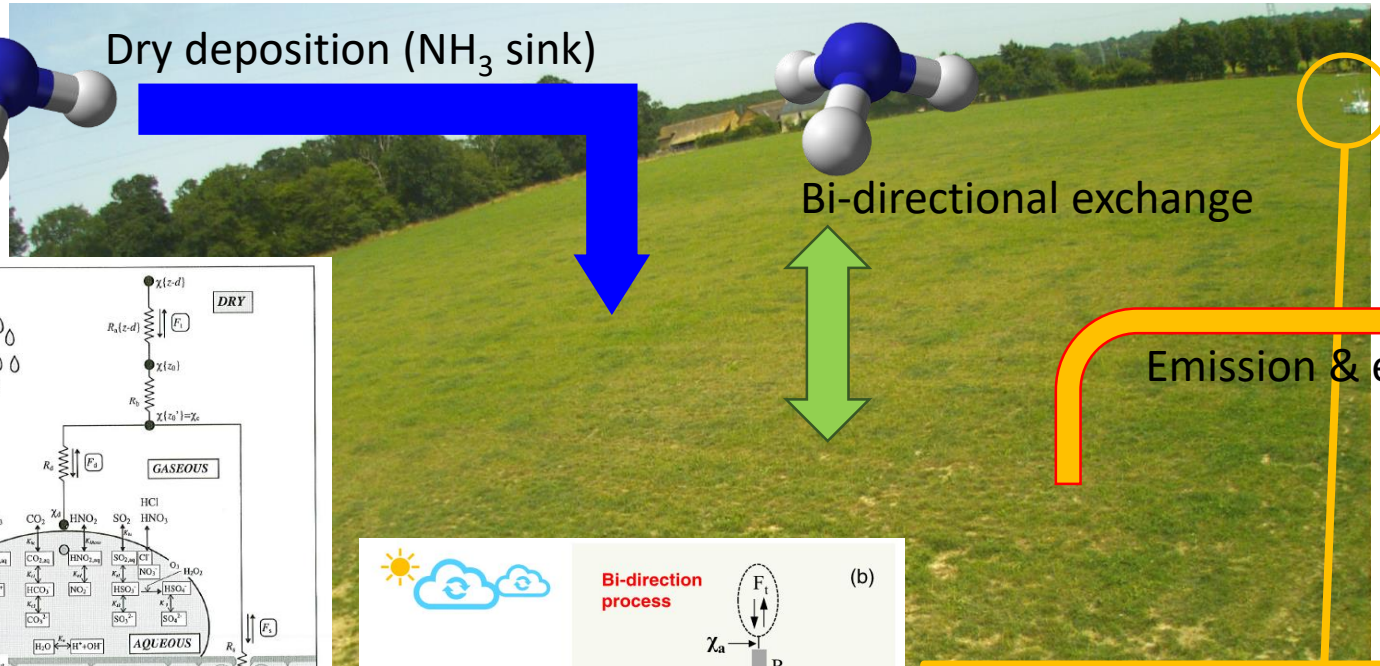
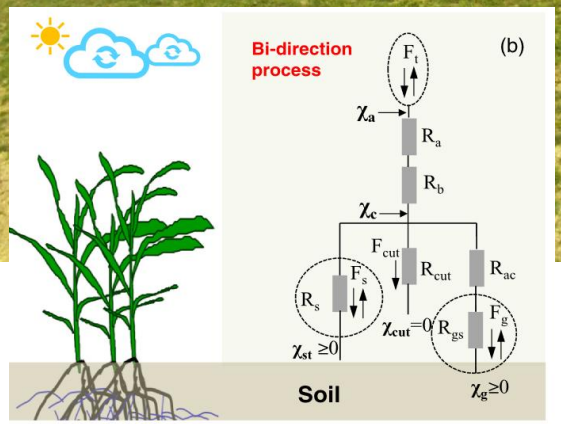
EMIGRAZE

Processes of bi-directional NH_3 exchange over managed grassland: background conditions (~ low ecosystem N status, winter)



