A Comparison between the Tower-Based Gradient Method and the Automated Chamber Method for Measuring N_2O Fluxes from an Agricultural Field

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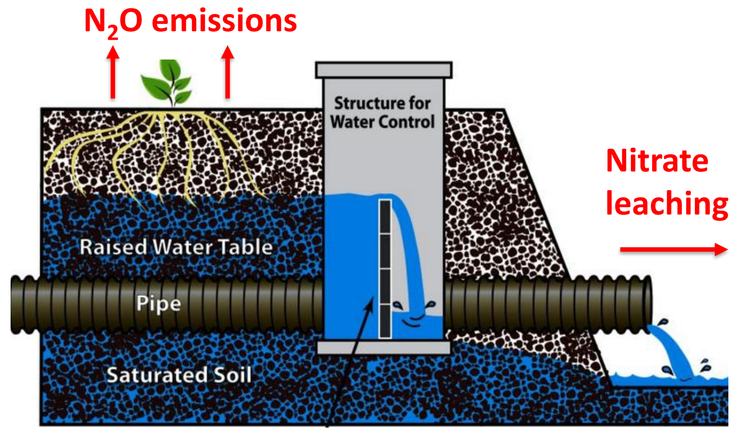
Introduction

- More than half of anthropogenic N_2O emissions result from agricultural activities.
- Drainage water management (DWM) reduces nitrate export by enhancing denitrification, but will it increase N_2O emissions?

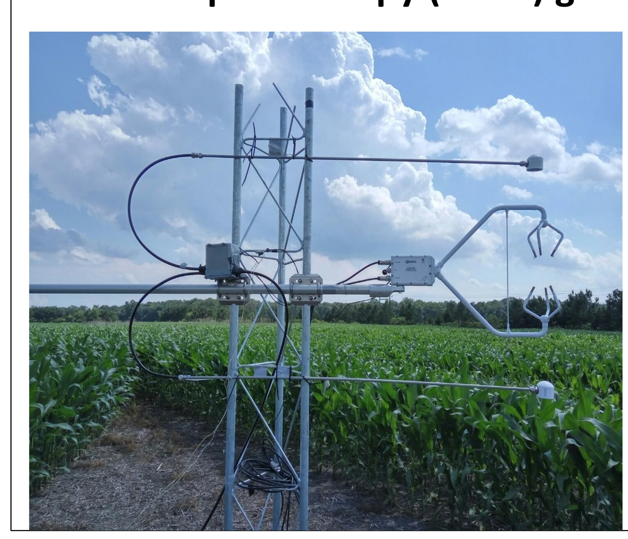


Objectives

- Quantify soil N_2O emissions in control and DWM treatment plots.
- Compare auto-chamber and micrometeorological gradient methods for N_2O flux measurement using fast response instruments in situ.

Experimental Design

- The fields were planted in corn on April 25, 2019 and fertilized with 22 kg/ha Urea Ammonium Nitrate (UAN) on April 25 and 202 kg/ha UAN on May 24.
- A 3 m tall tower was installed in each of four fields, containing a CSAT3B three-dimensional sonic anemometer (Campbell Scientific) and a pair of upper and lower inlets, allowed for near-continuous gradient flux measurements using an Aerodyne Quantum Cascade Laser (QCL).
- Four Eosense closed dynamic automated chambers (eocAC) and a multiplexer (eosMX) were installed near one tower and connected to a Picarro Cavity Ring-Down Spectroscopy (CRDS) gas analyzer (G2308).



