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Biophysical drivers of carbon dioxide and methane fluxes in a restored tidal freshwater wetland

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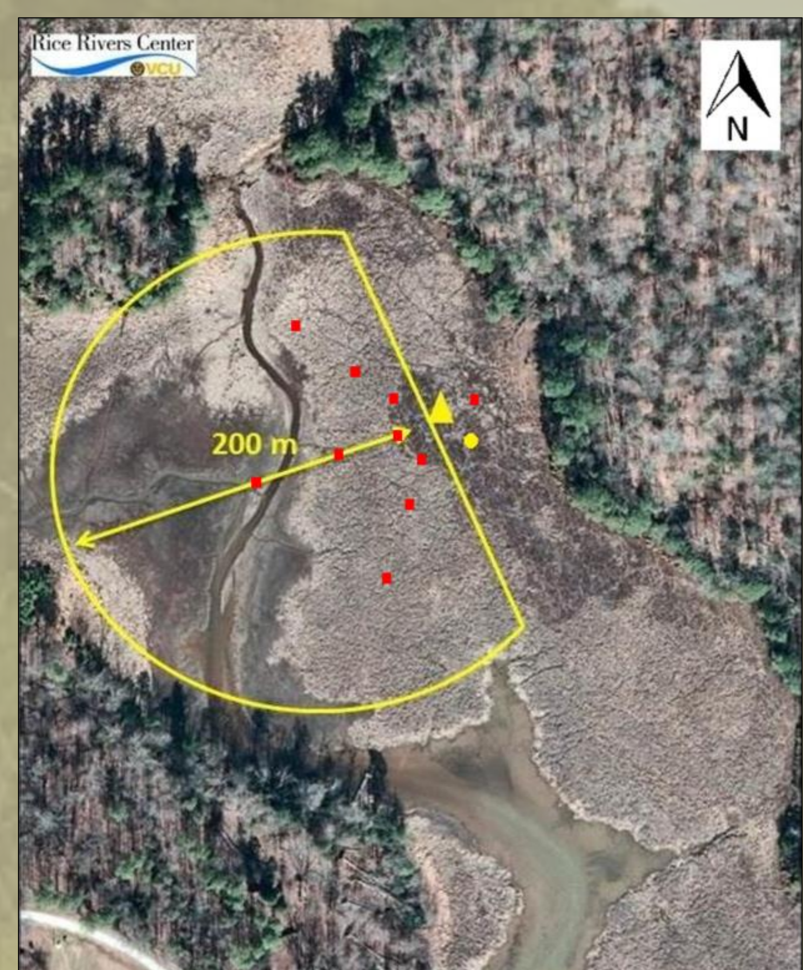
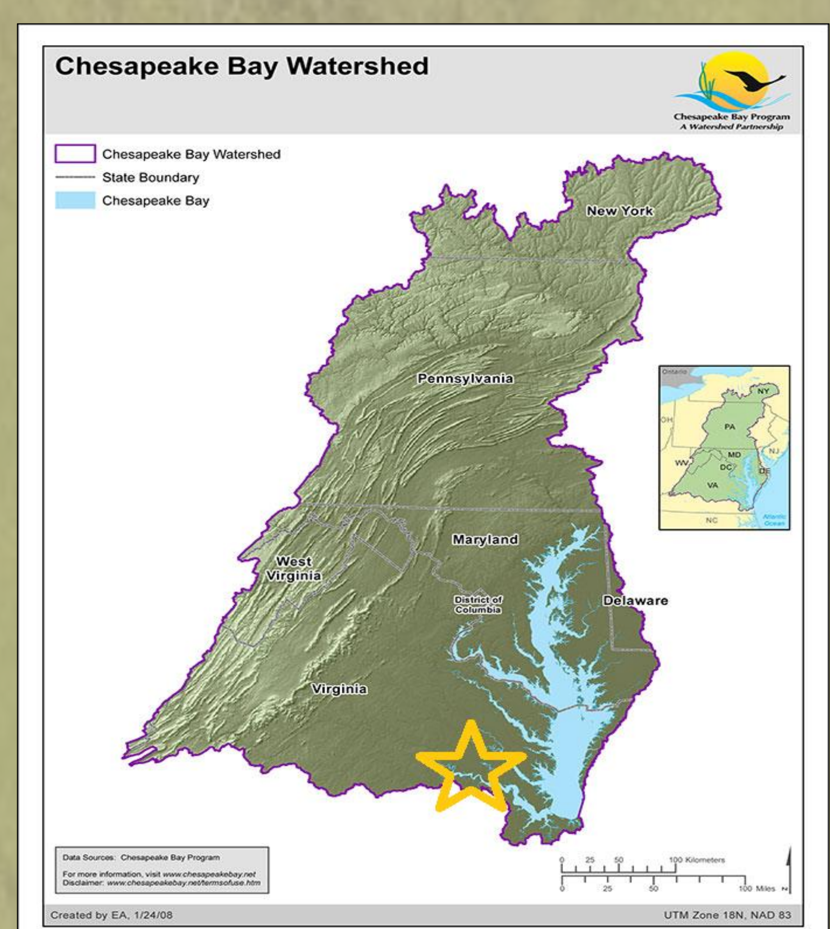
I. Background and Mapped Location

