Application of an automated canopy-scale chamber system to measure N_2O, CH_4, and CO_2 fluxes from rice (*Oryza sativa*) under commercial production

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Introduction

- Plant mediated fluxes of trace gases (e.g. CH_4 and N_2O) are potentially important components of the greenhouse gas budget in many ecosystems.
- Measurement of these fluxes is possible through a variety of methods. For measurements constrained to the canopy-scale, use of large (one to a few cubic meters in volume) closed-transient chambers has been common.
- At the canopy-scale, the most common chamber-based methods often involve manual sampling, limiting the ability of these methods to capture temporal dynamics. Automated chambers provide one option to improve temporal resolution, but have historically been challenging to implement, particularly under flooded field conditions.
- Here we describe a simple to use, automated canopy-scale chamber system for the measurement of plant-mediated trace gas fluxes. We demonstrate its performance using field data collected over a growing season in a commercial rice (*Oryza sativa*) field located in Arkansas.

Chamber system

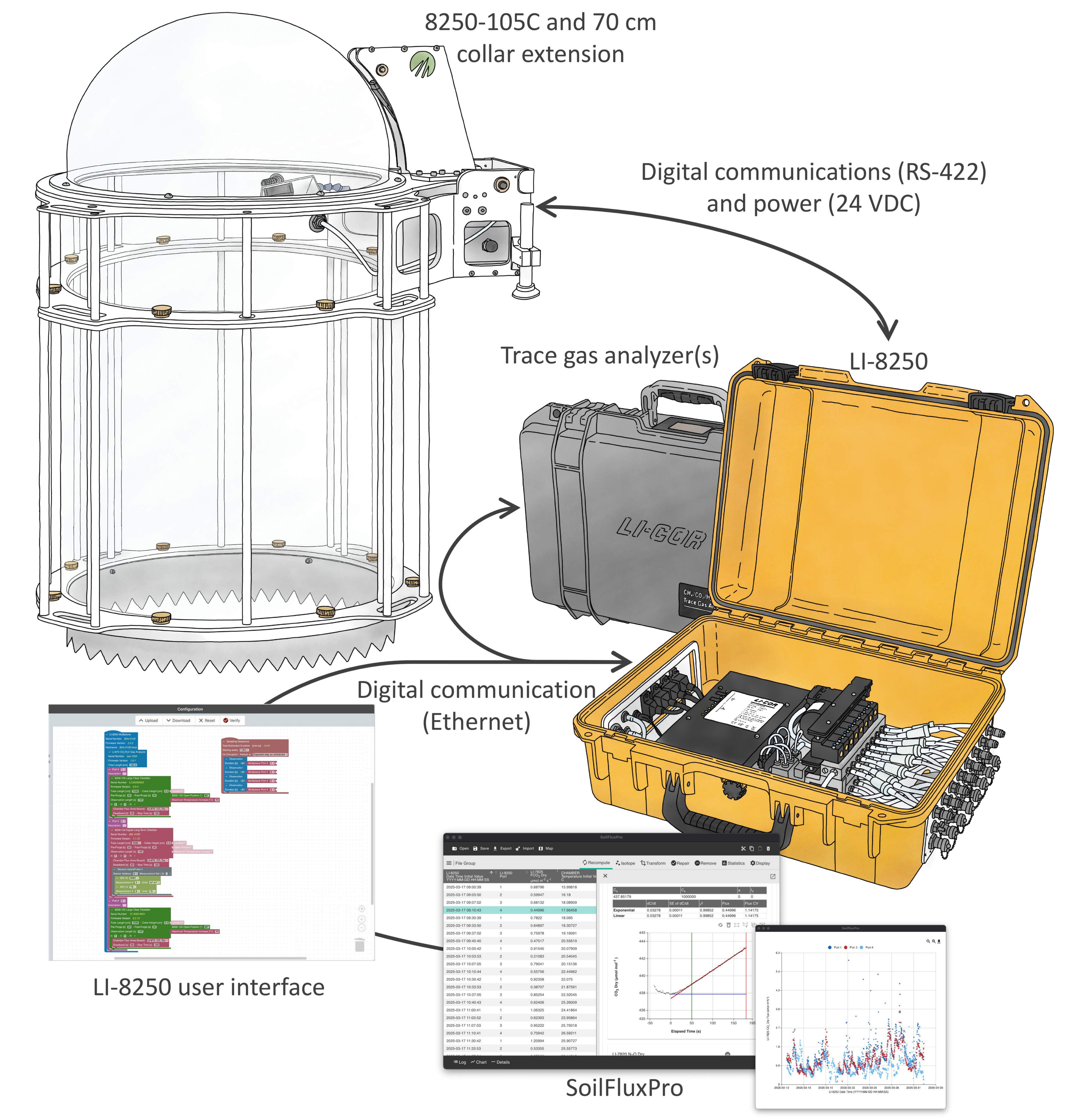

Figure 1: Key components of the integrated canopy chamber system. Note that the 8250-105C is special variant of the eosAC-LT (Eosense Inc.).