Flux Calculation

The basic calculation for the flux (F_c) is:

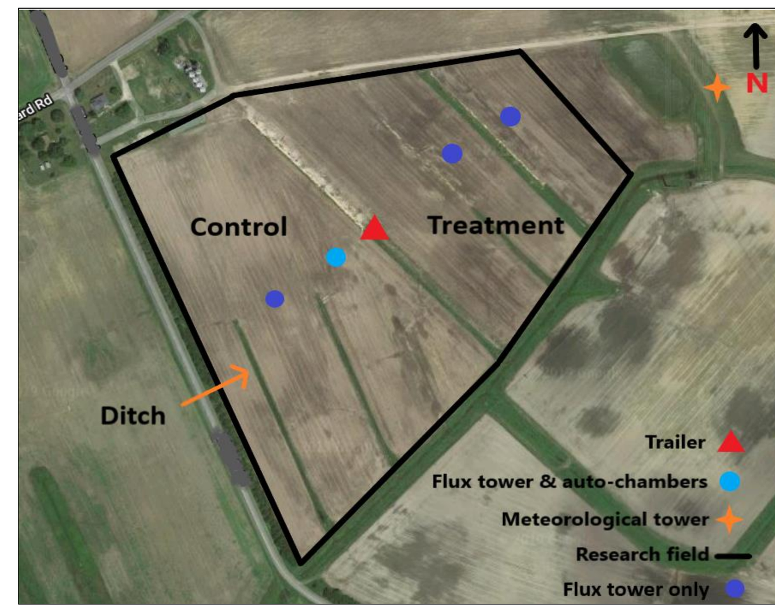
$$F_c = -K\frac{dC}{dz}$$

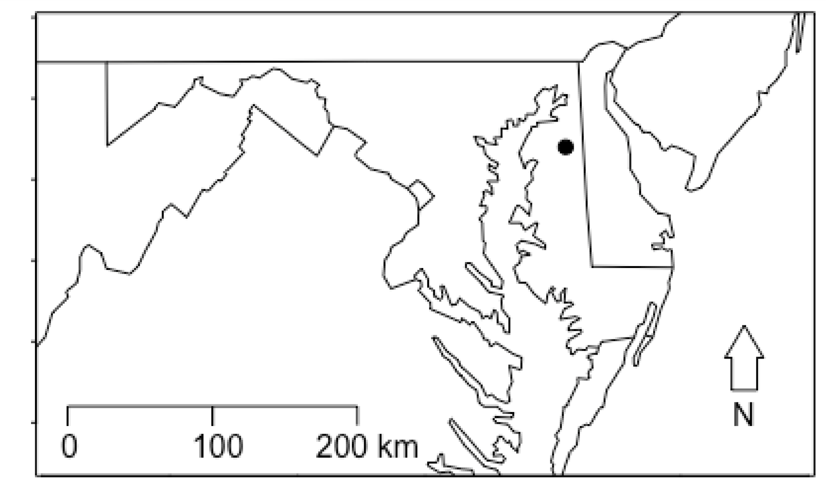
where dC is the concentration difference and dz is the height difference between the two intakes. K is the diffusion coefficient, as calculated in *Wagner-Riddle et al. (1996)*.

References

1. Wagner-Riddle, C., et al. "Nitrous oxide and carbon dioxide fluxes from a bare soil using a micrometeorological approach". Journal of Environ. Qual. 25: 898-907 (1996).
2. Wagner-Riddle, C., et al. "Intensive measurement of nitrous oxide emissions from a corn-soybean-wheat rotation under two contrasting management systems over 5 years". Global Change Biology 13: 1722-1736 (2007).
3. Pattey, E., et al. "Towards standards for measuring greenhouse gas fluxes from agricultural fields using instrumented towers". Canadian Journal of Soil Science 86: 373-400 (2006).
4. Edwards, G.C., et al. "Sources of variability in mercury flux measurements". Journal of Geophysical Research, Vol. 106, No. D6, 5421-5435 (2001).

