Continuous, Long-Term, Field-Integrated Measurements of N_2O Emissions Using Static Chambers and the Flux Gradient Method over Winter Wheat Fields in the Inland Pacific Northwest

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Introduction

- Nitrous oxide (N_2O) is a greenhouse gas and ozone depleting substance
- Agricultural soils are the largest single source of N_2O, due to the increase in available N from fertilizers
- N_2O is difficult to measure due to
  - spatial and temporal variability of emissions
  - precision of instrumentation
- The Intergovernmental Panel on Climate Change (IPCC) Tier I estimate for N_2O emissions: 1% of applied fertilizer N
- Need to identify management strategies that minimize emissions

Study Objectives: Establish a baseline of N_2O emissions for cereal-based agriculture in the Inland PNW:

1. Continuously monitor emission of N_2O at paired conventional till and no-till sites.
2. Compare results between chambers and micrometeorological techniques
3. Strategically use results from different measurement types to scale the emissions spatially and temporally

Site & Methods

Site Description:

- Paired sites at WSU Cook Agronomy Farm (CAF), located just outside of Pullman, WA
  - One no-till since 1998
  - One conventional tillage
- Grew winter wheat last season

Methods:

- Hybrid approach combining automated static chambers and the tower-based flux gradient technique[1,2] sharing one N_2O analyzer

$$F_{N_2O} = \frac{\Delta C}{\Delta t} * \frac{V}{A}$$

- Can detect very small N_2O fluxes
- Not subject to data loss due to ambient conditions (i.e. low turbulence)

$$F_{N_2O} = -K * \Delta N_2O$$

- K is calculated via similarity theory OR by using tmpr as a tracer
- Continuous measurements
- Integrates whole-field scale
- Minimal site disturbance