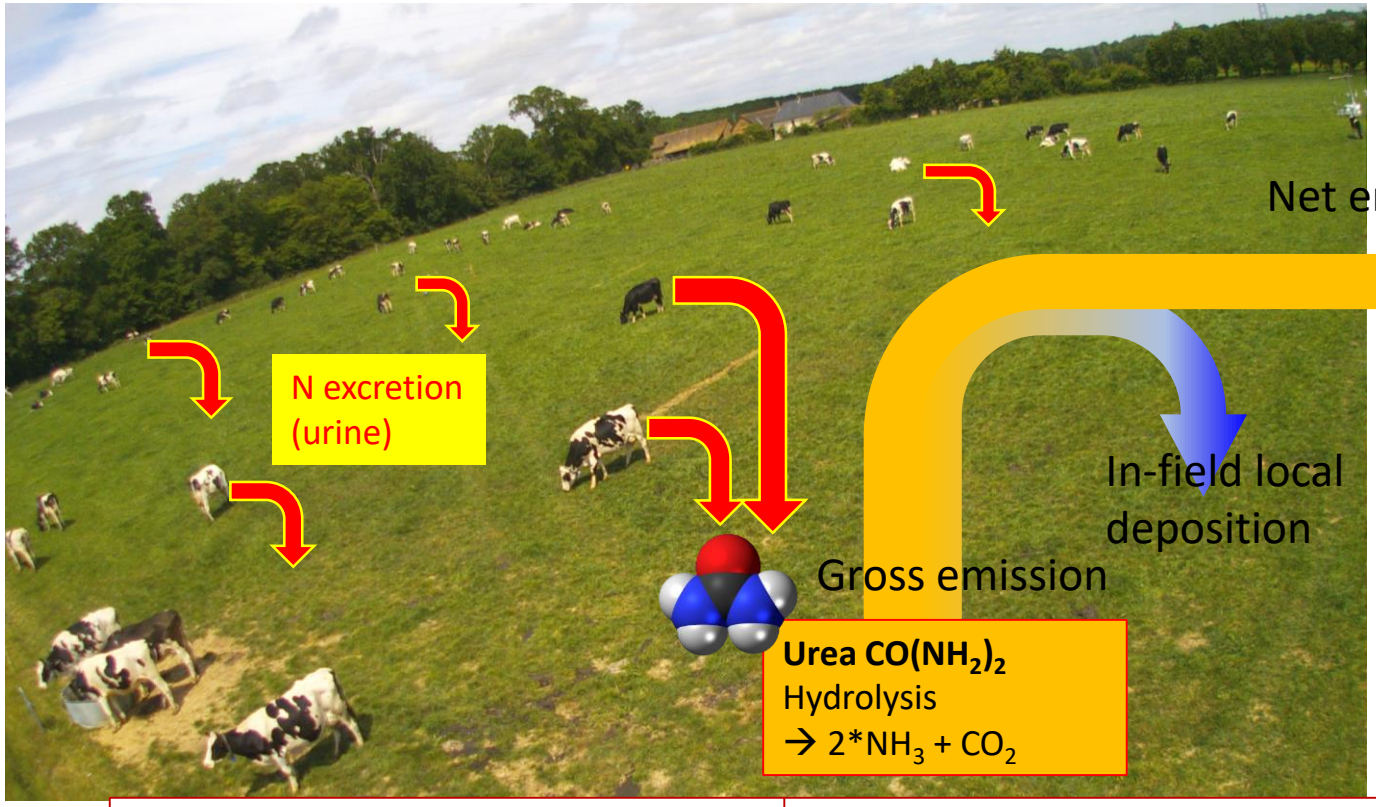
Flechard et al. 1999

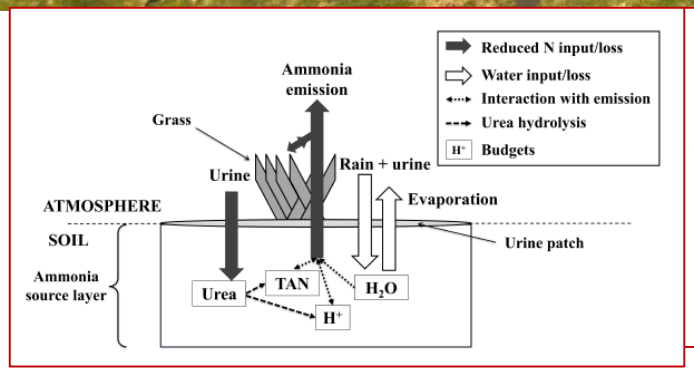


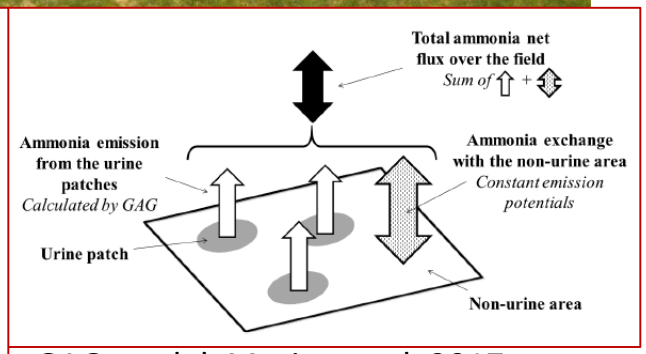
Qi Zhang et al. 2021

ICOS FR-Mej CO_2 flux tower
IEPL Méjusseaume, Brittany, NW France
https://meta.icos-cp.eu/resources/stations/ES_FR-Mej

Processes of bi-directional NH_3 exchange over managed grassland : grazing emissions (spring, summer)