Site Map

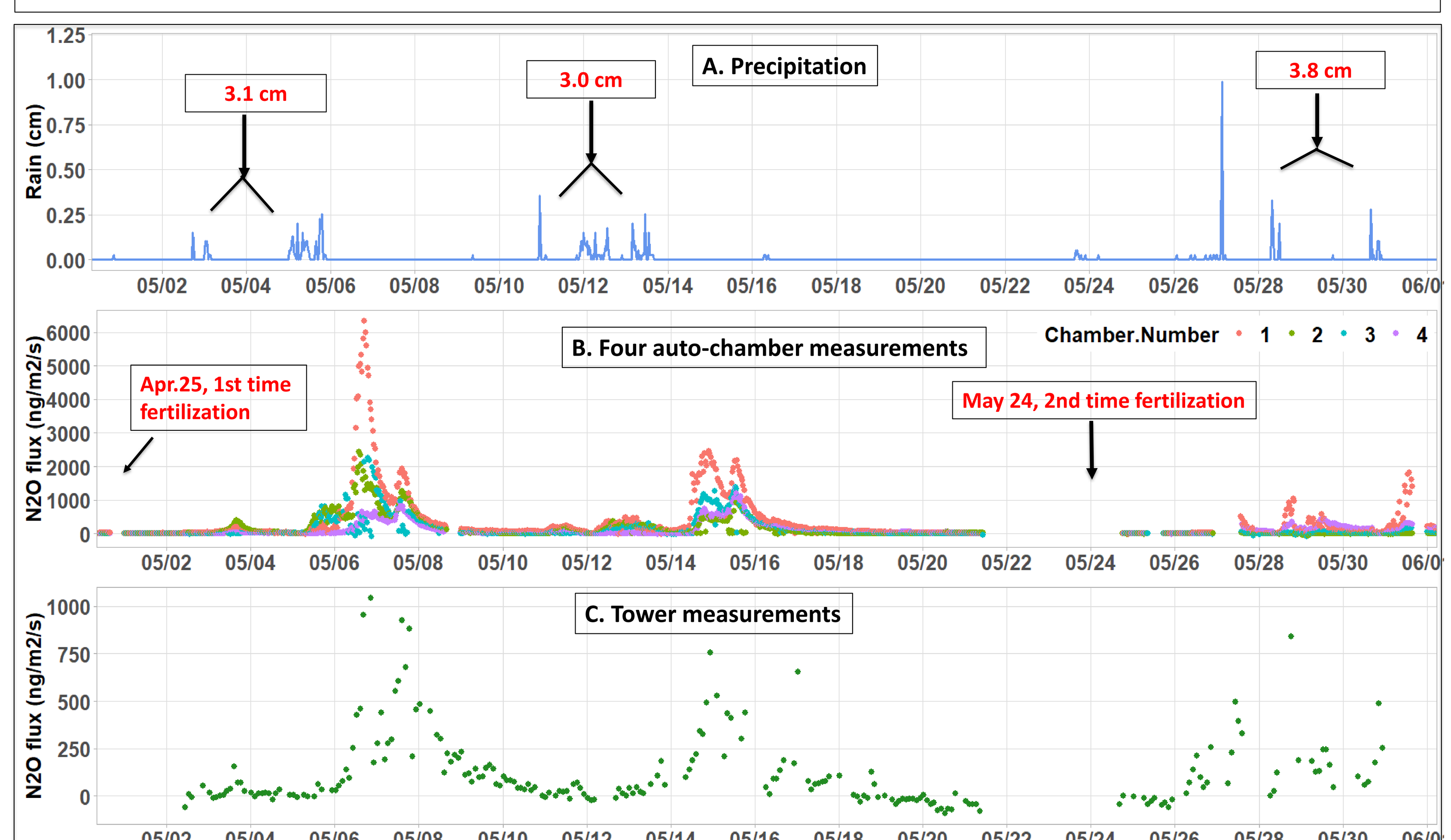


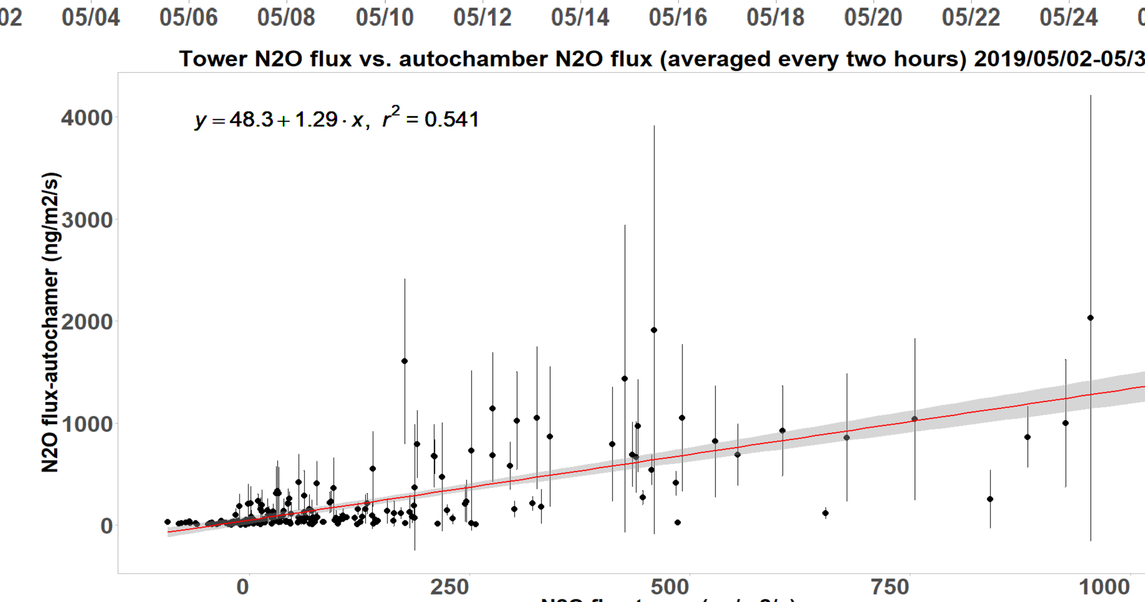


This study was conducted on the eastern shore of Maryland, USA

Tower and Chamber Comparison

- Both the automated chamber method and the tower-based gradient method captured strong pulses of N_2O fluxes after rainfall and fertilization events, demonstrating these major drivers of large emissions.
- Fluxes from the two methods were linearly correlated ($R^2 = 0.54$), but the slope (1.29 ± 0.08) and y-intercept (48.3 ± 19.2) indicate that the chambers generally estimated higher fluxes.
- Aggregating over the measurement period, the automated chamber estimate was 2.5 ± 0.1 kg N_2O-N/ha and the tower-based gradient estimate was 1.3 kg N_2O-N/ha in 19 days. Possible explanations include: (1) the tower footprint includes area (~4%) covered by ditches and could extend beyond the field at times; (2) the small number of chambers may have sampled an area of above average flux and (3) unknown measurement bias or interpolation error in one or both methods.

