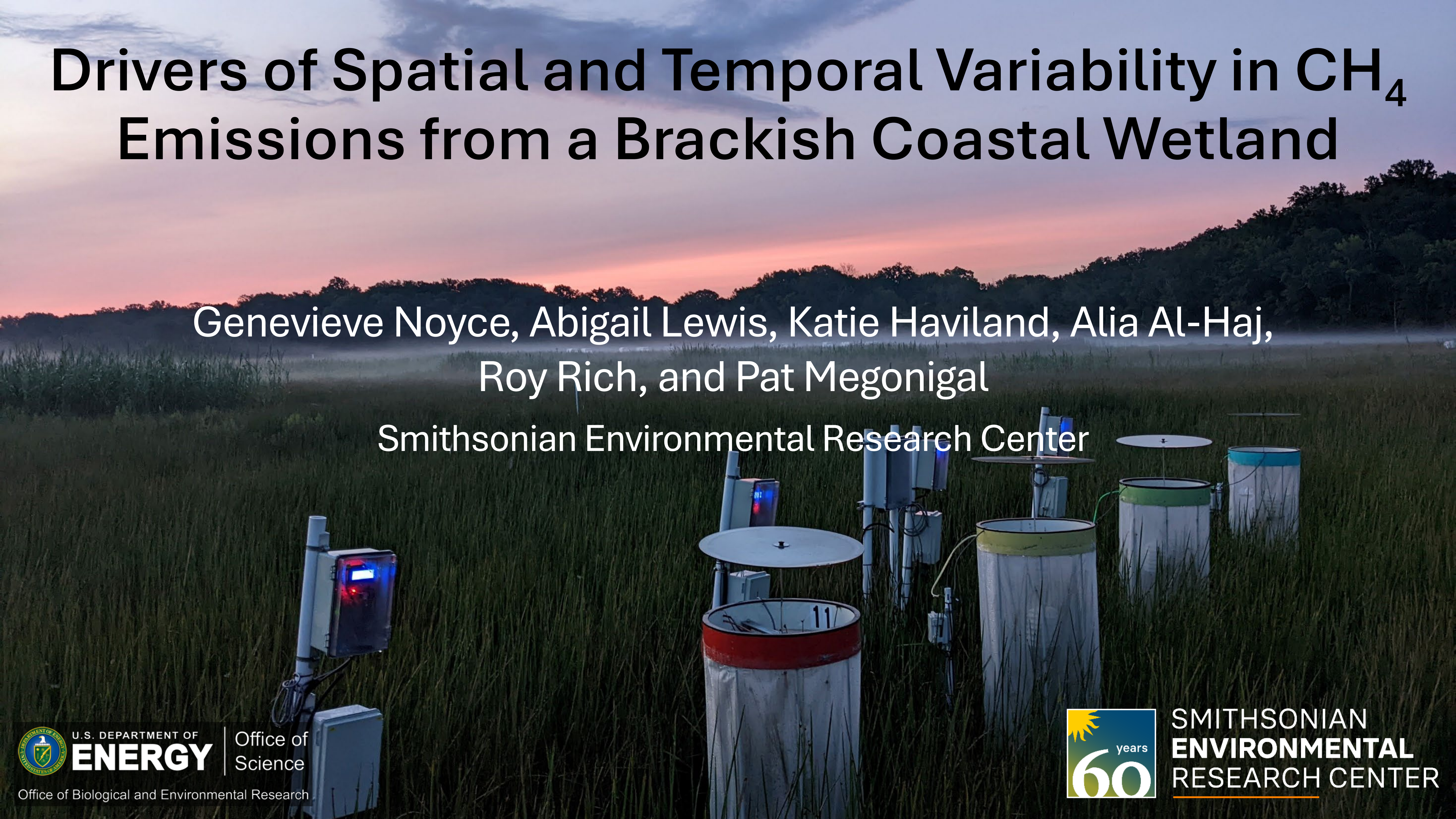
Drivers of Spatial and Temporal Variability in CH_4 Emissions from a Brackish Coastal Wetland

Genevieve Noyce, Abigail Lewis, Katie Haviland, Alia Al-Haj, Roy Rich, and Pat Megonigal

Smithsonian Environmental Research Center



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60 years

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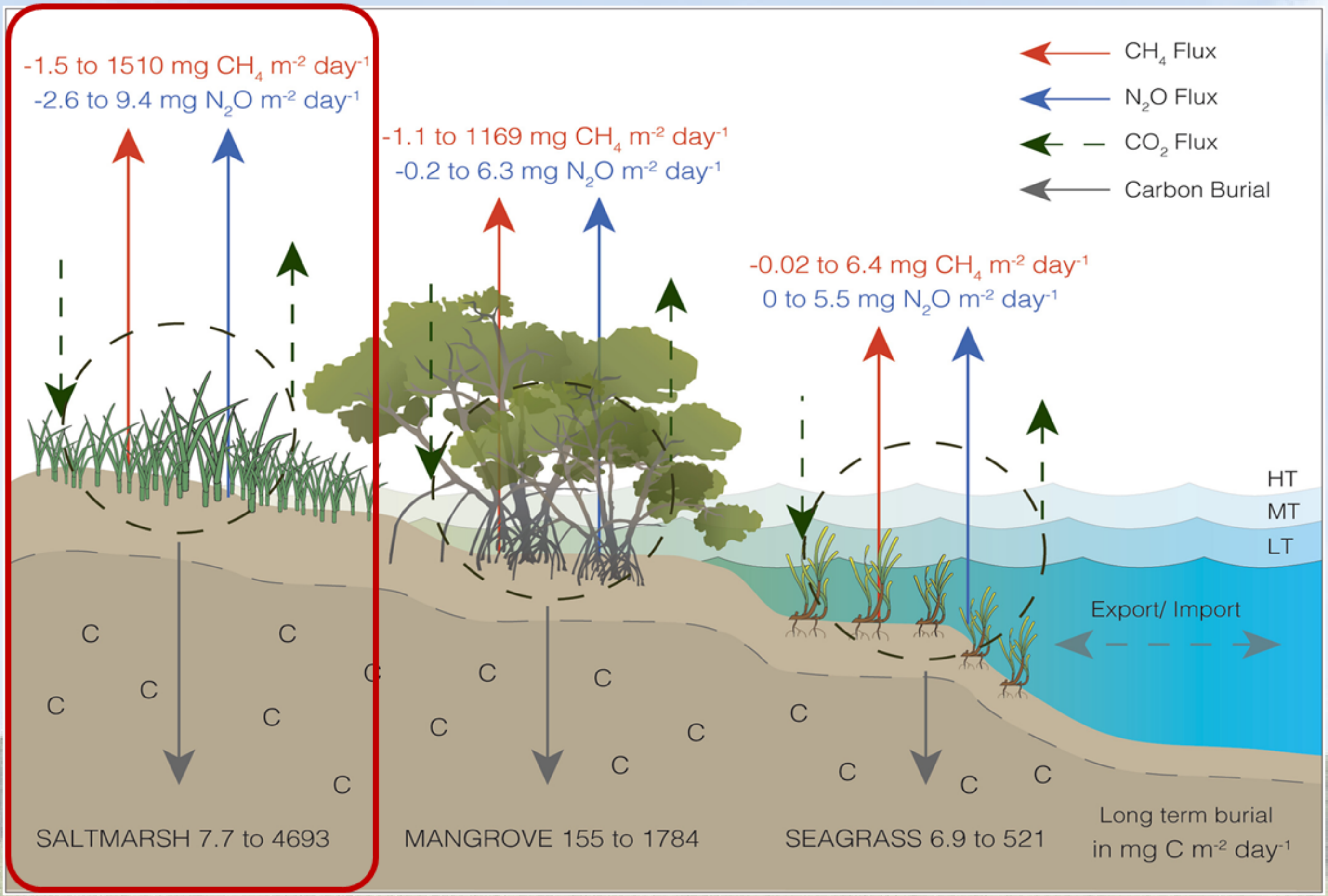
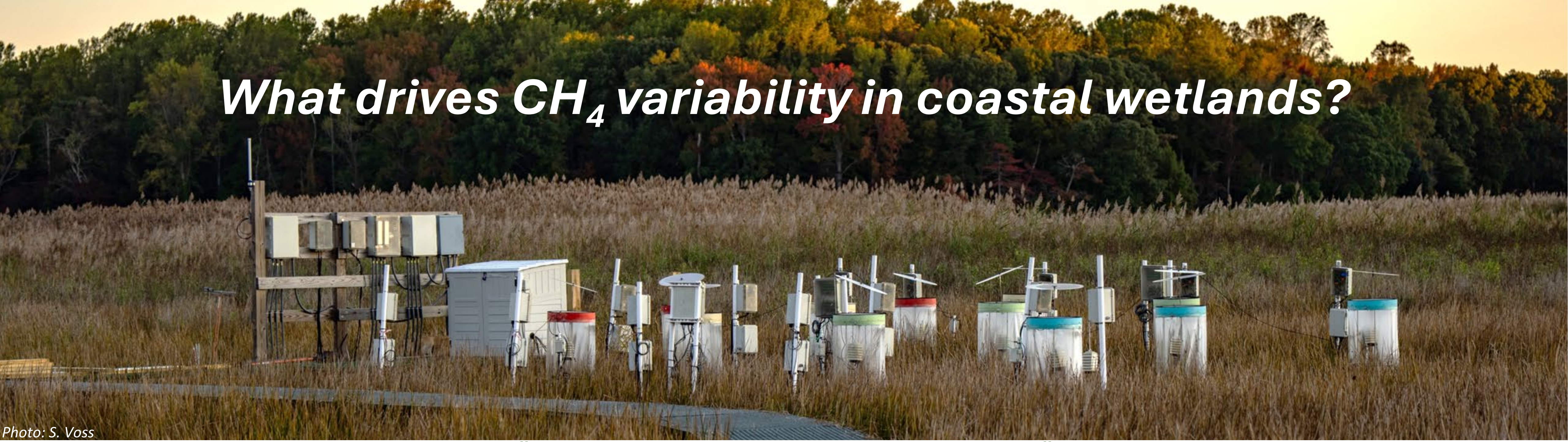
-1.5 to 1510 mg CH_4 m^{-2} day^{-1}