Results

Time series of N_2O fluxes

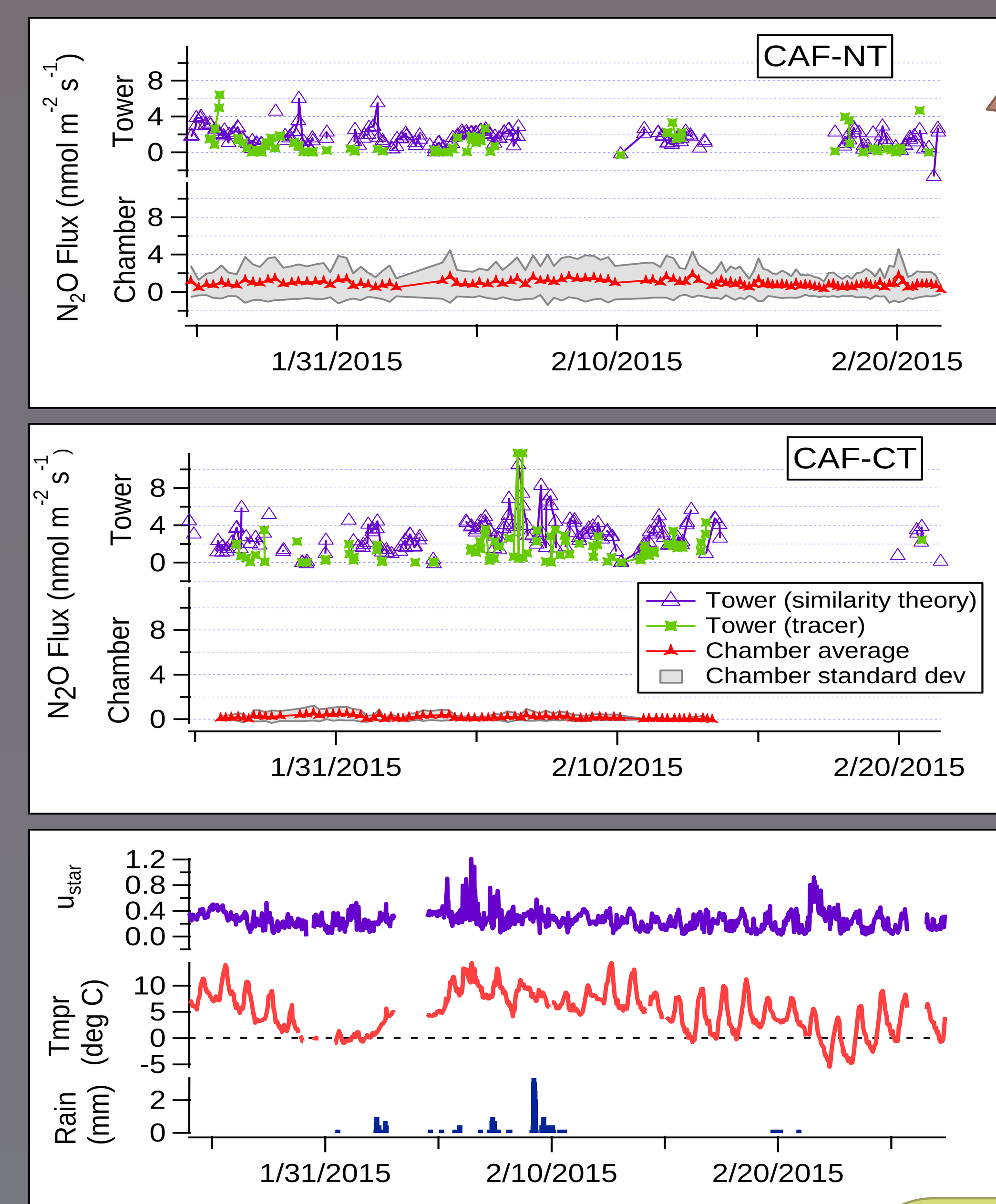


Figure 1: Time series plot comparing the N_2O fluxes measured by the chamber system vs. those measured using the flux gradient technique (FG). CAF-NT is the no-tillage site on the north field of the Cook Agronomy Farm; CAF-CT is the conventional tillage site west of Cook Agronomy Farm. It is possible that the chambers at CAF-CT were malfunctioning (leaking) at CAF-CT.

Ambient temperature and precipitation are also plotted; two factors that can influence N_2O production and emission.

