# A comparison between the tower-based gradient method and the automated chamber method for measuring N2O fluxes from an agricultural field

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**Abstract**

Nitrous oxide (N2O) is a potent greenhouse gas and stratospheric ozone-depleting substance. More than half of anthropogenic N2O emissions result from agricultural activities. A broad objective of this on-farm research in eastern Maryland was to investigate whether drainage water management, which reduces nitrate export, would increase greenhouse gas emissions, but here we focus upon comparing chamber and tower measurements of N2O fluxes from a single field. Chamber methods usually suffer from poor spatial and temporal resolution. Automating chambers using in situ fast response analyzers improves temporal but not spatial resolution. Tower-based micrometeorological methods improve both temporal and spatial resolution, but require a high-frequency, high-sensitivity laser instrument. We compared auto-chamber and micrometeorological gradient methods for N2O flux measurement during a period early in the 2019 corn-growing season. A 3 m tall tower was deployed to allow for near-continuous gradient flux measurements using an Aerodyne Quantum Cascade Laser. Four Eosense closed dynamic automated chambers (eocAC) and a multiplexer (eosMX) were installed near the tower and connected to a Picarro G2308 gas analyzer. Both methods captured strong pulses of N2O fluxes after rainfall and fertilization events, demonstrating these major drivers of large emissions. Fluxes from the two methods were linearly correlated (R2 = 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 kg N2O-N/ha in 19 days, whereas the tower-based gradient estimate was 1.3 kg N2O-N/ha in 19 days. The tower footprint includes some area (4%) covered by ditches and could extend beyond the field at times, but this is unlikely the only explanation. The small number of chambers may have sampled an area of above average flux, or there could be unknown measurement bias or interpolation error in one or both methods. To our knowledge, this is the first such methodological comparison of N2O fluxes since these sensitive, fast response instruments have become available, and our results demonstrate that additional work is needed to gain more confidence in reported fluxes by either method.

# 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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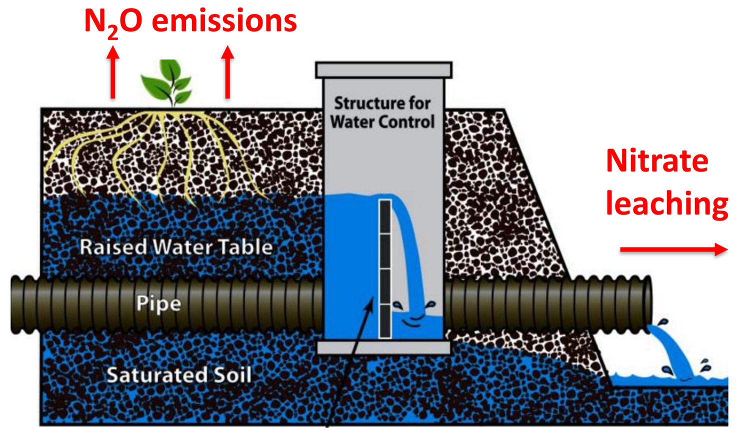
## Introduction

- 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?




(Image source: http://www.empireconstructionandtrenching.com/agricultural/drainage-water-management/)