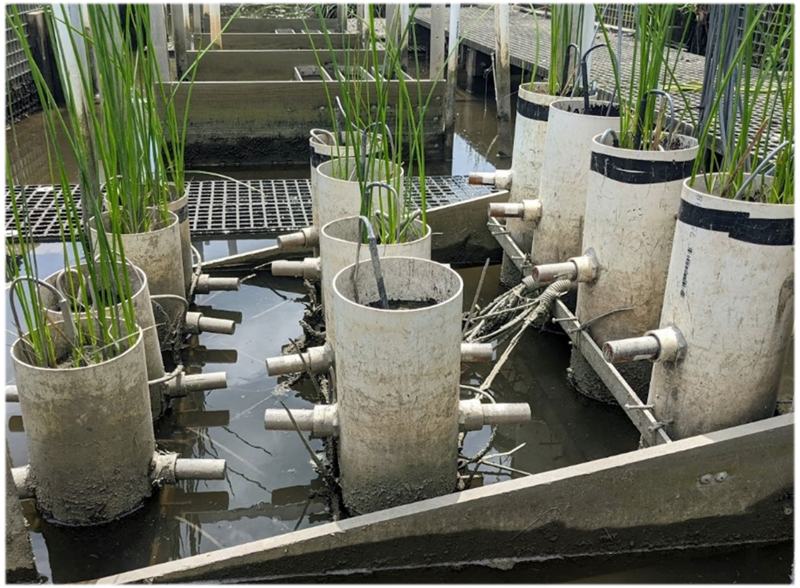


7.7 to 4693 mg C m^{-2} day^{-1}
(long term burial)

Rosentreter et al., 2021



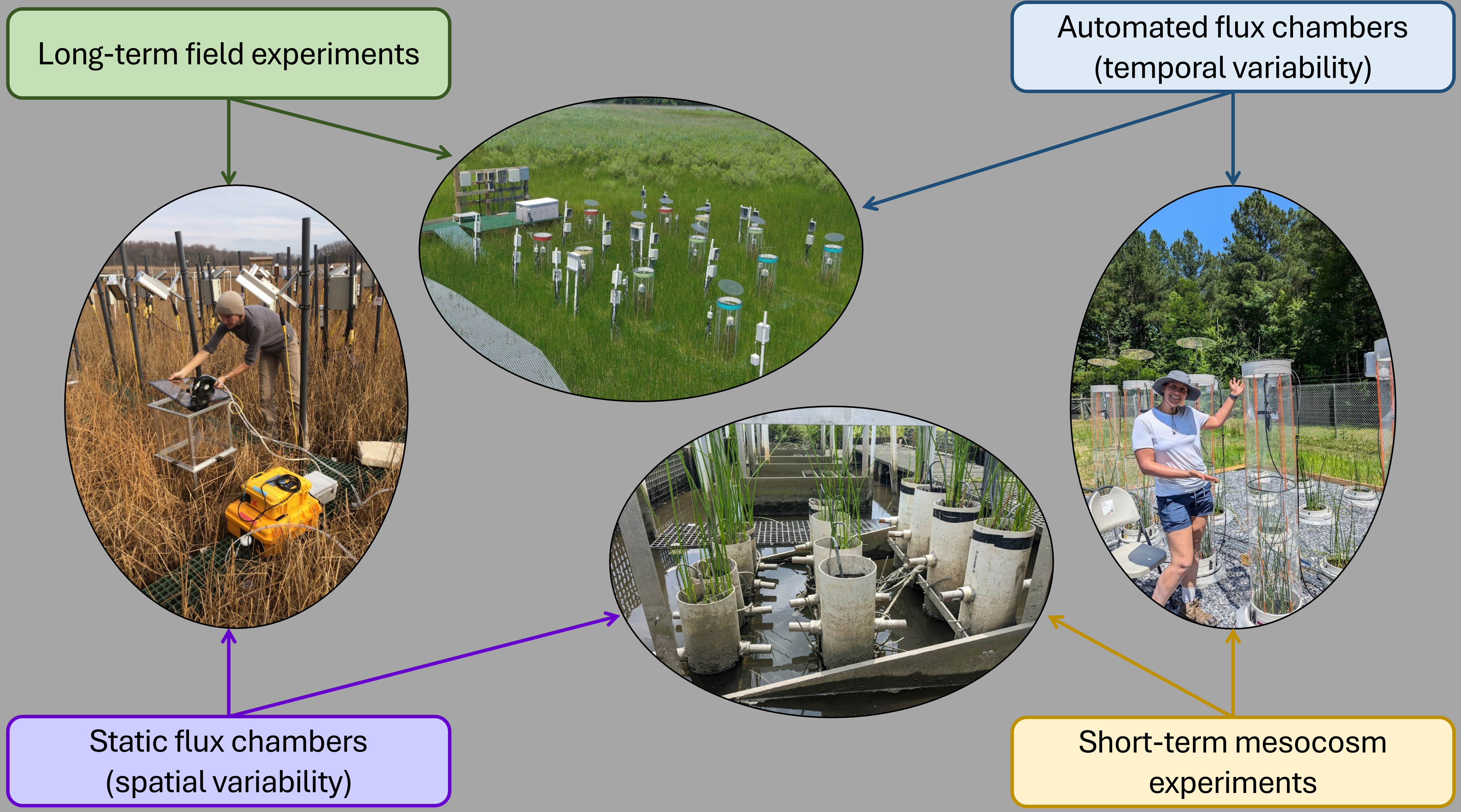
Flooding and Salinity

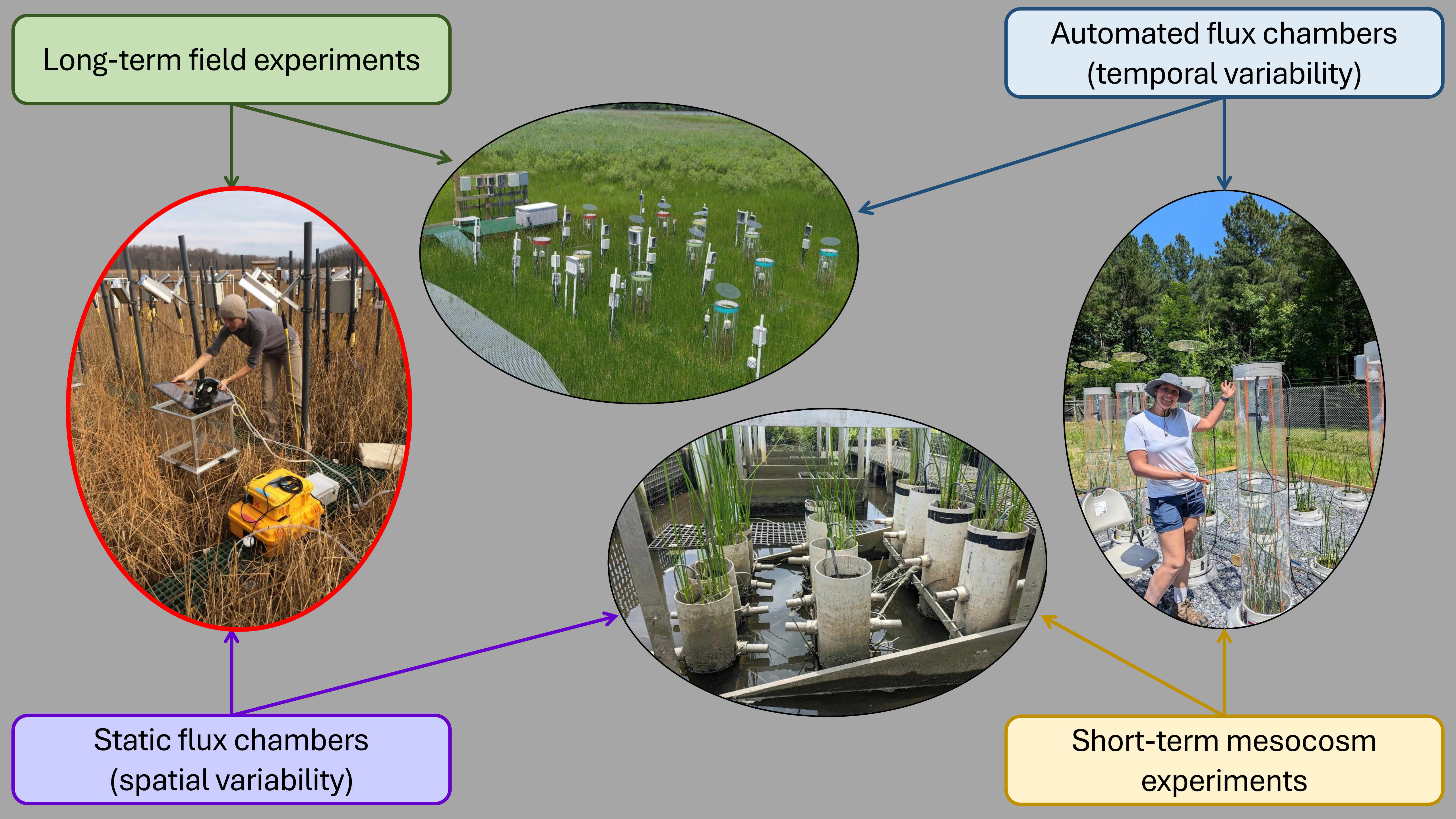


Warming

Plant Community

Global Change Research Wetland (GCReW)