N_2O emission budgets for the monitoring period

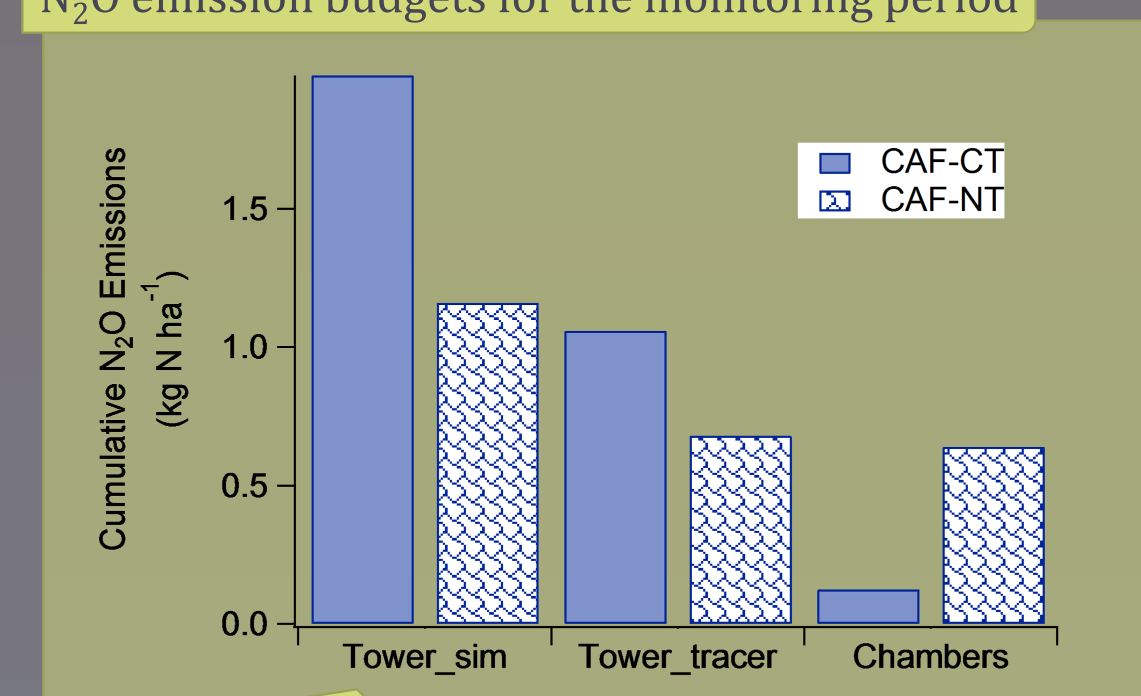


Figure 3: Cumulative N_2O emissions over the monitoring period (25 January – 21 February 2015; 28 days) in kg N ha^{-1}. The difficulty of determining N_2O budgets is highlighted by the variability between the methods. These fields have higher emission of N_2O than the "average" field – the IPCC Tier 1 estimate of 1% of fertilizer N lost as N_2O would result in emissions of only ~1-2 kg N_2O-N ha^{-1} yr^{-1}.

Scaling from the monitoring period (28 days) to a whole years yields an annual emission from 1.6 to 26 kg N_2O-N ha^{-1} yr^{-1} at CAF-CT and from 8.3 to 15 kg N_2O-N ha^{-1} yr^{-1} at CAF-NT. The average of the cumulative chamber results from the 2013-2014 crop year at CAF-NT was 10± 6 kg N_2O-N ha^{-1} yr^{-1}.

Diurnal Trends

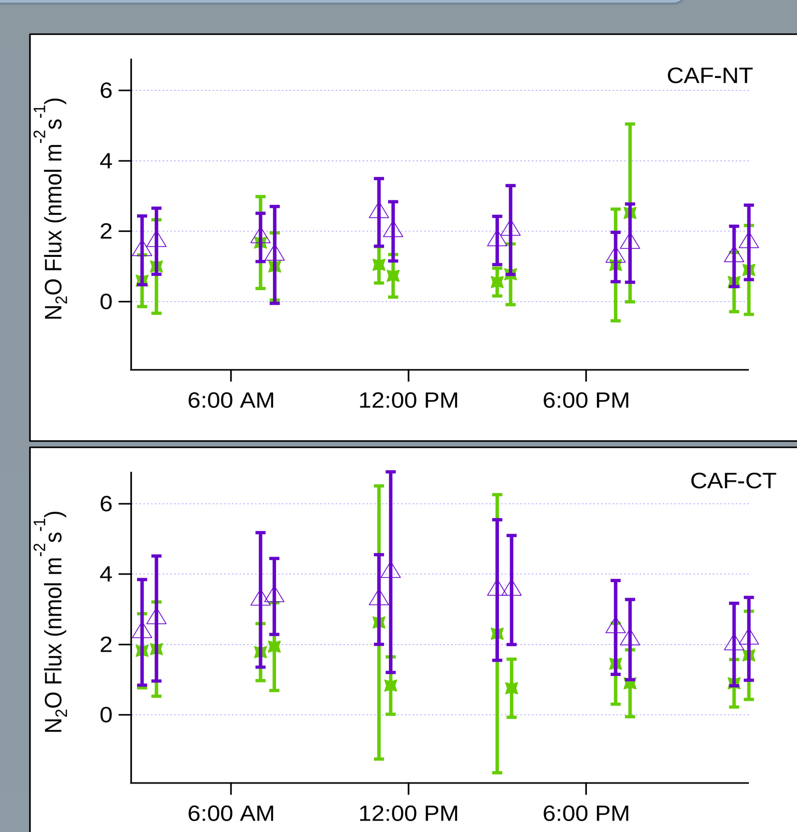
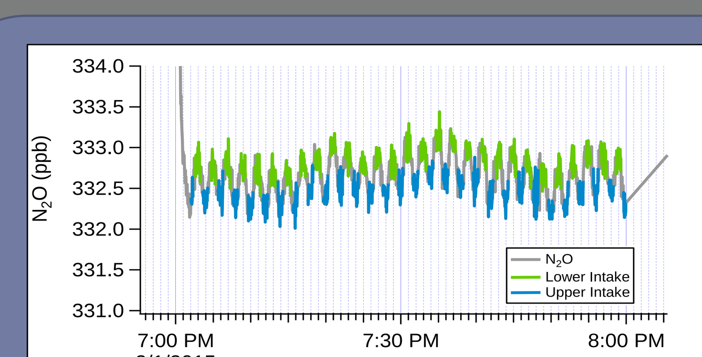


Figure 2: The diurnal trend exhibited at both the no-till and conventional tillage sites. The pattern of higher emissions during the day and lower at night gives us confidence in the accuracy of the tower flux measurements.