## 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:

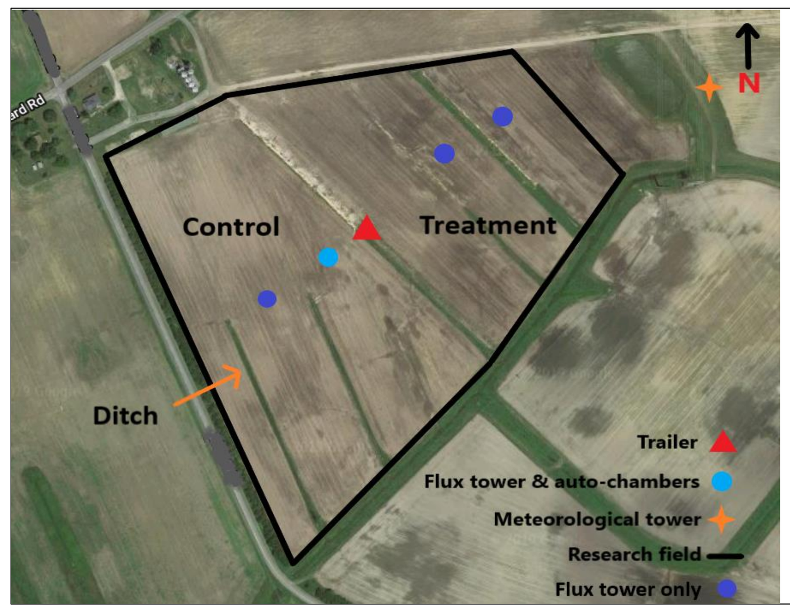
$$F_c = -K\frac{dC}{dz}$$

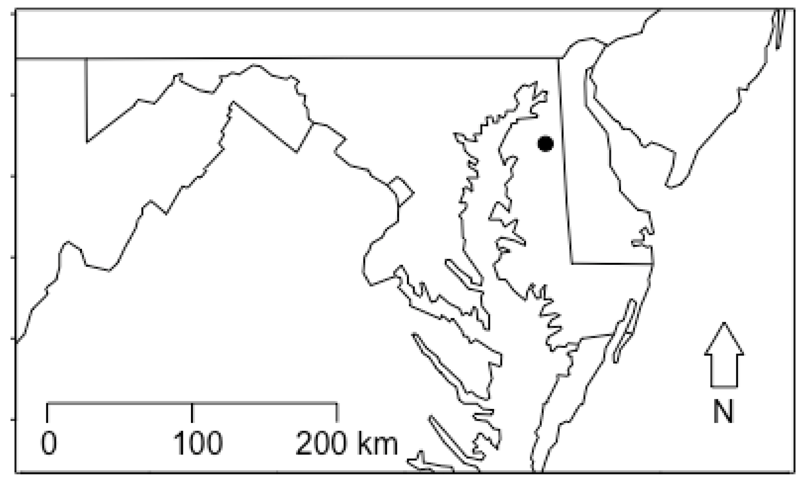
where $dC$ is the concentration difference and $dz$ is the height difference between the two intakes. $K$ is the diffusion coefficient, as calculated in *Wagner-Riddle et al. (1996)*.