Long-term field experiments
Automated flux chambers
(temporal variability)
Static flux chambers
(spatial variability)
Short-term mesocosm
experiments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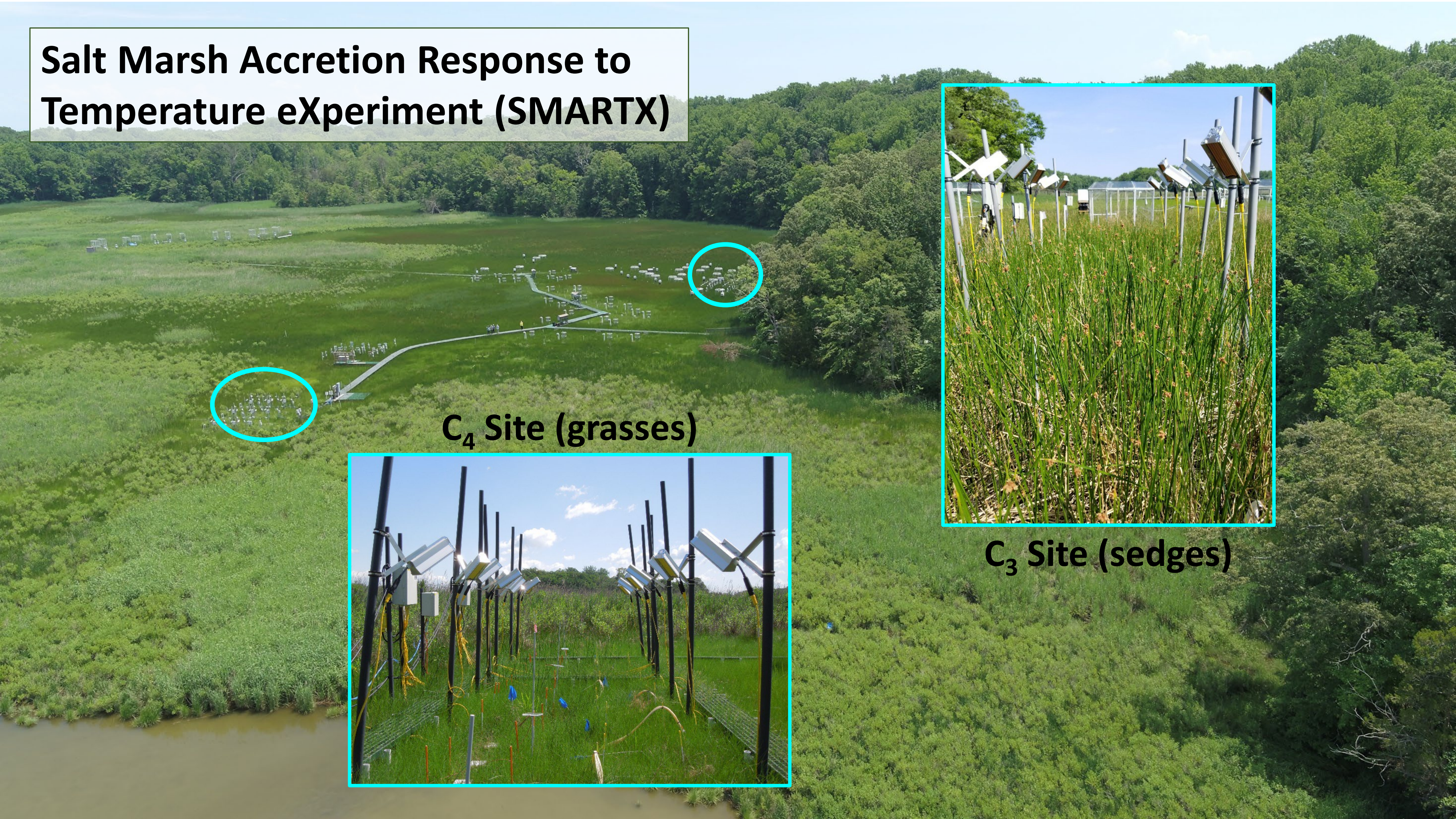
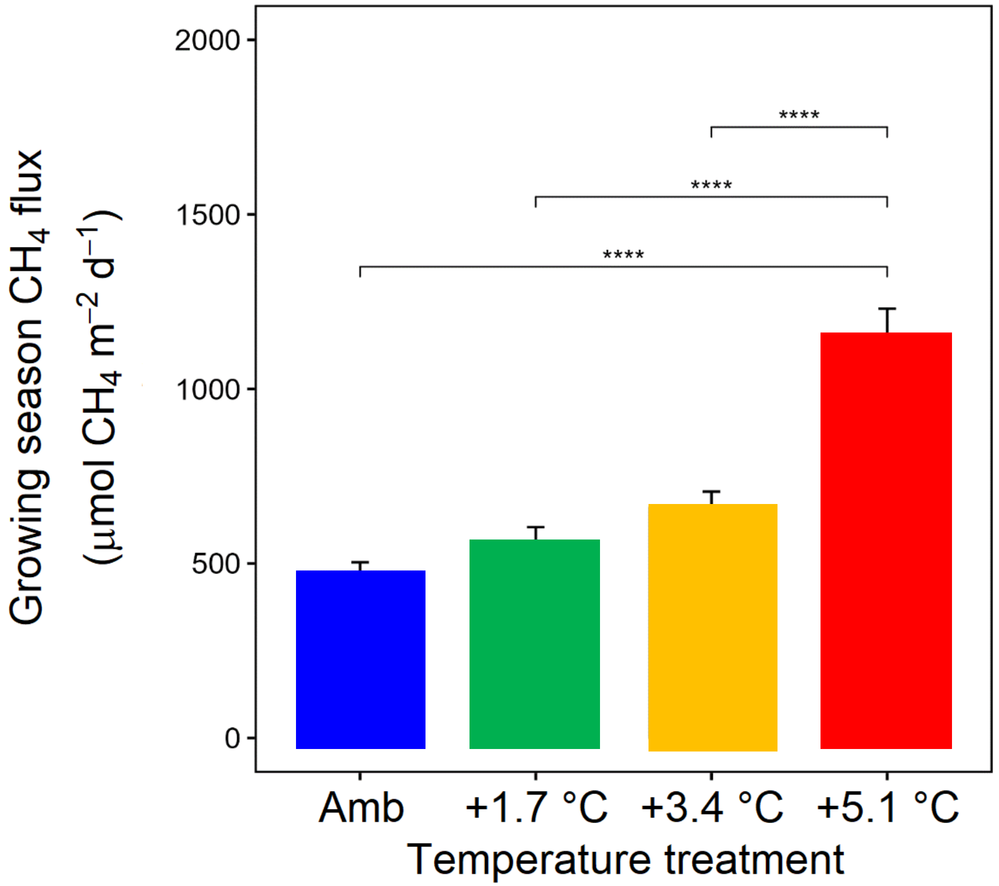
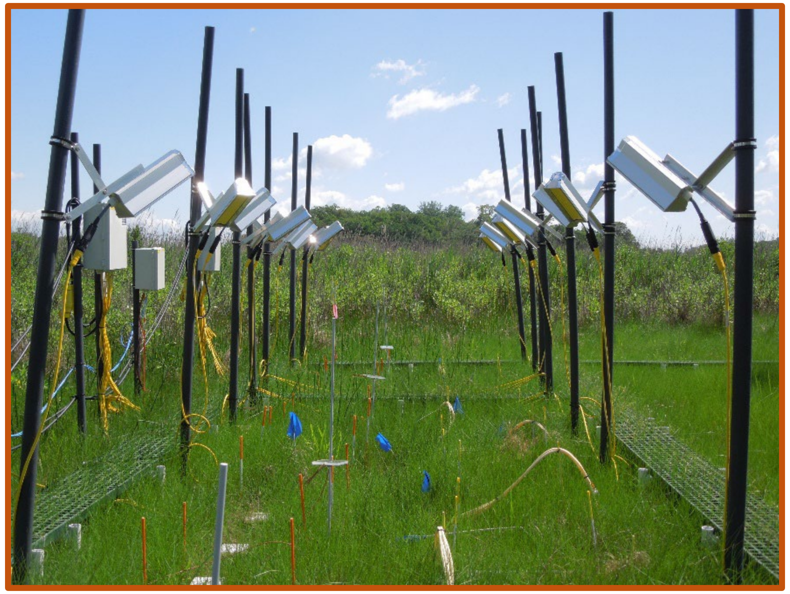

Salt Marsh Accretion Response to Temperature eXperiment (SMARTX)
C_4 Site (grasses)
C_3 Site (sedges)

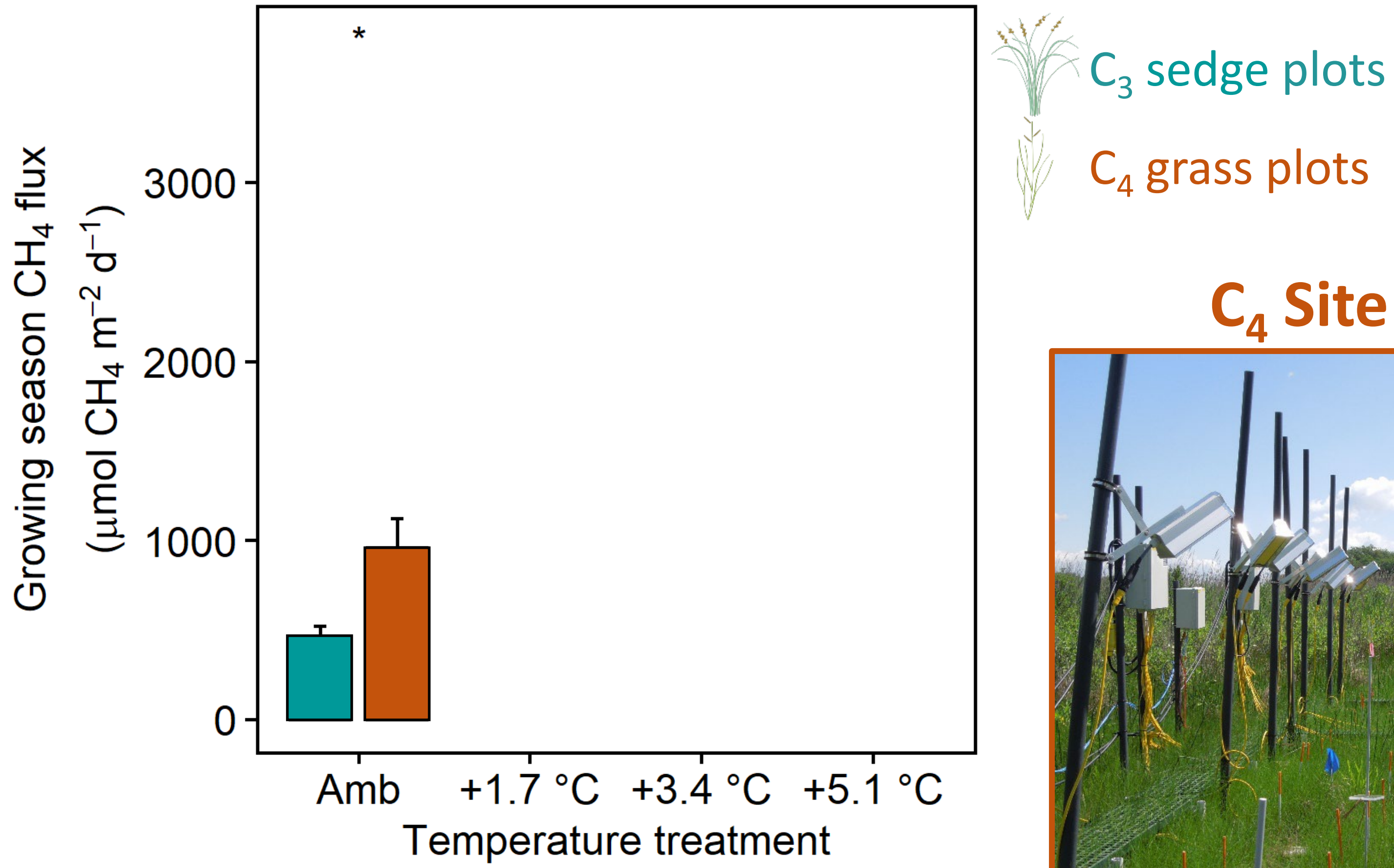


C_4 Site (grasses)



C_3 Site (sedges)

Methane emissions were consistently higher from drier *Spartina* (C_4 grass) sites than from wetter *Schoenoplectus* (C_3 sedge) sites.