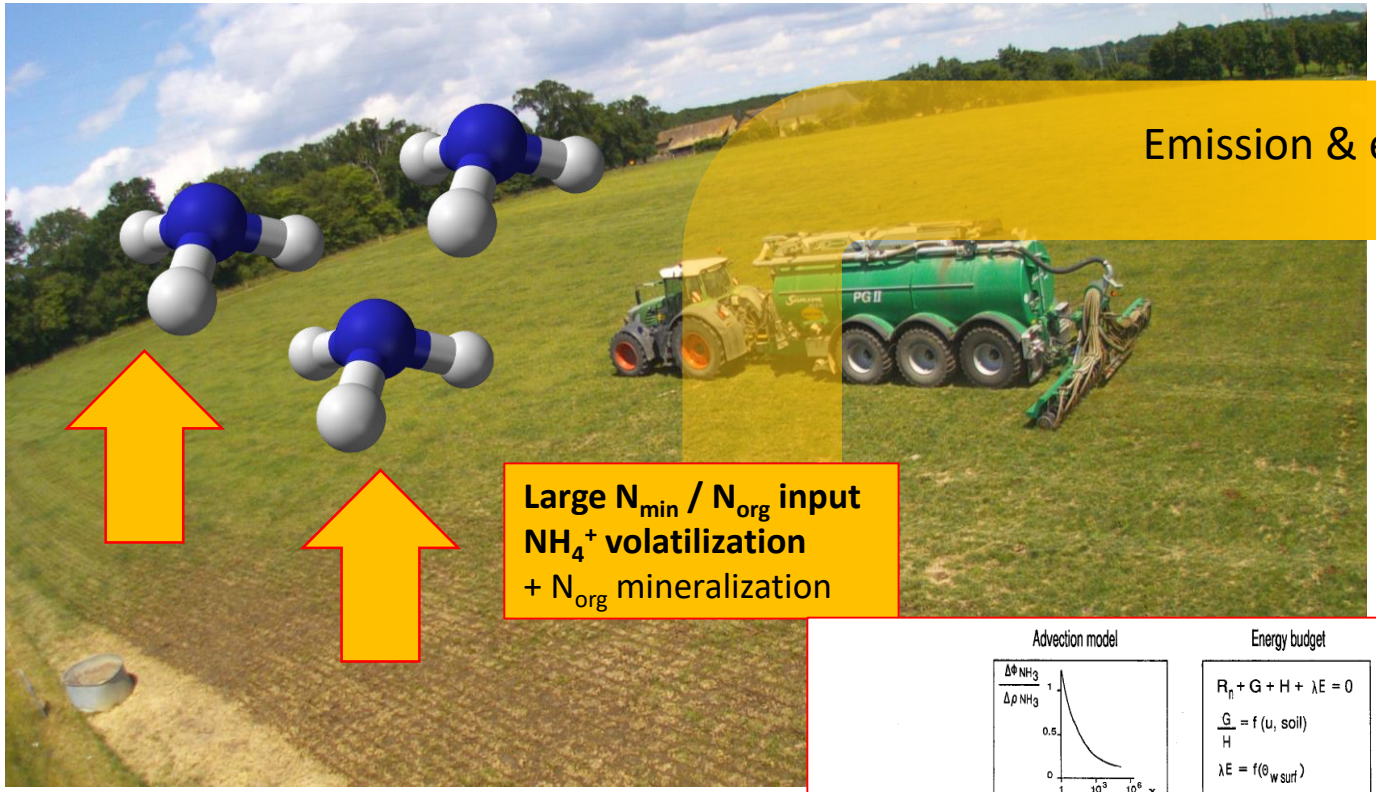






GAG model, Moring et al. 2017

Processes of bi-directional NH_3 exchange over managed grassland : manure/fertilizer application



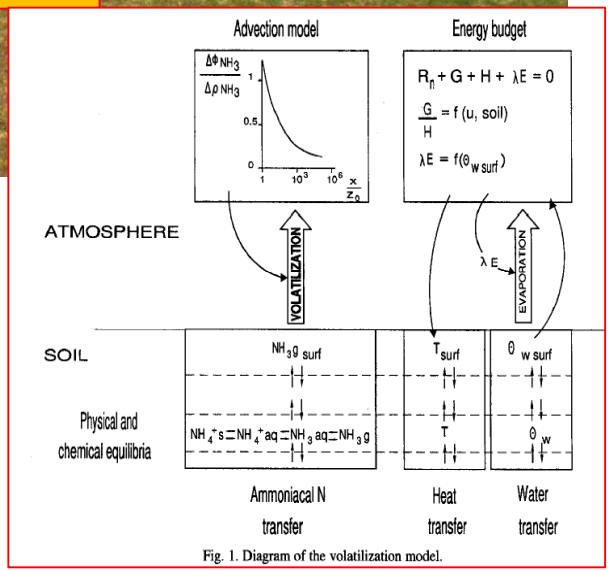


Fig. 1. Diagram of the volatilization model.