Time series of N_2O measurements showing the gradient in mixing ratios over a height of ~1.3 m

Importance of Continuous Monitoring

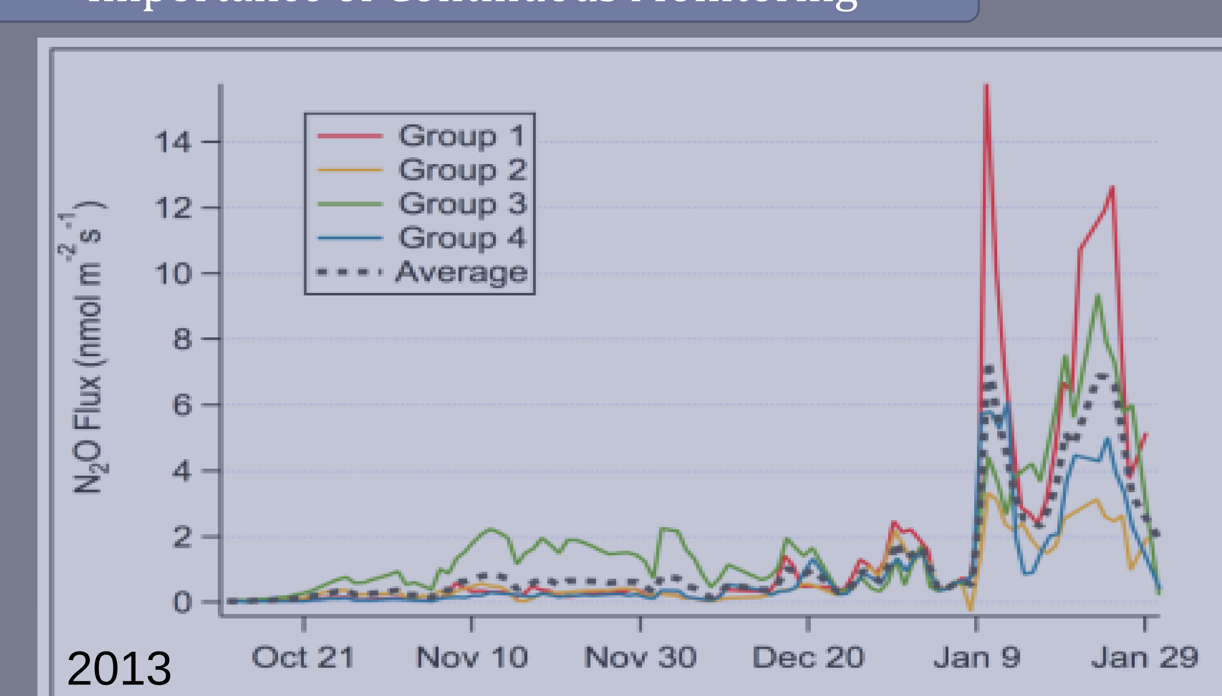


Figure 4: This time series shows a hot moment (notice y-axis scale) observed in the winter of 2013-2014, likely catalyzed by freeze-thaw cycles in the soil. These elevated emissions were unexpected since temperatures were so low. Unfortunately, the tower-based monitoring was not deployed last winter for comparison.

This winter has been more mild and emissions have remained at "baseline" levels.

Conclusions & Ongoing Work

The multi-scale monitoring system is effective at measuring N_2O fluxes at useful scales in time and space. We plan to keep these paired systems deployed for >1 year, monitoring both hot moments (Figure 4) and background fluxes. The results will allow our group to determine an annual N_2O emission budget for the field, and give insight into how emissions are impacted by management activities and environmental conditions. Ongoing work includes:

- Monitoring at a paired conventional tillage site
- Refining the quality control and filtering procedure for the FG results
- Optimizing timing of chamber vs. FG monitoring
- Developing techniques for scaling from chambers to field-scale[3] (weighted averages, non-linear regressions)
- Investigating relationship between emissions and environmental variables (temperature, soil moisture, fertilization rate, tillage, etc)
- Comparing empirical results to model results for this region[4], and using the measurements to improve field scale and regional models such as CropSyst.

References

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