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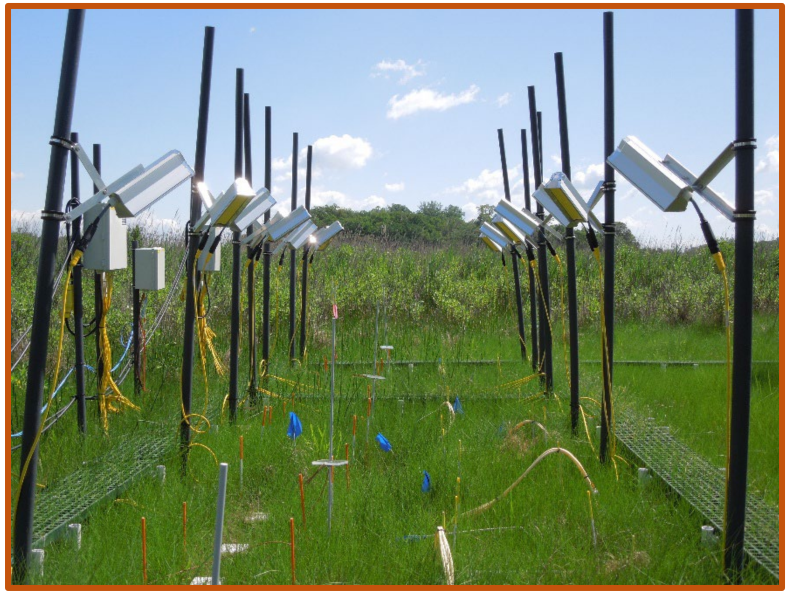

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Noyce and Megonigal (2021), *Biogeosciences*

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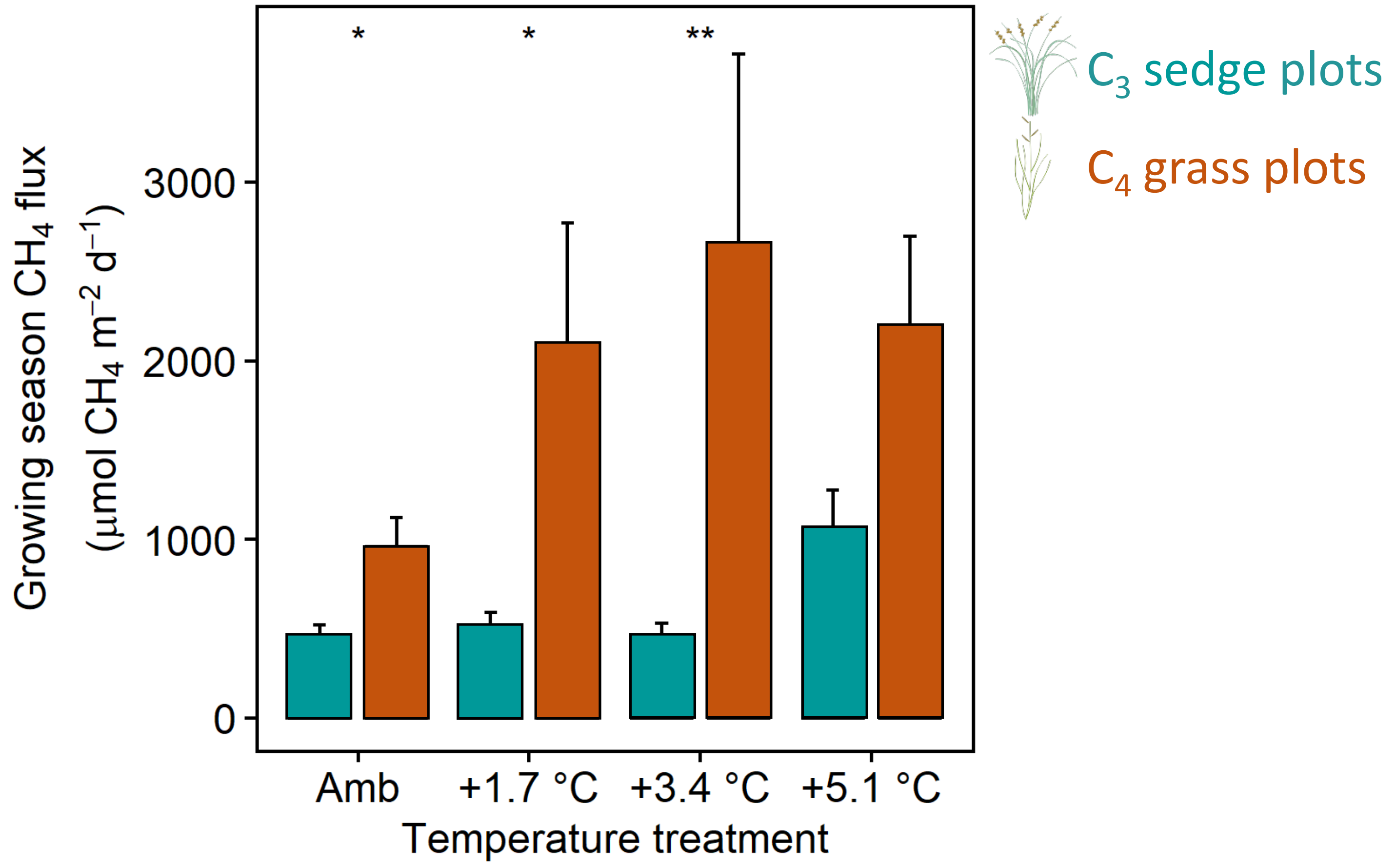
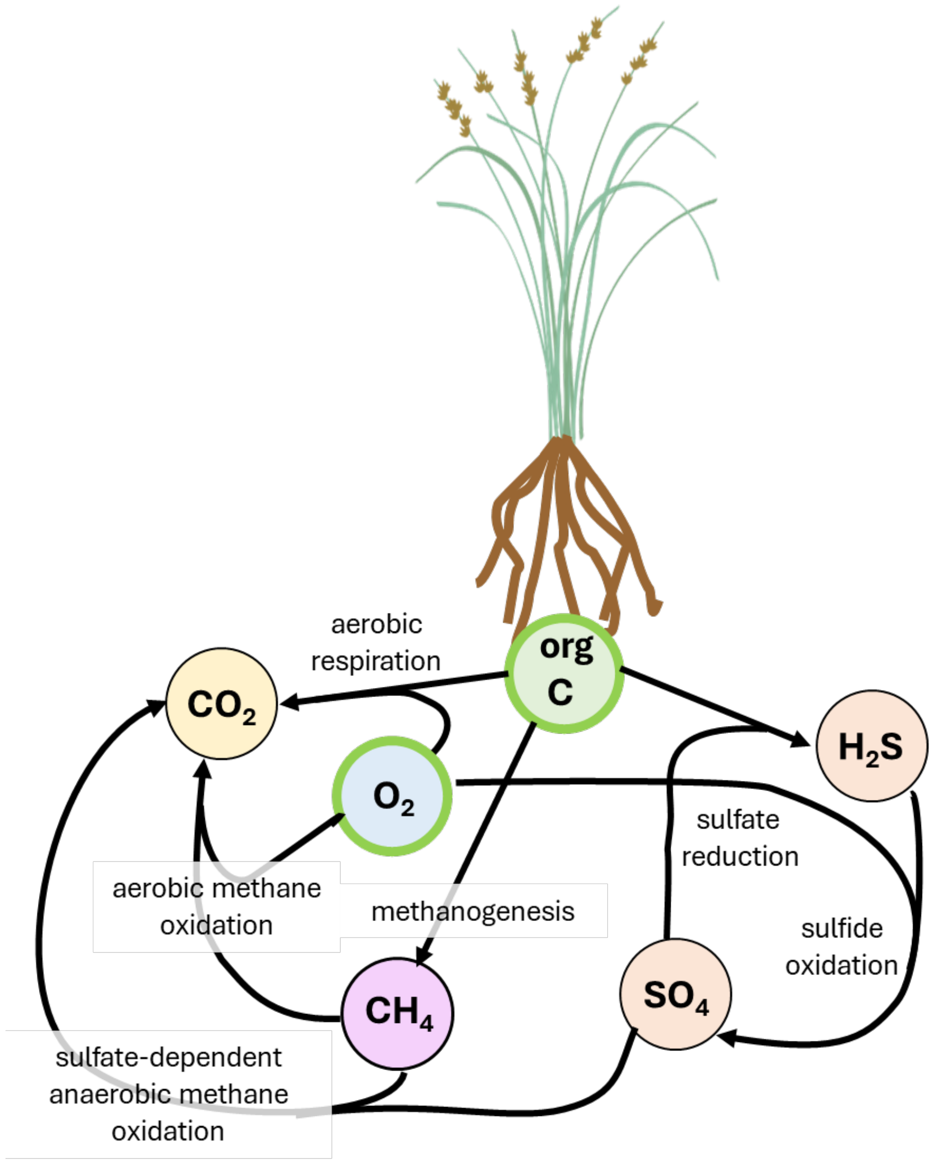
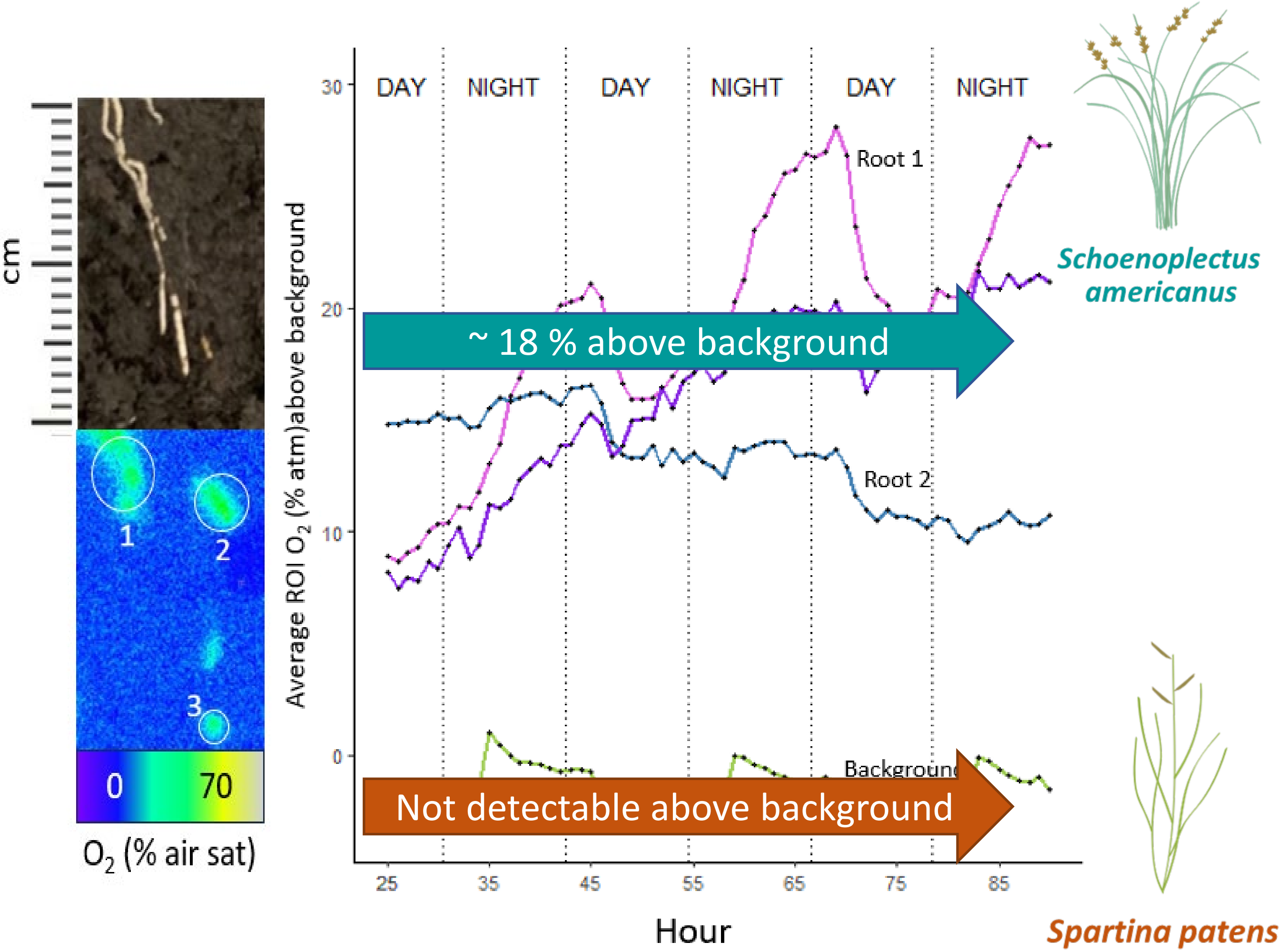
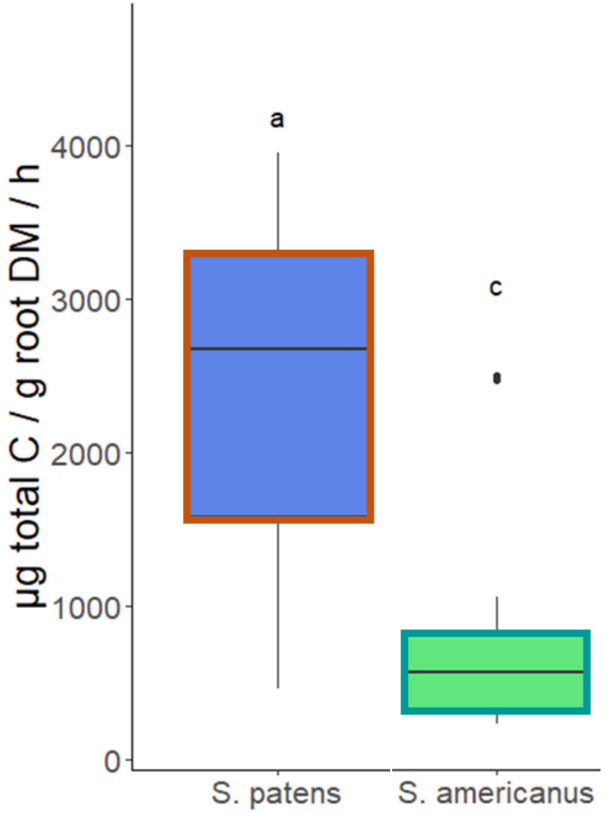