- Wetlands store large amounts of carbon (C) in biomass and soils, playing a crucial role in offsetting greenhouse gas (GHG) emissions; however, they also account for 30% of global yearly CH_4 emissions.
- Anthropogenic disturbance has led to the decline of natural wetlands throughout the United States, with a corresponding increase in created and restored wetlands.
- Studies characterizing biogeochemical processes in restored forested wetlands, particularly those that are both tidal and freshwater, are lacking but essential for informing science-based carbon management.



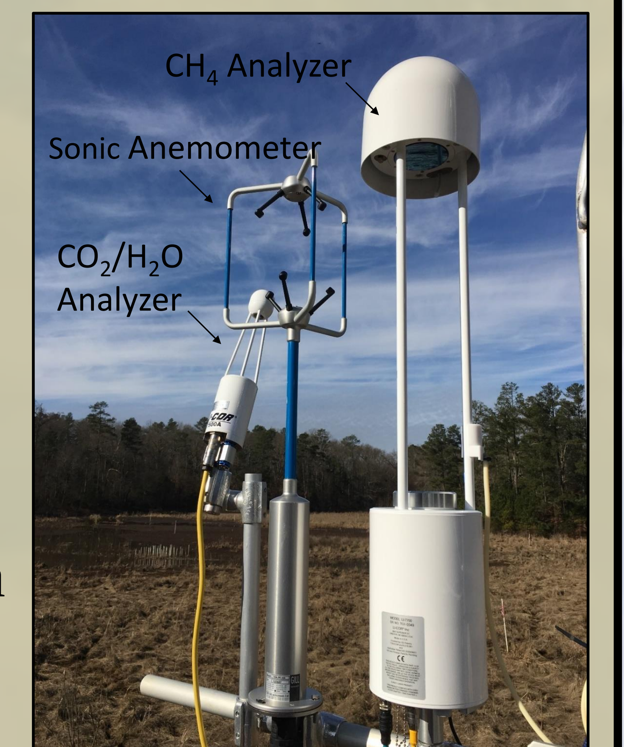
► The Rice Rivers Center flux tower (yellow triangle) and solar panel locations (yellow dot) are on the eastern bank in the northern tidal portion of the VCU Rice Rivers Center wetland. The flux footprint is outlined in a yellow semi-circle, with prevailing winds from the west. Red dots mark the locations of chamber-flux, water level, and soil carbon measurements.



► Restored and reference wetlands are 500 m apart and connect to the James River in the southern Chesapeake Bay watershed.

II. Site and Instrument Specifications

- The restored wetland at VCU's Rice Rivers Center was originally a tidal forested wetland before it was clear-cut and dammed to create a lake in the early 1900s.
- Tidal hydrology was restored in 2011 and the site now contains a mixture of native grasses, bald cypress (*Taxodium distichum*), black willow (*Salix nigra*), red maple (*Acer rubrum*), musclewood (*Carpinus caroliniana*), and loblolly pine (*Pinus taeda*).



► The set up of LI-COR eddy flux instrumentation on the tower.

