A 2.5-Year Eddy Covariance Study of Nitrous Oxide Fluxes in Winter Barley, Sugar Beet and Winter Wheat: Responses to Environmental and Management Factors

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I

IMPORTANCE

- **Nitrous Oxide** (N_2O) is one of the three most important **greenhouse gases**
- Largest source of stratospheric NOx → ozone depletion
- 67% of anthropogenic emissions arise from agriculture (FAOSTAT)

CHALLENGES

- High **spatial & temporal variability** of N_2O fluxes
- Measurements difficult due to **intensive management**
- Chamber measurements have limitations in time & space

AIMS

- Improving the quantification of N_2O fluxes using non-intrusive & spatially integrated **Eddy Covariance** (EC) measurements
- Understanding the **drivers** of N_2O fluxes from **croplands**

II

MATERIAL & METHODS

Site description

- EC flux tower on a 10 ha field at **Reinshof**, Germany **(DE-Rns)** managed with common agricultural practice
- 51.49 °N, 9.93 °E, 155 m a.s.l.
- MAP = 618 ± 114 mm , MAT = 9.5 ± 0.7 °C
- Fluvisol, loamy soil, pH = 7.0

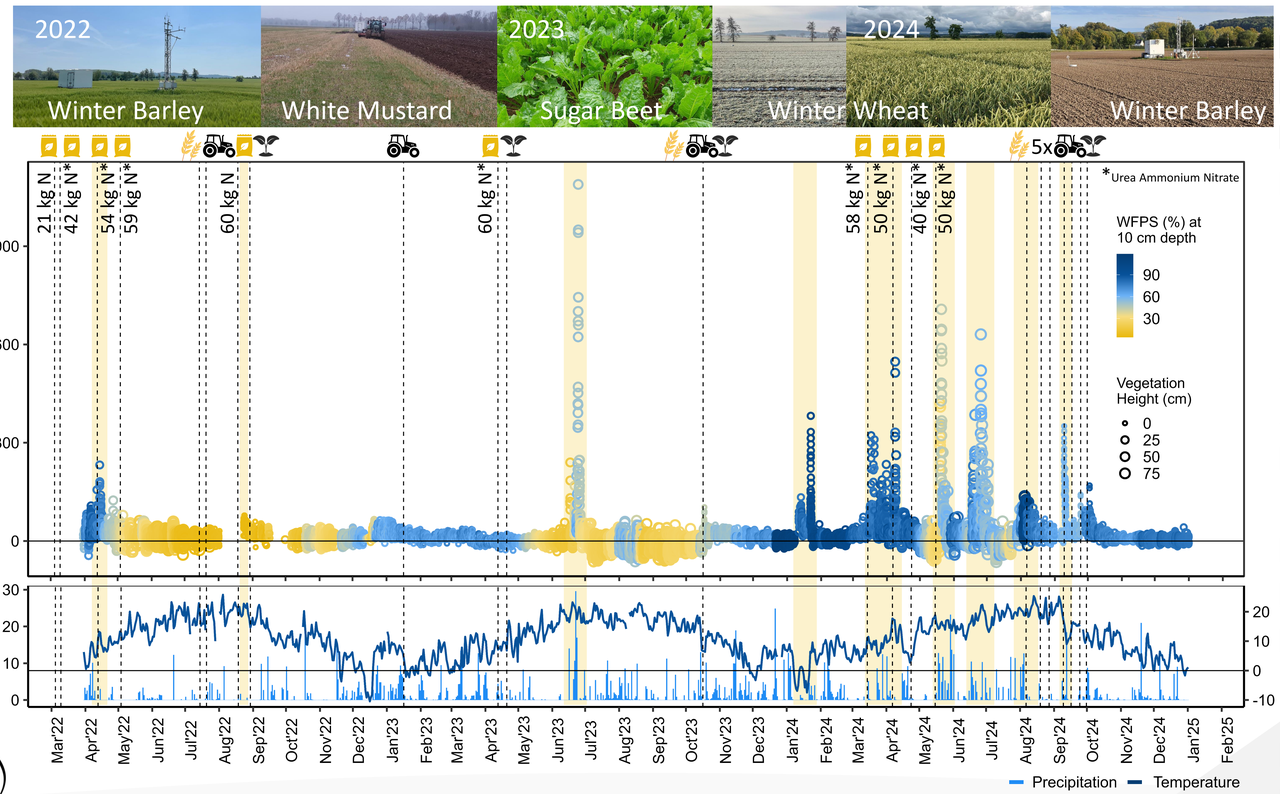
Flux tower setup

- Closed-path N_2O analyzer (**Los Gatos Research**)
- Sensors for soil moisture & temperature, precipitation and air temperature
- **Flux calculation** with EddyPro® with fixed time lag
- Filtering for u* < 0.11, QC = 0 and footprint 70%
- Recording of **management practices**:

fertilization tillage sowing harvest

Footprint (acc. Kljun et al. 2015)

- lines from 10 to 90% in 10% steps
- field in the south same management



III

RESULTS & DISCUSSION

- **N_2O peaks** were induced by nitrogen (N) **fertilization, rainfall, freeze-thawing or tillage** events
- Periods showing **negative N_2O fluxes** were associated to highest crop biomass → plants and soil microbes compete for soil mineral N
- In total, **cumulative N_2O emissions** of 4.03 kg N_2O-N ha^{-1} → **emission factor (EF) of 0.94%** of applied N

2022:	1.08 kg N_2O-N ha^{-1}	(EF 0.62%)	**Winter Barley**:	0.47 kg N_2O-N ha^{-1}	(EF 0.42%) → *from Apr*
2023:	0.74 kg "	(EF 1.23%)	**Sugar Beet**:	0.29 kg "	(EF 0.48%)
2024:	2.22 kg "	(EF 1.12%)	**Winter Wheat**:	2.15 kg "	(EF 1.09%)

- 22% of the cumulative N_2O emissions were induced by three rainfall events and one freeze-thawing event, while 29% occurred within three weeks after N fertilizations

IV

CONCLUSIONS

- High temporal variability of cropland N_2O fluxes due to **environmental** (soil moisture, soil temperature) and **management** factors (fertilization, tillage, crop growth)
- N_2O fluxes at half-hourly resolution from several years can help us to better estimate N_2O budgets of crop cultivation and to **develop mitigation strategies**
- **Outlook**: application of decision tree-based machine learning approaches for gap-filling and identification of the most important drivers

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Abbreviations
u*: Friction velocity
QC: Quality control
WFPS: Water filled pore space

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