## 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

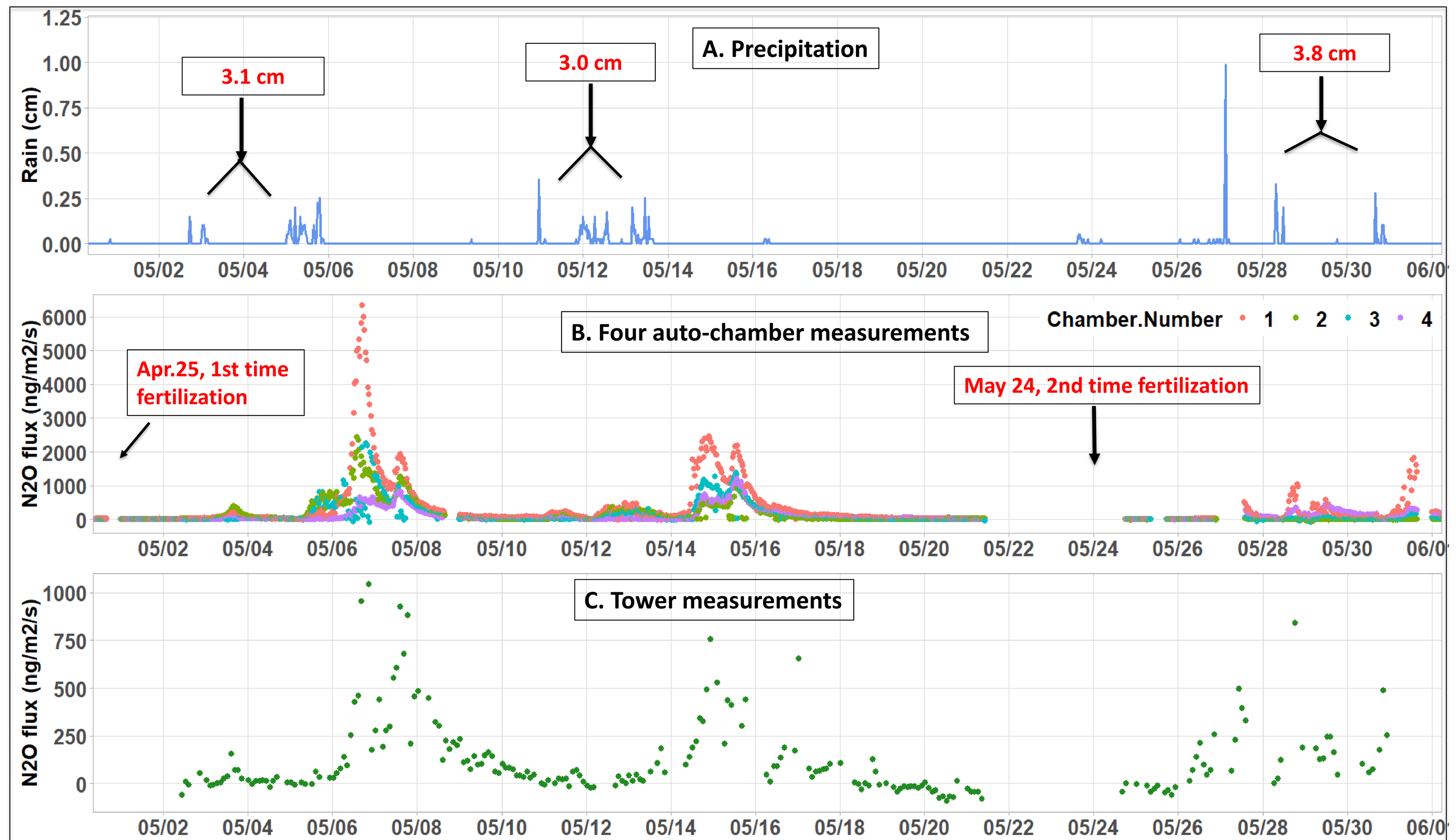


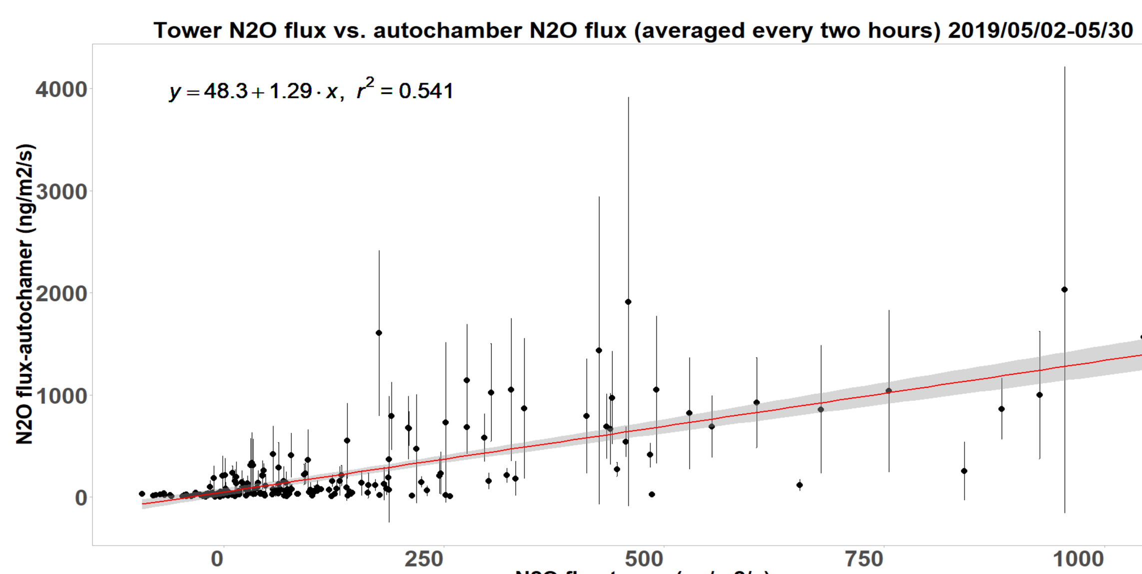




This study was conducted on the eastern shore of Maryland, USA

## 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 ($1.29 \pm 0.08$) and y-intercept ($48.3 \pm 19.2$) indicate that the chambers generally estimated higher fluxes.
- Aggregating over the measurement period, the automated chamber estimate was $2.5 \pm 0.1$ 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.