VOLT'AIR model
Genermont et al. 1997

Assessing the NH_3 budget of productive/managed grasslands

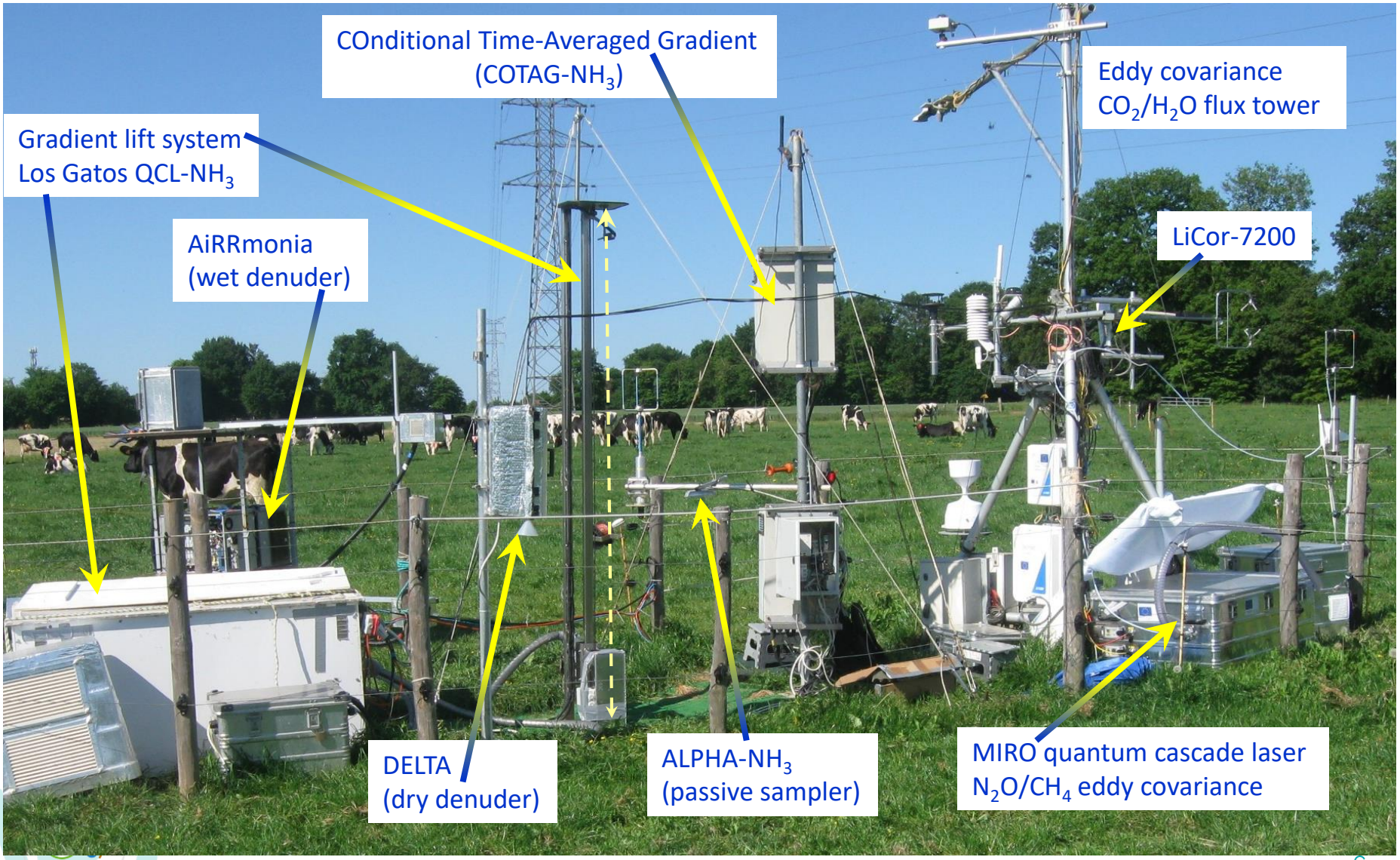
Alternating net emission and net deposition phases

- Short term emission peaks during grazing & fertilization (a few days to weeks)
- Bi-directional transition phase. Flux sign depends on temperature, moisture, ecosystem N status
- Winter half-year: dry deposition prevails
    - **What is the net annual balance?**

Measurement strategy to characterize the NH_3 budget

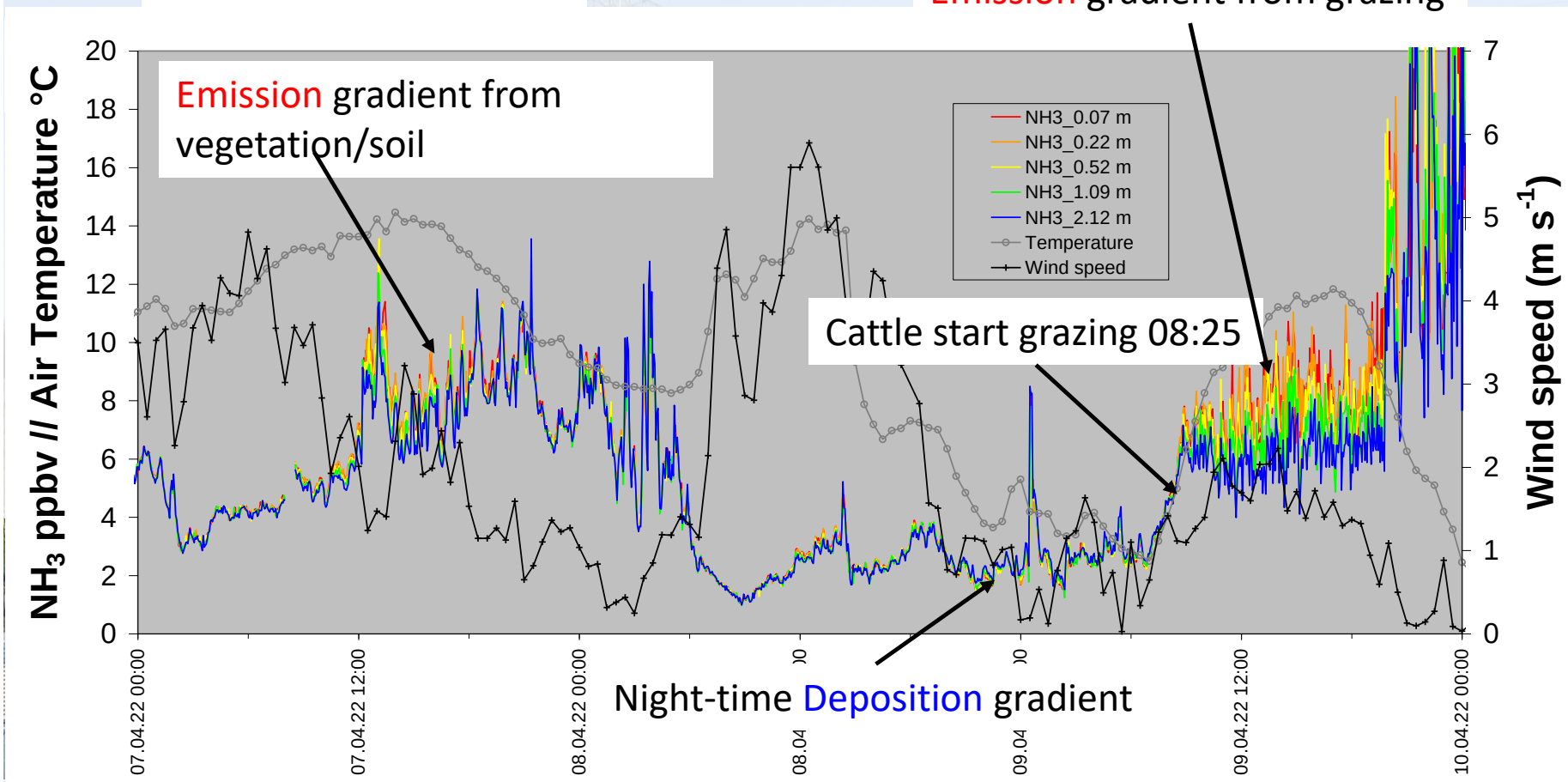
- **Intensive measurement campaigns** (a few weeks in spring/summer)
    - Short-term (hours-days) response to sudden ecosystem disturbances (grazing, fertilization)
    - High resolution (hourly) flux data for process understanding
    - Use data to develop/parameterize/calibrate emission models
- **Long-term, low-resolution, low-cost flux measurements** (e.g. COTAG)
    - Low maintenance and low frequency allow multi-annual measurements
    - Robust data for long-term budgets, but not adequate for process understanding