Field deployment

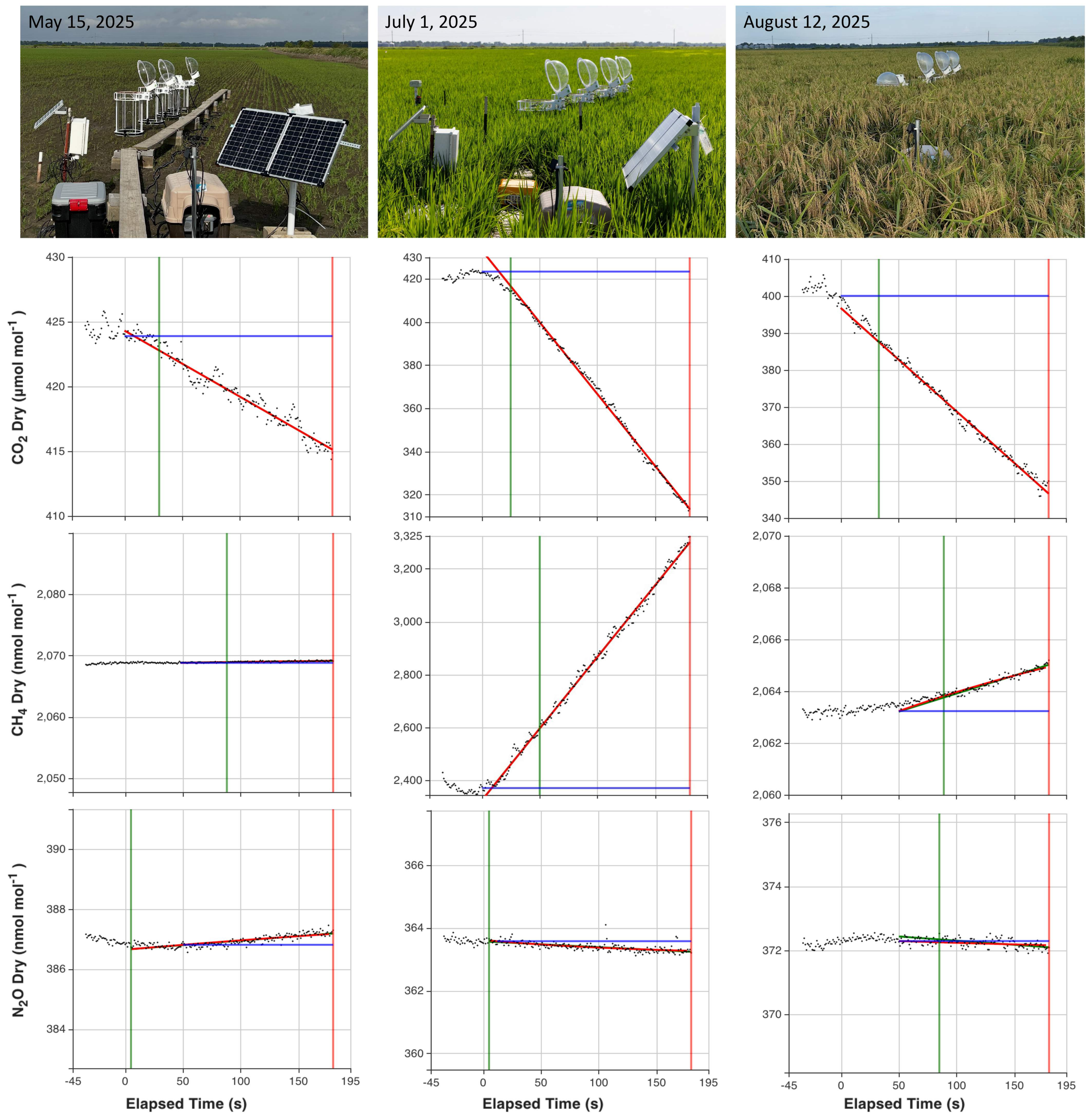

Figure 2: A four-chamber system, including an LI-7810 (CO_2 and CH_4) and LI-7820 (N_2O) trace gas analyzer, was deployed in a commercial rice field over a growing season. Images at top show the chambers and canopy conditions at the start (May 15, 2025), middle (July 1, 2025) and end (August 12, 2025) of the deployment. Plots below the images show a set of representative accumulation curves from a single chamber collected at mid-day on the date of the image. Vertical green and red lines mark the start and stop of data used in flux calculations, respectively, determined using SoilFluPro's guidance tools.