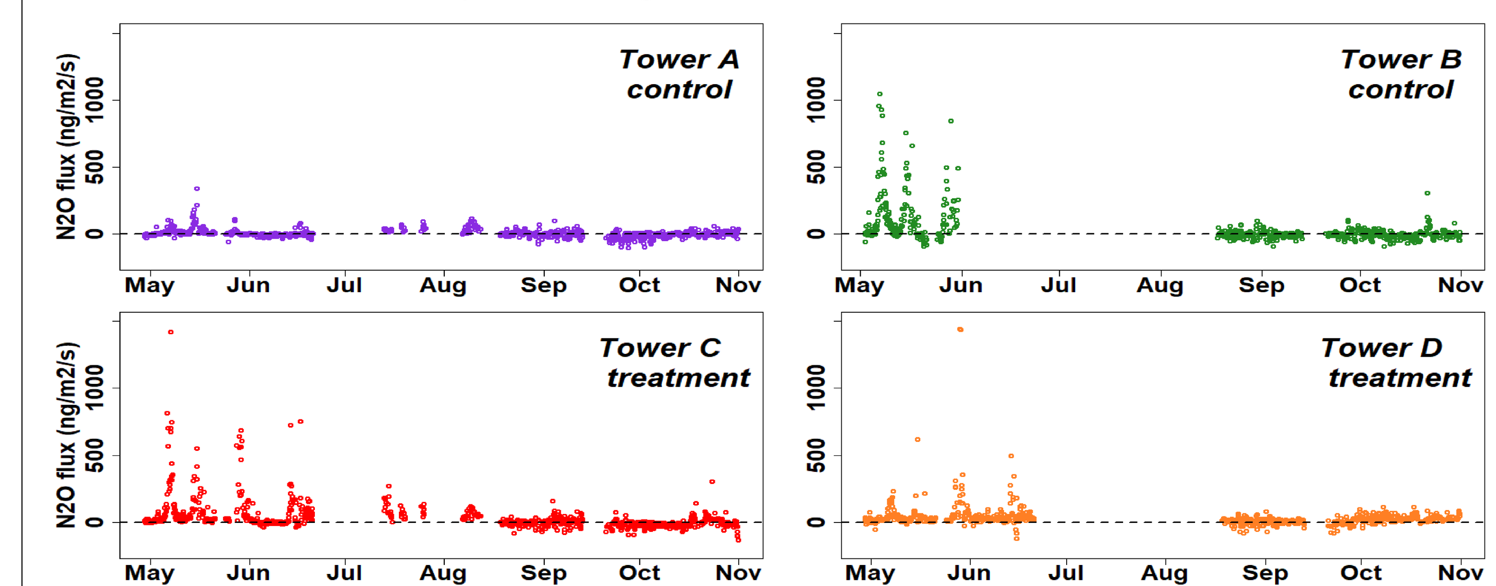




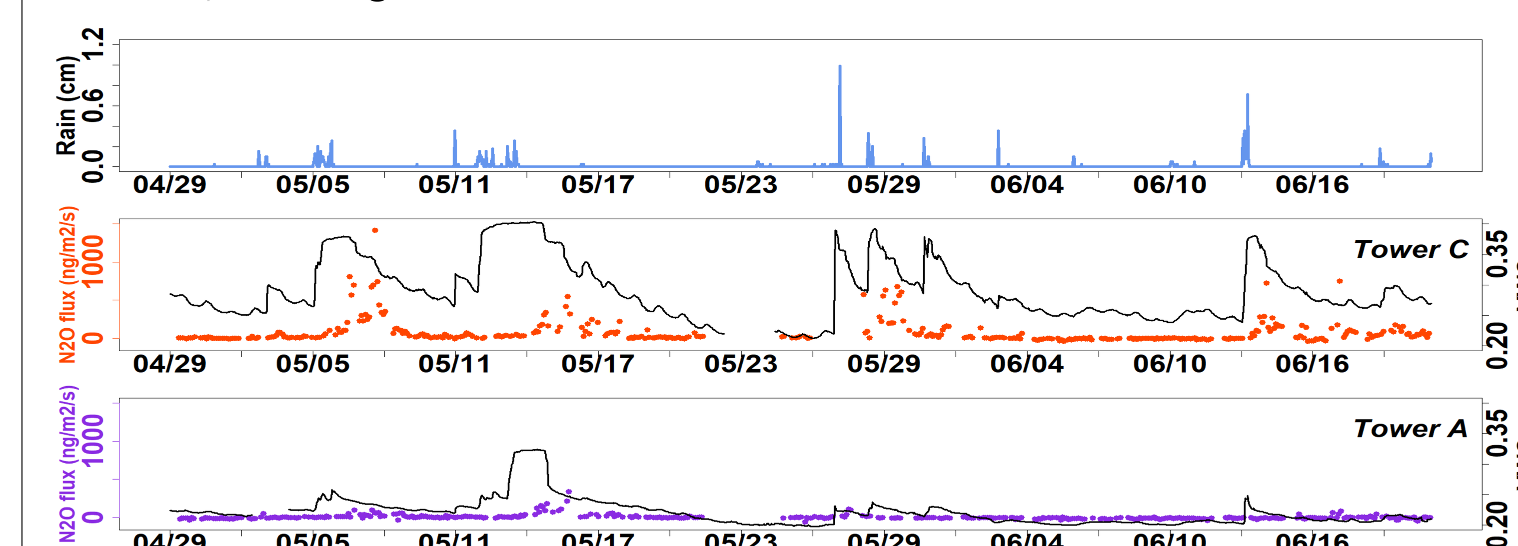
(Vertical error bars: standard deviations of the four auto-chambers)