Noyce and Megonigal (2021), *Biogeosciences*



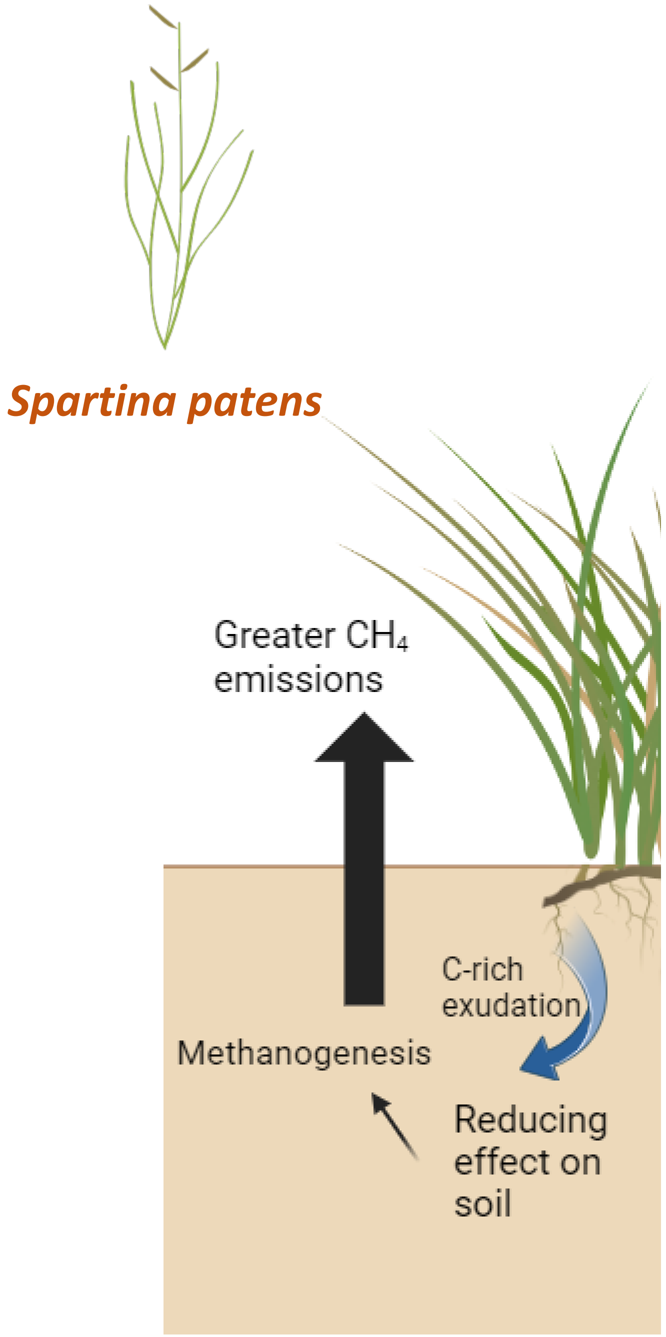


Katie Haviland

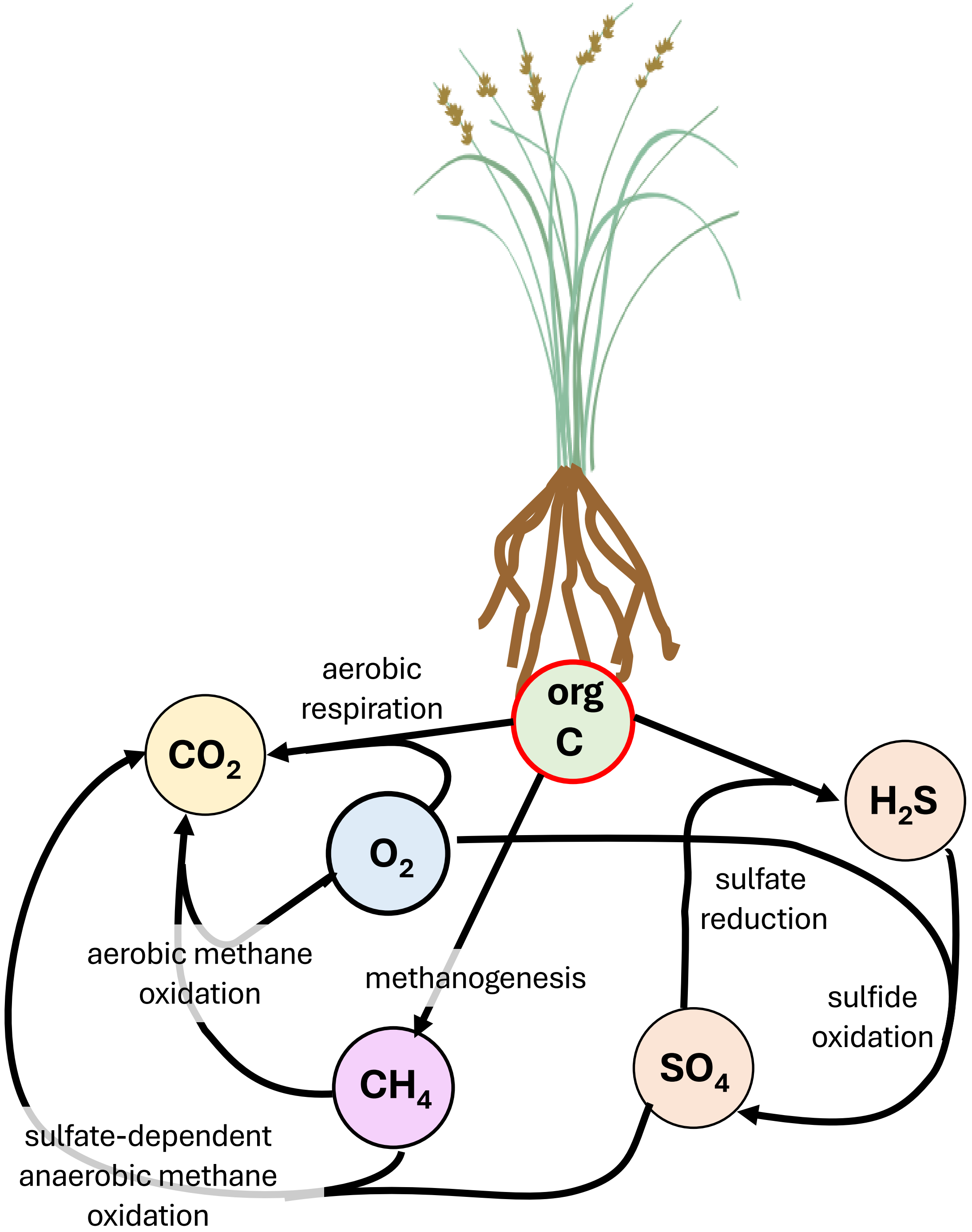
Schoenoplectus had a higher rate of root oxygen loss than *Spartina*