Figure 3: To accommodate flood and drain cycles during the experiment each chamber base was fitted with a pair of manually operated gate valves (right) and chamber volume used in the flux calculations was corrected for water depth.

Flux measurements

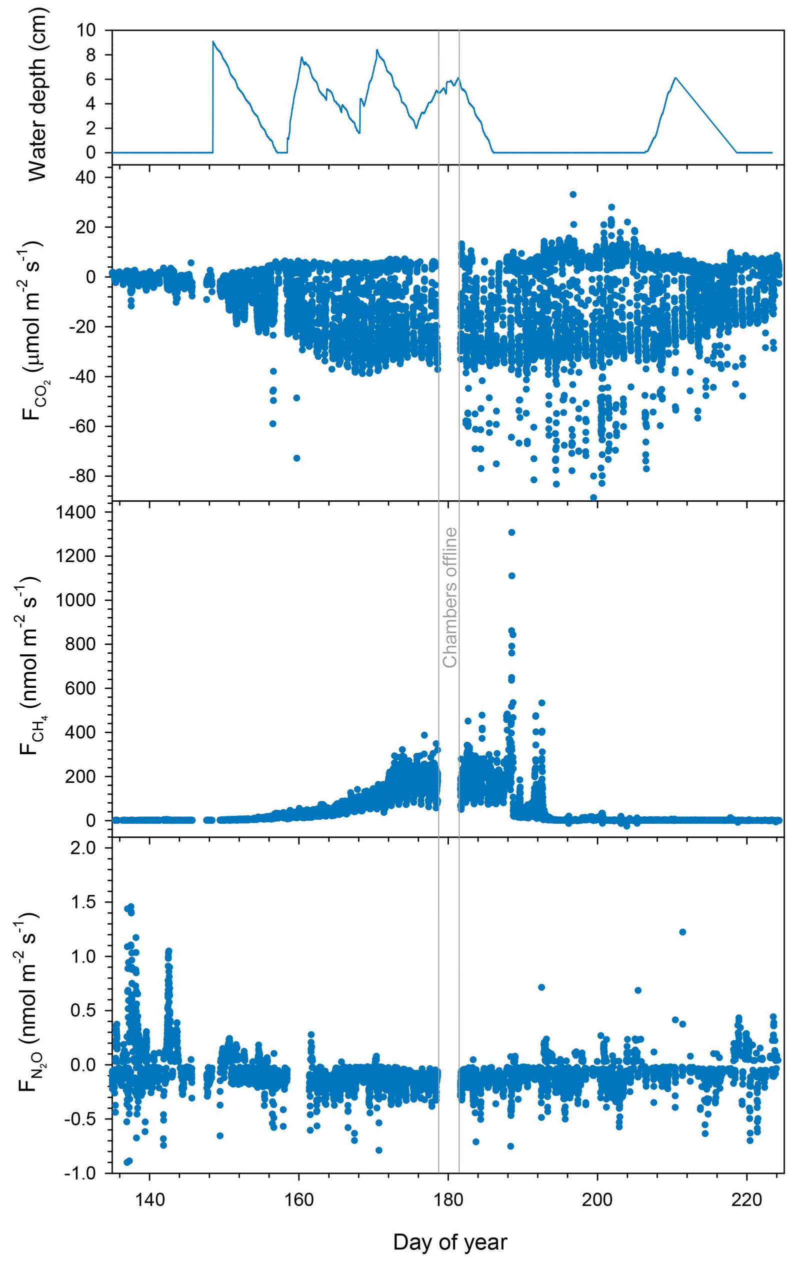

Figure 3: Water depth and fluxes observed over the 91-day field deployment. Of the 15895 observations made with the chamber system, 2994 were removed after filtering the raw time series data for hardware related quality flags. Fluxes shown are additionally filtered for T_0<30, R2>0.1, relative uncertainty<3, and flux<3σ from adjacent observations, reducing the number of observations to 10747 for CO_2, 8932 for CH_4, and 5105 for N_2O.