Instrumental setup & inter-comparison

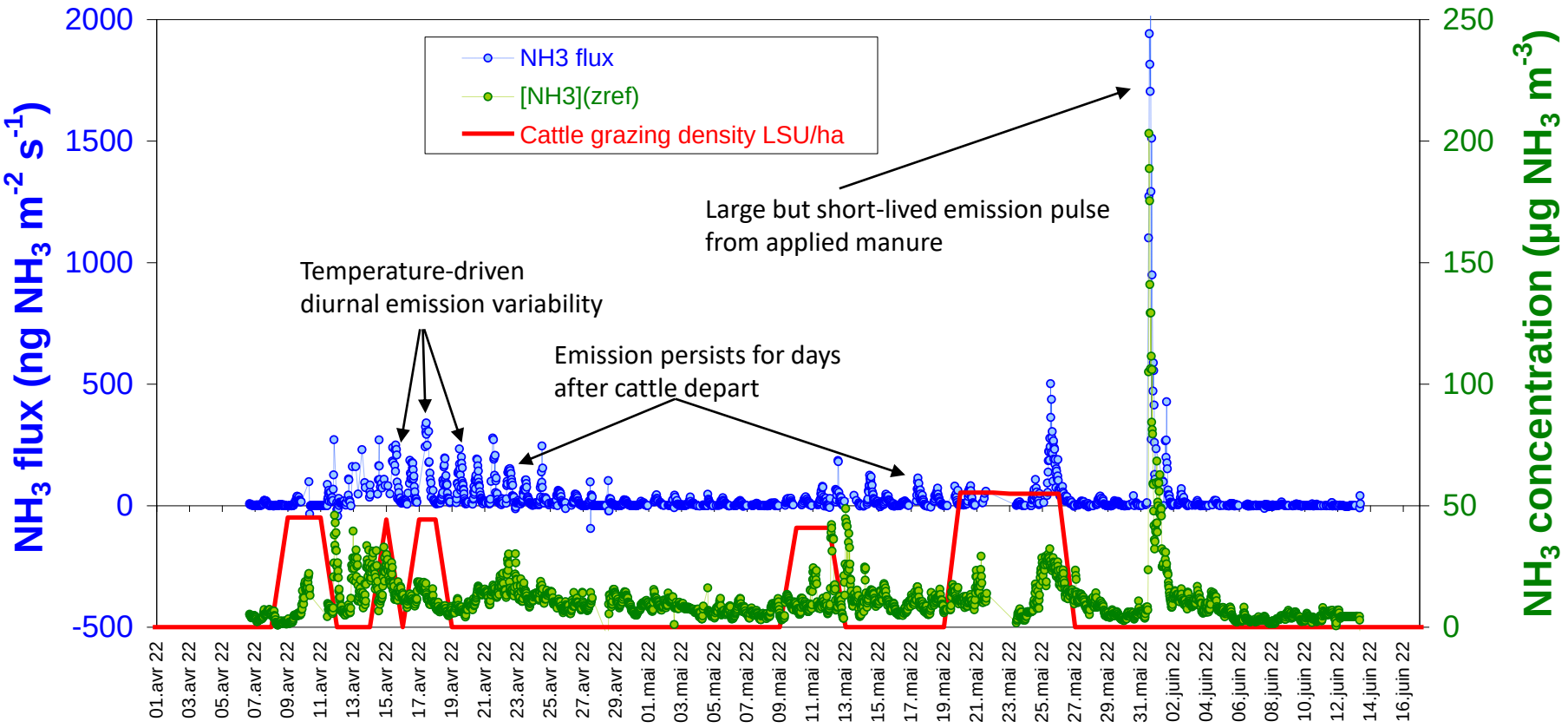


Grazing-related NH_3 emissions: aerodynamic gradient method using Los Gatos quantum cascade laser (QCL) & lift system

$$F_\chi = -ku_* \frac{\partial \chi}{\partial\left[\ln(z-d) - \psi_H\{\zeta\}\right]}$$