Seasonal Trend and Treatment Effect

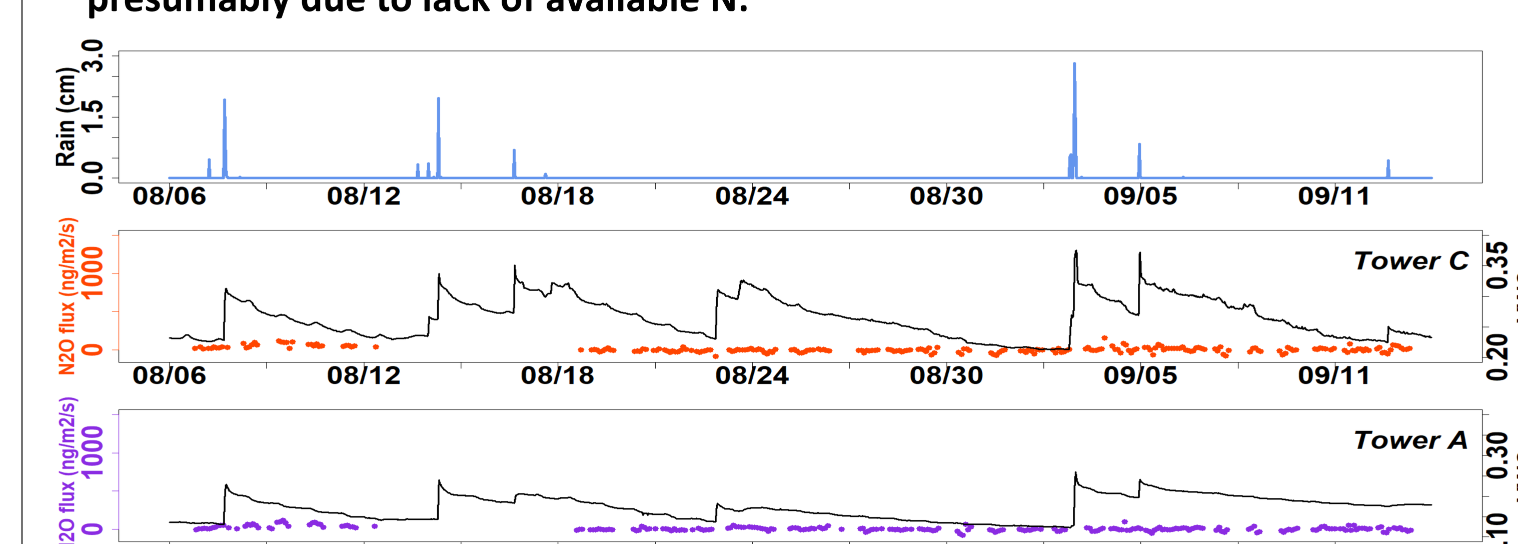
- N_2O emissions had the same general trend over time in all four fields: peaking in May after fertilization and precipitation events and decreasing to close to zero for the remainder of the year. No significant DWM treatment effect was found.



- Emissions of N_2O (colored dots) coincided with increases in soil moisture (as VWC below: Volumetric Water Content, black lines) at 5 cm depth in the early growing season, following fertilization:



- Later in the same year, wet-up events did not produce increased N_2O fluxes, presumably due to lack of available N:



Summary

- To our knowledge, this is one of the first tower/chamber comparisons of N_2O fluxes since these sensitive, fast response instruments have become available. While they demonstrated similar temporal patterns of pulsed emissions after spring rains, the chamber estimate was higher for unknown reasons.
- There were differences among plots, but the DWM treatment had no significant effect on N_2O fluxes. If confirmed by further research, DWM can be used to reduce nitrate leaching without increasing N_2O emissions.

Acknowledgement

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