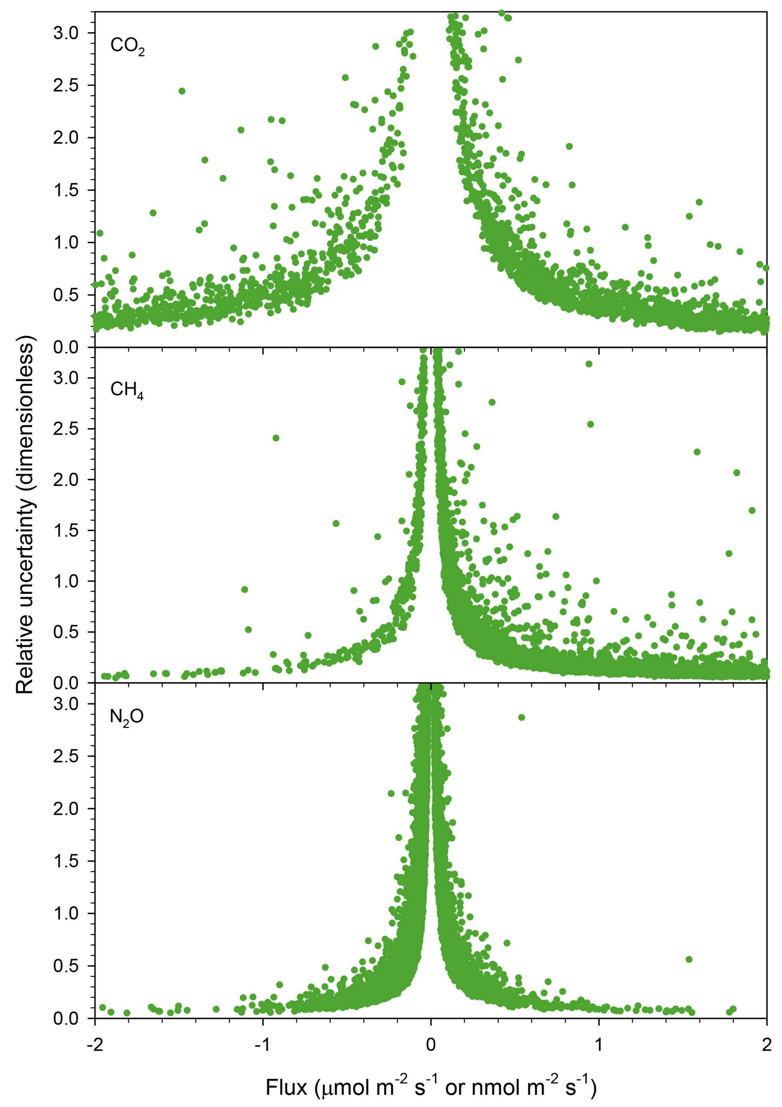

Figure 4: Flux uncertainty expressed relative to the absolute value of the flux for fluxes near zero. Uncertainty was estimated on a per observation basis from the standard error of the slope (SES) and the number of data points in the observation ($l-d$):

$$\text{Uncertainty} = \frac{VP_0\left(1-\frac{W_0}{1000}\right)}{RS(T_0+273.15)} SES\sqrt{l-d}$$

Conclusions

- This work demonstrates suitability of an automated canopy-scale chamber system for measurement of greenhouse gas flux measurements in wetland environments.
- The automated nature of the measurement system allowed for measurements at fine temporal resolution, capturing dynamic and episodic flux behavior.
- Despite complex and variable canopy conditions, variations in water depth, and the large chamber volume, the chamber system was able to resolve fluxes with low uncertainty.
- Uncertainty estimates (99.7% confidence interval) suggest a limit of detection between 0.1 and 0.2 µmol m⁻² s⁻¹ for F_{CO2}, and between 0.01 and 0.1 nmol m⁻² s⁻¹ for both F_{CH4} and F_{N2O} for the chamber system as deployed here.

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