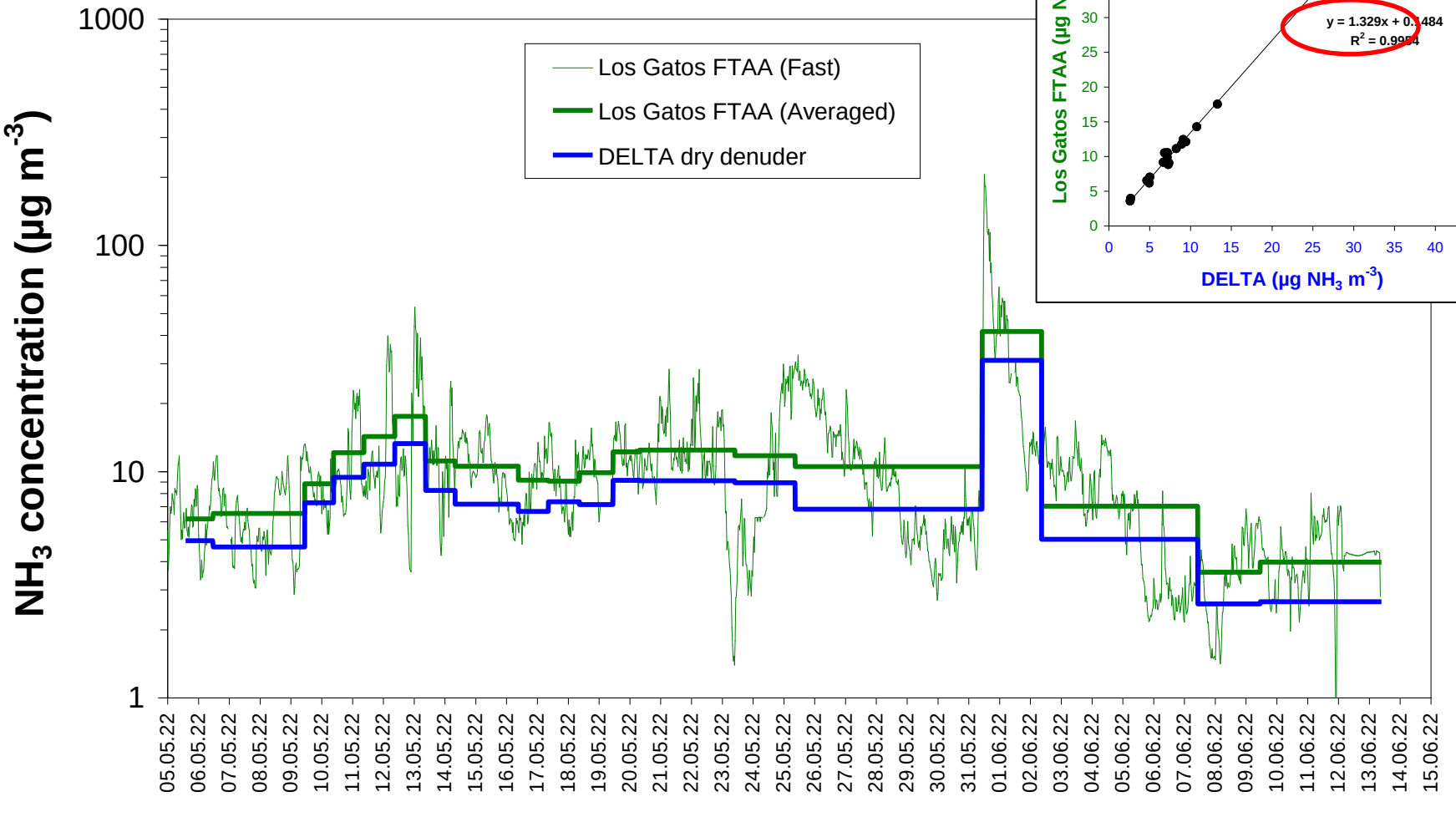


Intensive NH_3 flux campaign Spring 2022 - overview

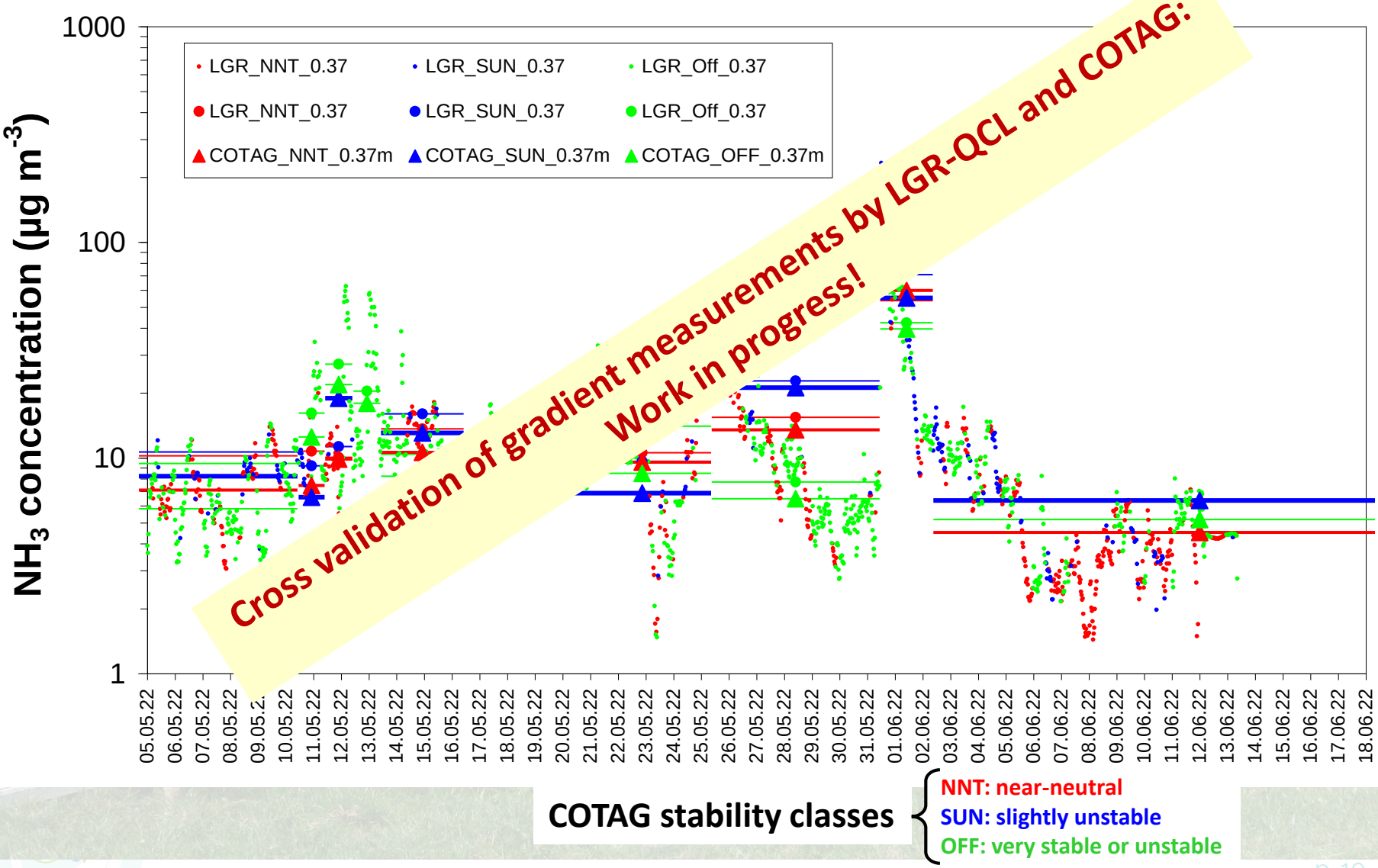


- **Grazing** : moderate but lasting emission fluxes driven by urea hydrolysis on soil surface
- **Organic manure application**: instantaneous release (volatilization) by NH_4^+-rich substrate (phase equilibrium)

NH_3 measurement intercomparison: Los Gatos QCL vs DELTA