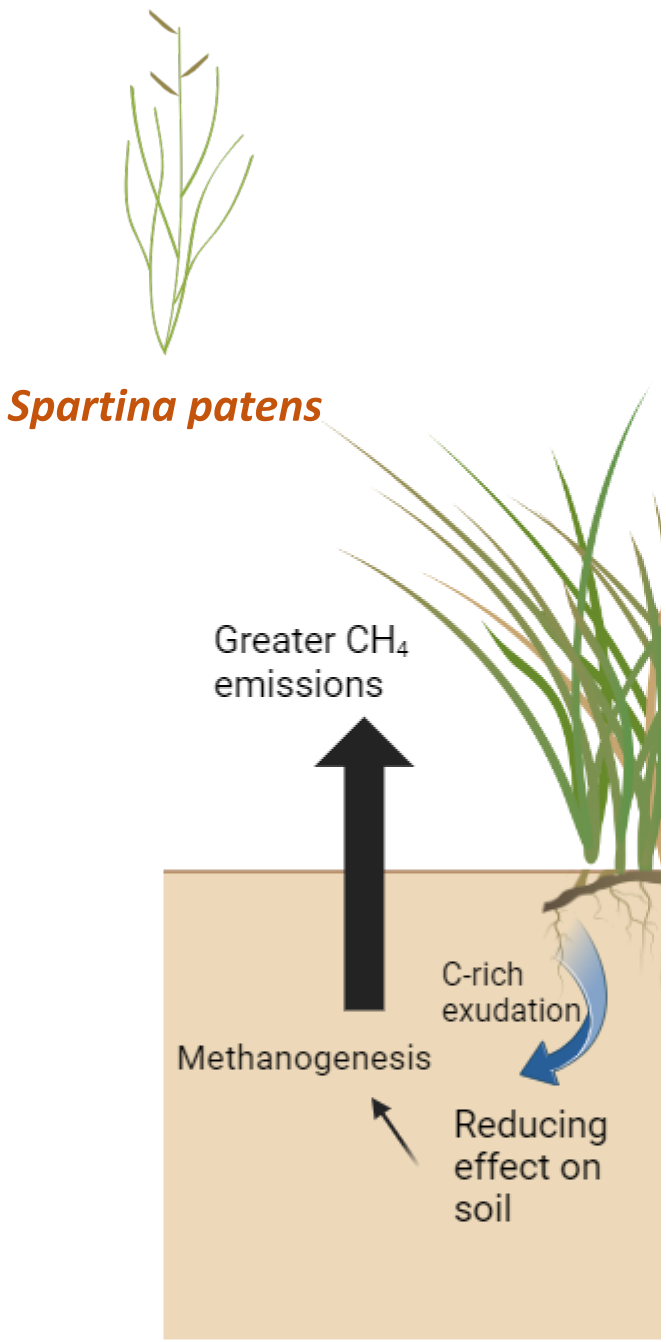
Spartina had a higher rate of C exudation than *Schoenoplectus*

Haviland & Noyce (2024), *Biogeosciences*

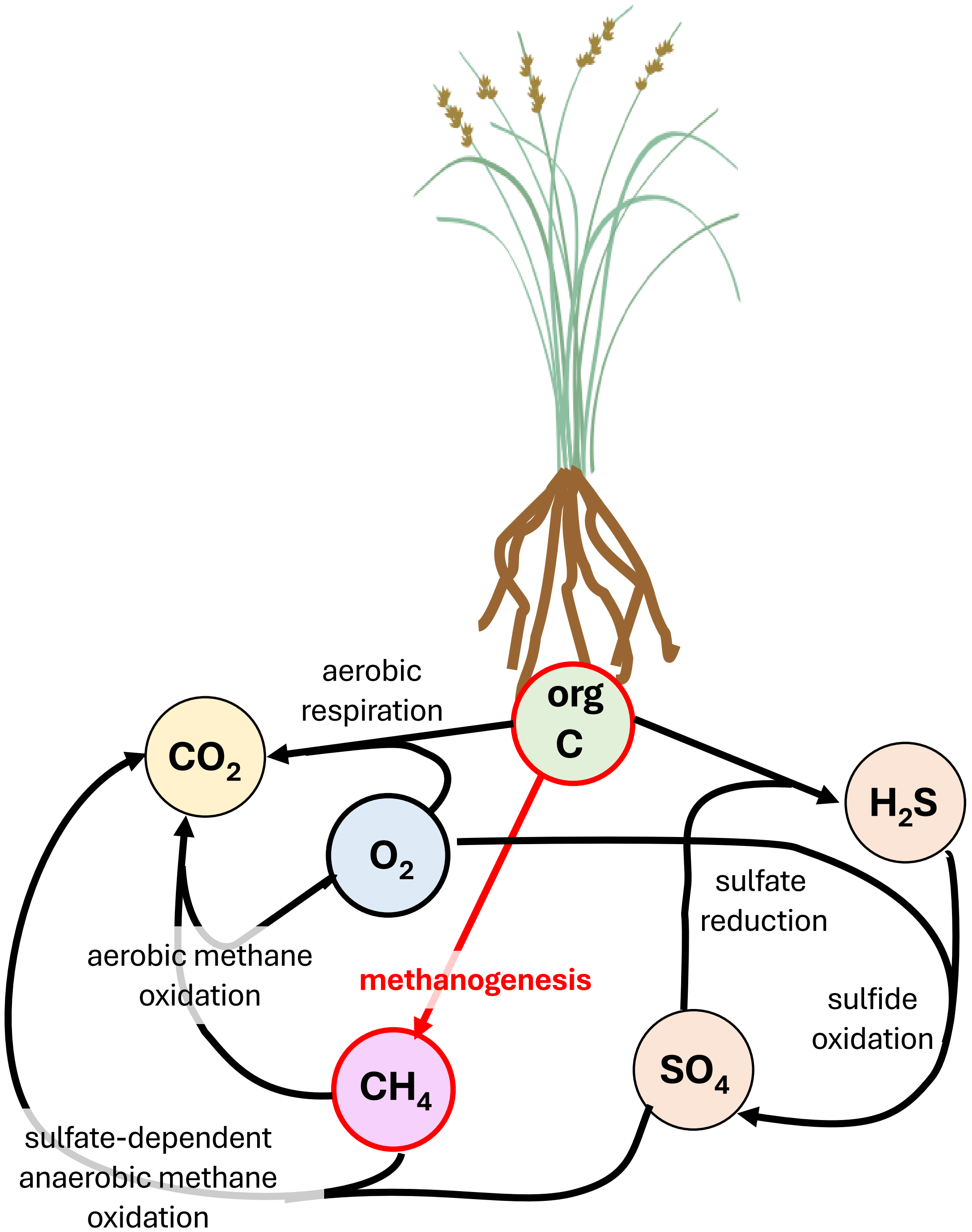


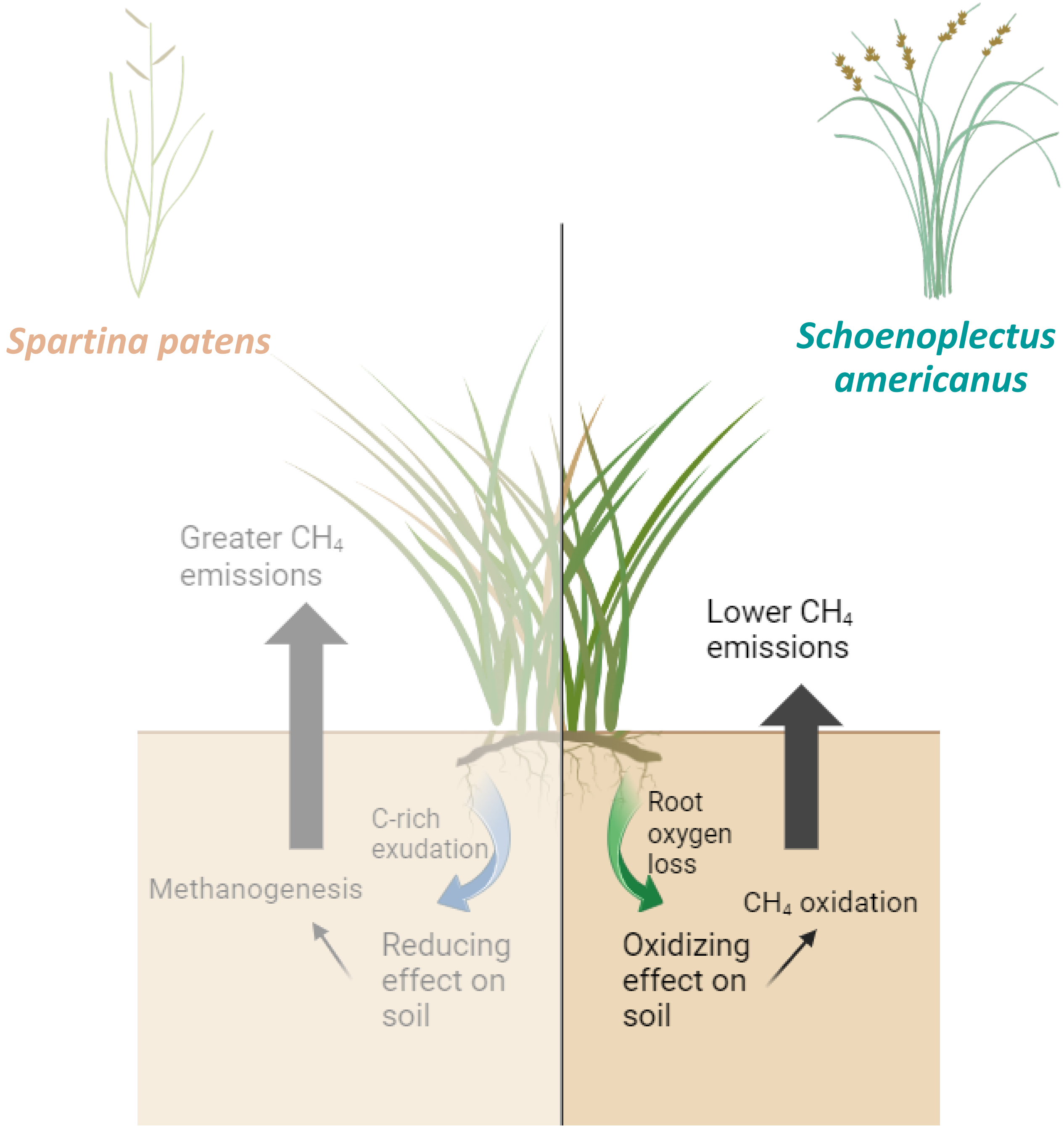
Haviland & Noyce (2024), *Biogeosciences*