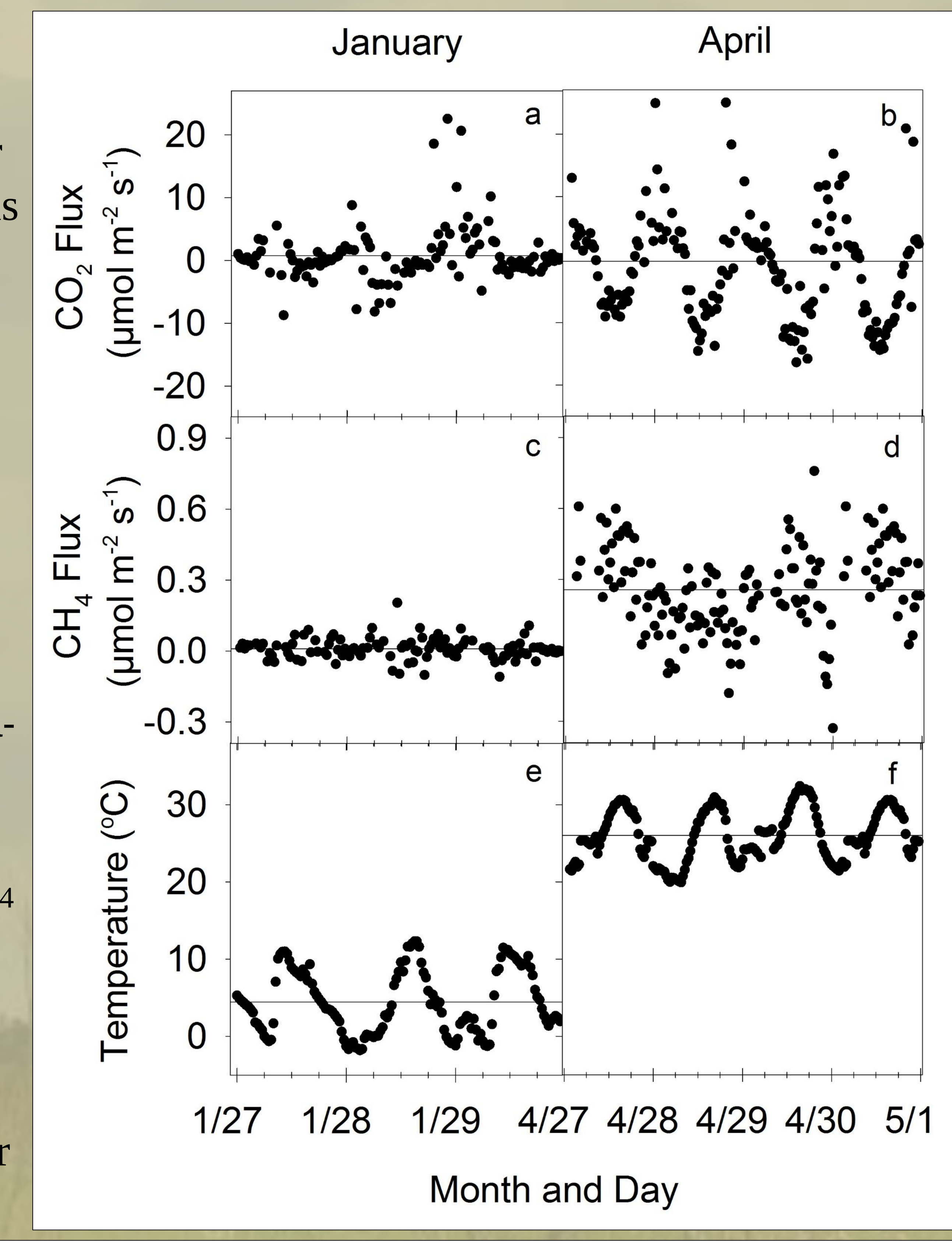
- Flux tower instrumentation is 6m above the marsh surface (twice canopy height), while the flux tower fetch extends 200 m.

III. Research Objectives

- Carbon fluxes in a restored tidal freshwater wetland:
  1. Quantify CO_2 and CH_4 exchange (flux);
  2. Interpret underlying biological and physical drivers of ecosystem-scale wetland-atmosphere C exchange and sequestration.
- Compare a restored wetland to a natural reference wetland:
  1. Pair chamber CO_2 and CH_4 fluxes and soil C measurements in adjacent established and restored wetlands to evaluate the extent to which restoration activities reestablish C cycling processes.

IV. 2017 CO_2 and CH_4 Fluxes

The amplitude of CO_2 flux exchange increased from January to April, but mean half-hourly fluxes were similar in early growing and dormant seasons (a, b). CH_4 fluxes were low during January, and more dynamic in April, likely due to increased methanogen microbial activity as well as passive diffusion through vegetation.



► Figure 1. Diurnal time series of CO_2 flux (a, b), CH_4 flux (c, d), and temperature (e, f) at the Rice Rivers Center in January and April 2017. Negative values indicate gas uptake (a-d). The solid line represents the mean value.

The magnitude of monthly mean CH_4 fluxes did not differ between an average winter month and the warmest February on record. This could indicate that microbial activity was limited by potential lags in water temperature or that diffusion via vegetation makes up a greater proportion of CH_4 efflux into the atmosphere.

Table 1. Mean monthly temperature, CO_2 (carbon dioxide) flux, and CH_4 (methane) flux at Kimages Creek restored wetland during an average (January), an extremely warm (February) winter month, and a spring month (April) in 2017. Negative values indicate flux into the wetland while positive values indicate flux into the atmosphere. Asterisks (*) represent p = <0.0001.

Month	Temperature (° C)	Daytime Temperature (° C)	CO_2 Flux (μmol m^{-2} s^{-1})	CH_4 Flux (μmol m^{-2} s^{-1})
January	4.4*	9.2*	0.474	0.009
February	11.0*	19.4*	-0.058	0.003
April	21.1*	23.9*	0.139	0.170*

V. Future Work

- Compare chamber-based CO_2 and CH_4 fluxes and soil C to quantitatively compare C cycling function between restored and established wetlands.
- Within the tower footprint, characterize spatial variation in CO_2 and CH_4 fluxes by landform, vegetation type, and hydrology over the course of a year.

Acknowledgements

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