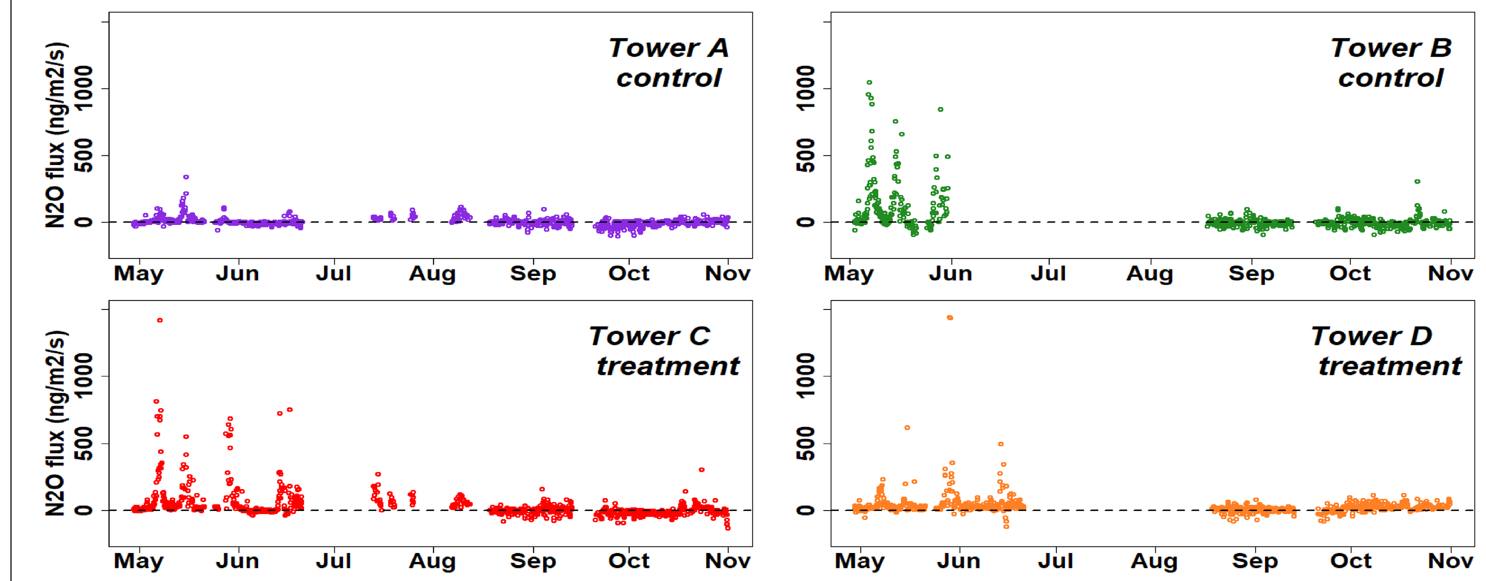


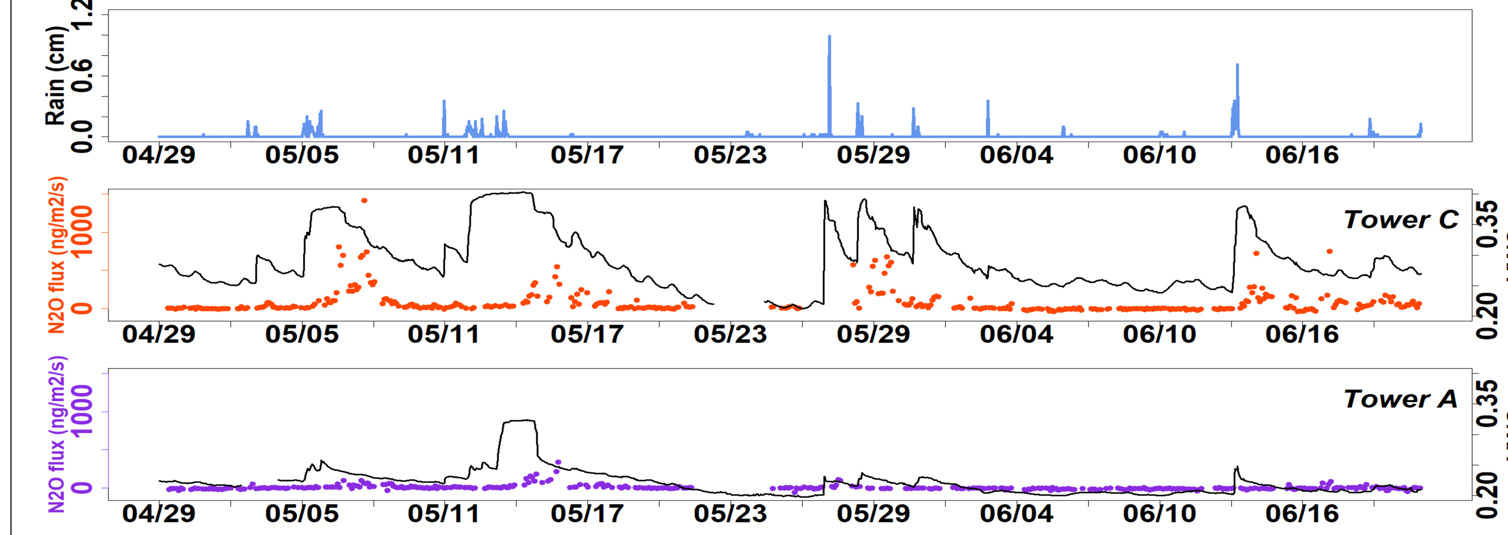

(Vertical error bars: standard deviations of the four auto-chambers)

## Seasonal Trend and Treatment Effect

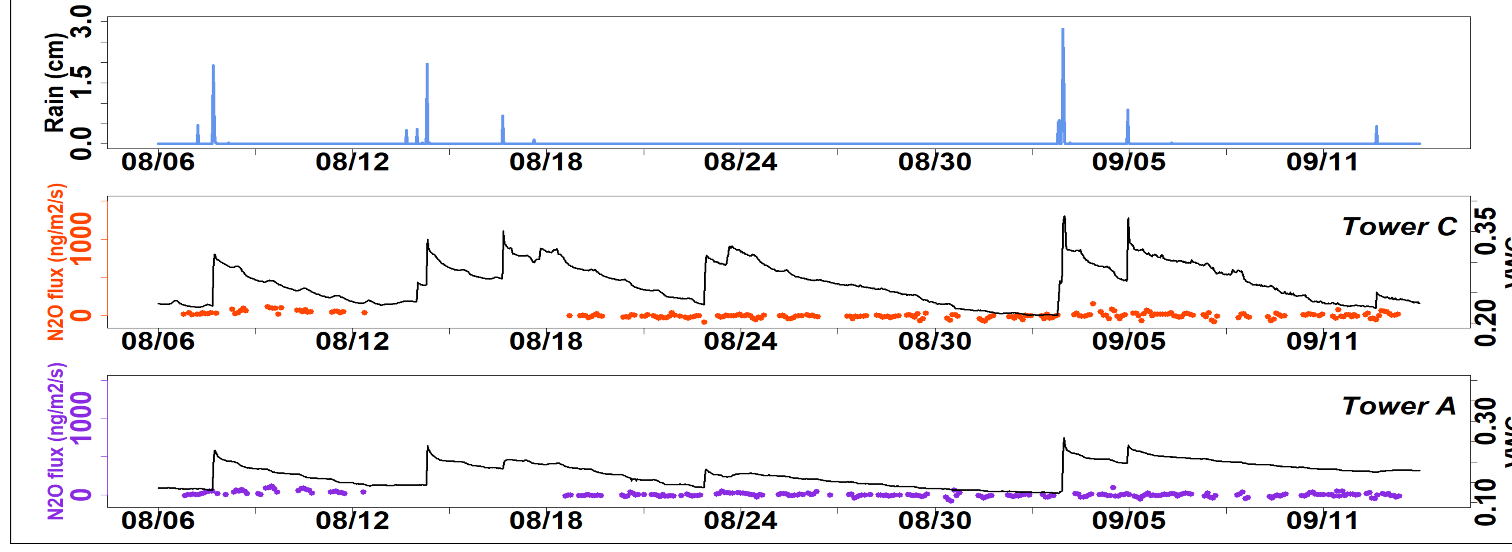
- $N_2O$ emissions had the same general trend over time in all four fields: peaking in May after fertilization and precipitation events and decreasing to close to zero for the remainder of the year. No significant DWM treatment effect was found.




- 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.

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