NH_3 concentration & gradient intercomparison: Los Gatos QCL vs COTAG



COTAG stability classes

- NNT: near-neutral
- SUN: slightly unstable
- OFF: very stable or unstable

Gap-filling of COTAG-derived flux data

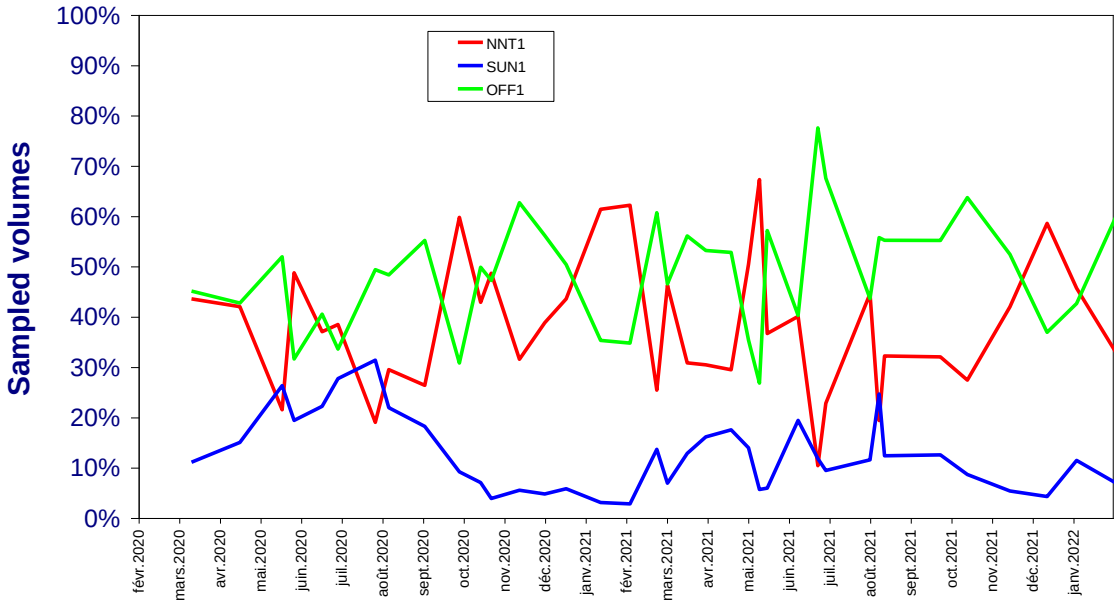
COTAG: relaxed aerodynamic gradient method

$$F_\chi = -ku_* \frac{\partial \chi}{\partial\left[\ln(z-d) - \psi_H\{\zeta\}\right]}$$