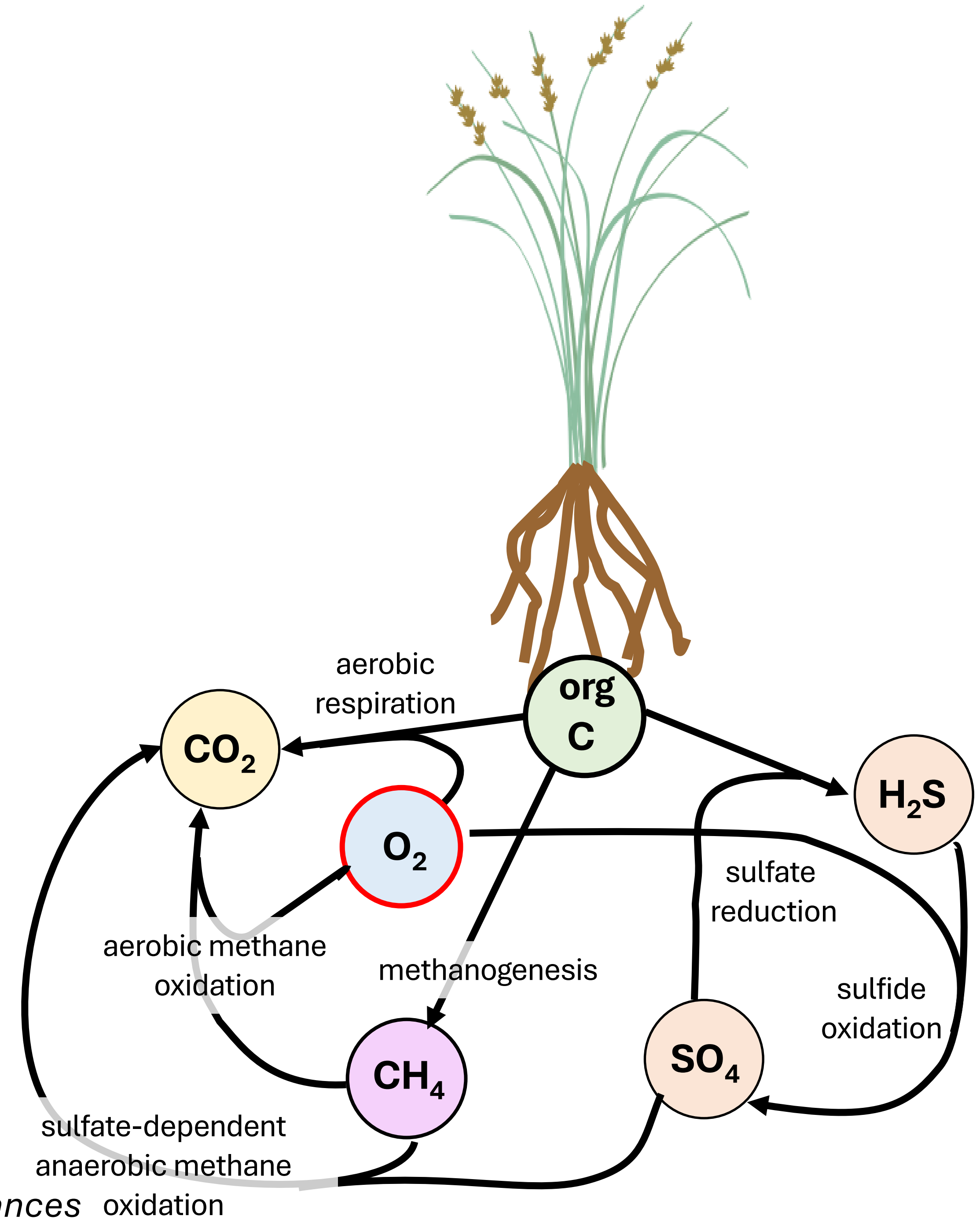




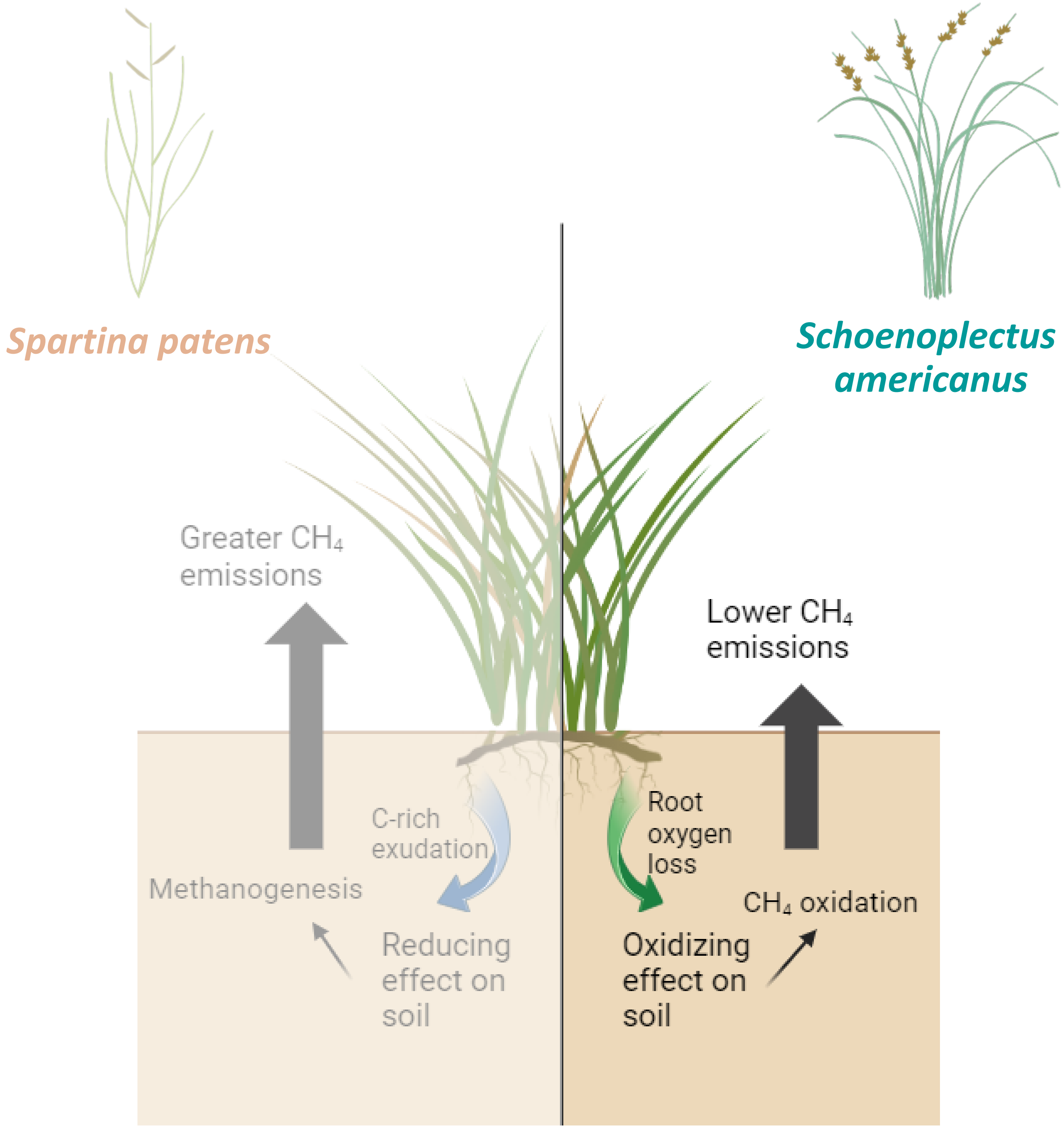
Haviland & Noyce (2024), *Biogeosciences*