- Turbulence and vertical concentration gradient averaged over several hours or days,
- …but only valid for near-neutral or slightly unstable atmospheric conditions

COTAG stability classes { **NNT: near-neutral**, **SUN: slightly unstable** } → F_{NH3}_NNT & F_{NH3}_SUN measured

OFF: very stable or unstable → F_{NH3}_OFF not measured



- To obtain time-integrated total COTAG NH_3 flux, **~50% of the data** (OFF periods) must be gap-filled
- Develop gap-filling strategy based on inferential modelling and locally-derived ecosystem-scale emission potential ($\Gamma_{surface} = NH_4^+/H^+$)

C. R. Flechard et al.: The ammonia budget of fertilised grassland

Swiss grassland NH_3 flux study 2006-07

Biogeosciences, 7, 537–556, 2010
www.biogeosciences.net/7/537/2010/

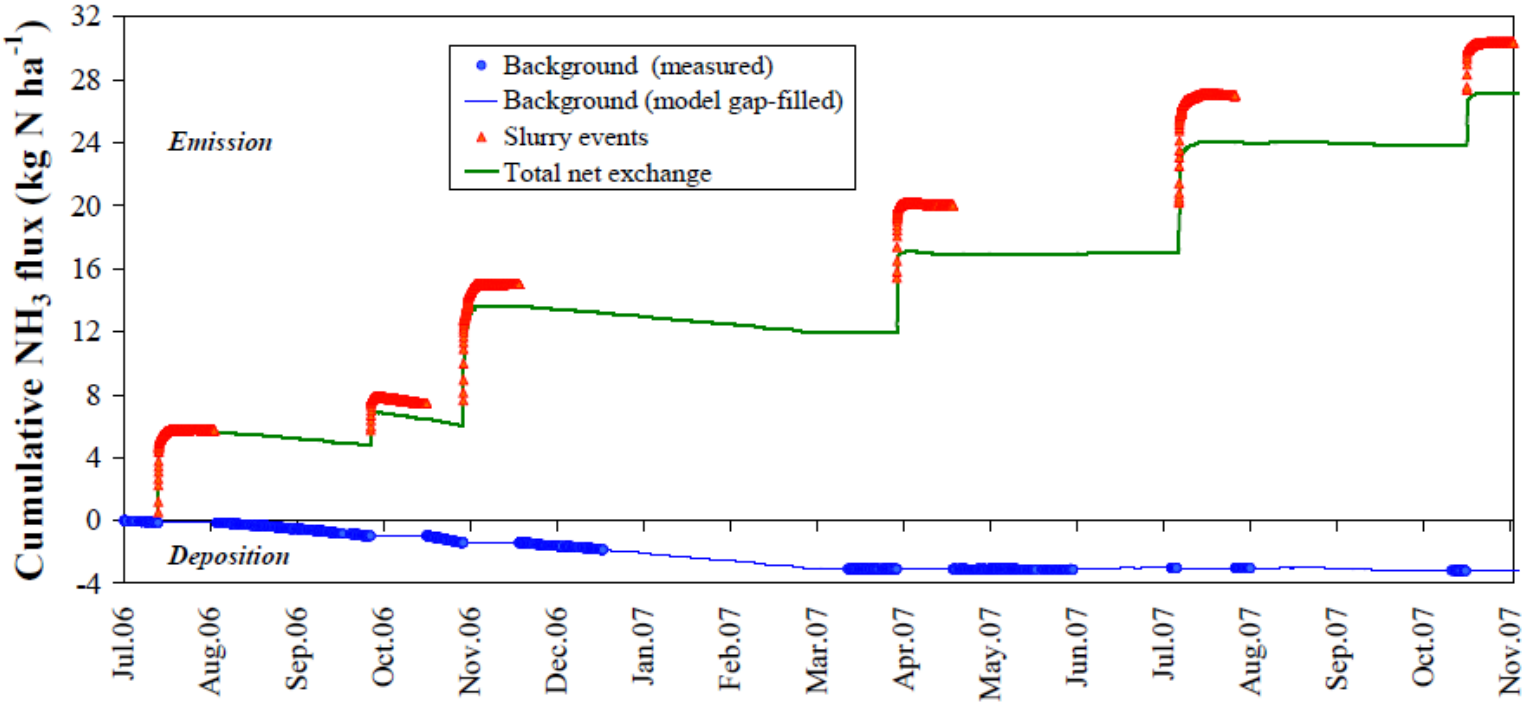


Fig. 6. Cumulative 17-month NH_3 exchange with contributions from background exchange and slurry application events.

Conclusion & take home

Managed grasslands are (generally) net NH_3 sources

- Large emissions by manure applications
- Significant emissions by grazing herbivores (though possibly reduced *per capita* compared with indoor dairy systems)
- Dry deposition / bi-directional exchange in background conditions still relevant for net long term NH_3 budget, and for N-cycling process understanding
- Magnitude and sign of NH_3 flux depends on ecosystem N status and weather

Still too few long-term datasets to support model development

- Field measurements: combine low-cost and high-tech techniques
- Intercomparison of instruments crucial for NH_3 !!

(See Twigg et al. 2022 AMT paper, https://doi.org/10.5194/amt-2022-107)

- Link up ecosystem biogeochemistry and surface-atmosphere exchange.

Inferential modelling requires adequate quantification of surface emission potentials.

- Even COTAG-type methods require good modelling for defensible gap-filling

Thanks for your attention !