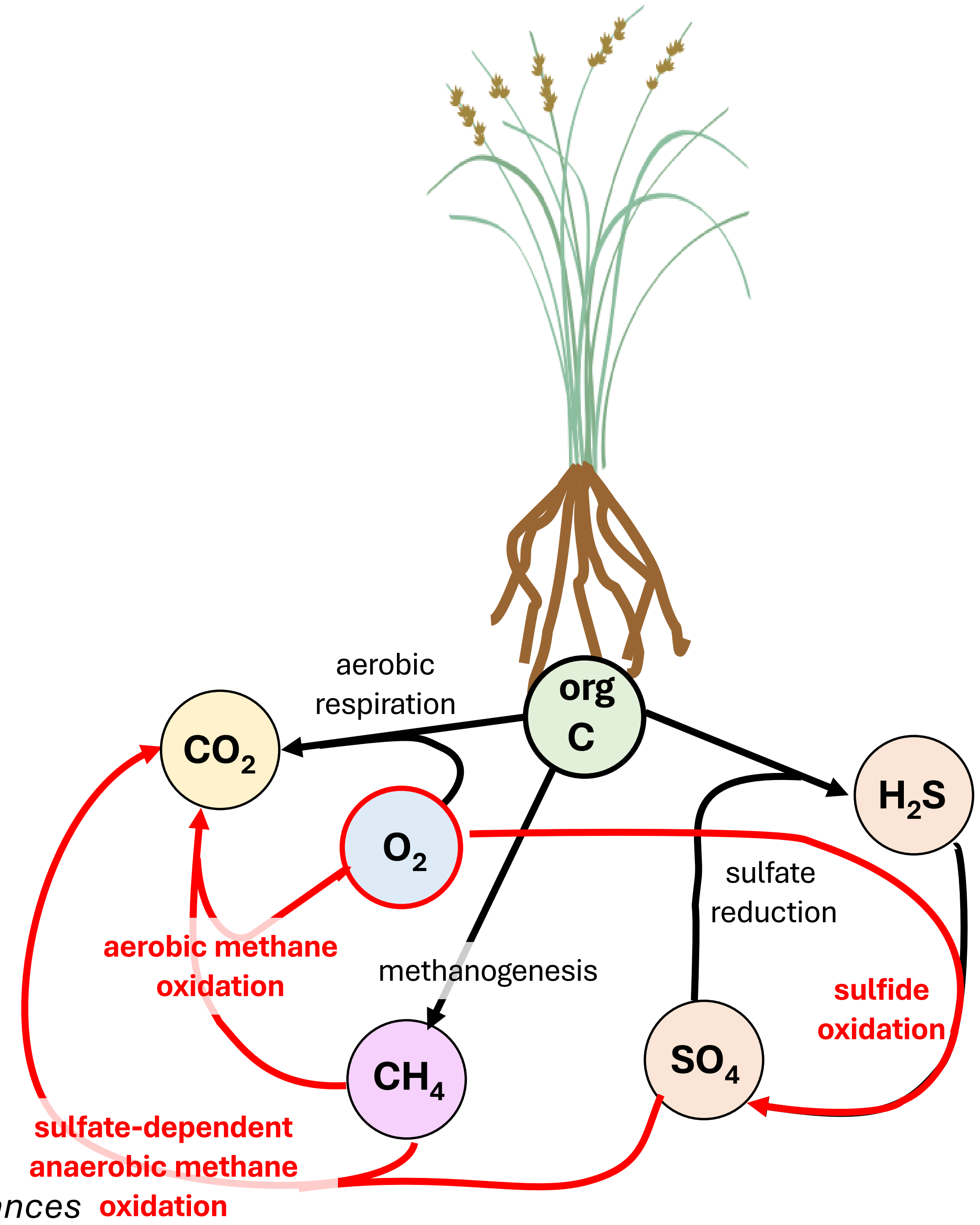






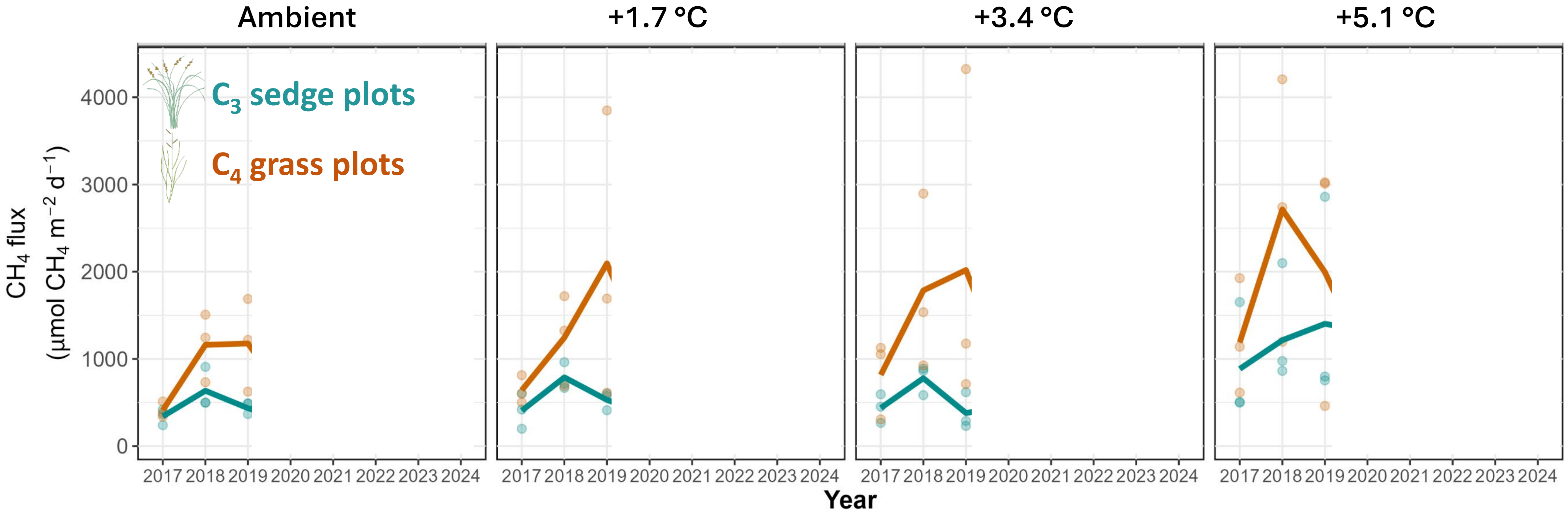
Haviland & Noyce (2024), *Biogeosciences*; Lee et al. (2025), *Science Advances*





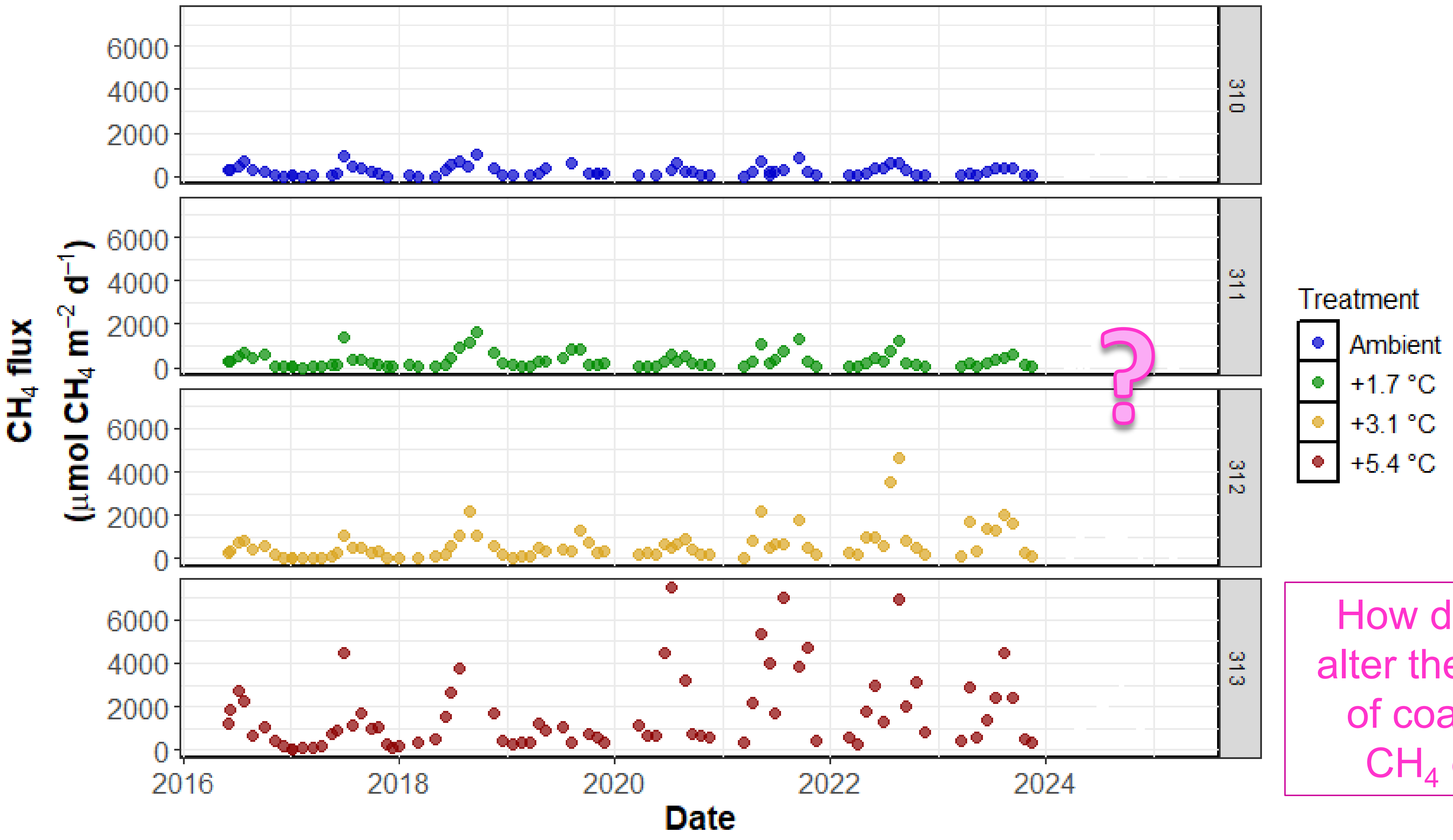
Haviland & Noyce (2024), *Biogeosciences*; Lee et al. (2025), *Science Advances*

However, vegetation effects in warmed plots have shifted over time.



Does this interannual variability affect our ability to predict future CH_4 emissions?

Can we use 8 years of CH_4 fluxes to predict what will happen next year?

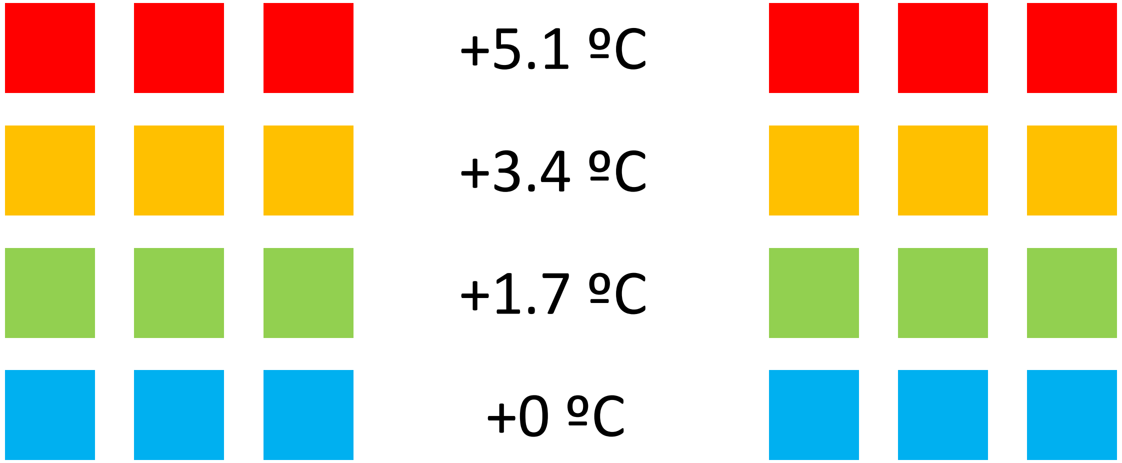


Abby Lewis

How does warming alter the predictability of coastal wetland CH_4 emissions?

Evaluated six-month forecasts of CH_4 emissions using 10 models at each plot

Lewis et al., *under review*



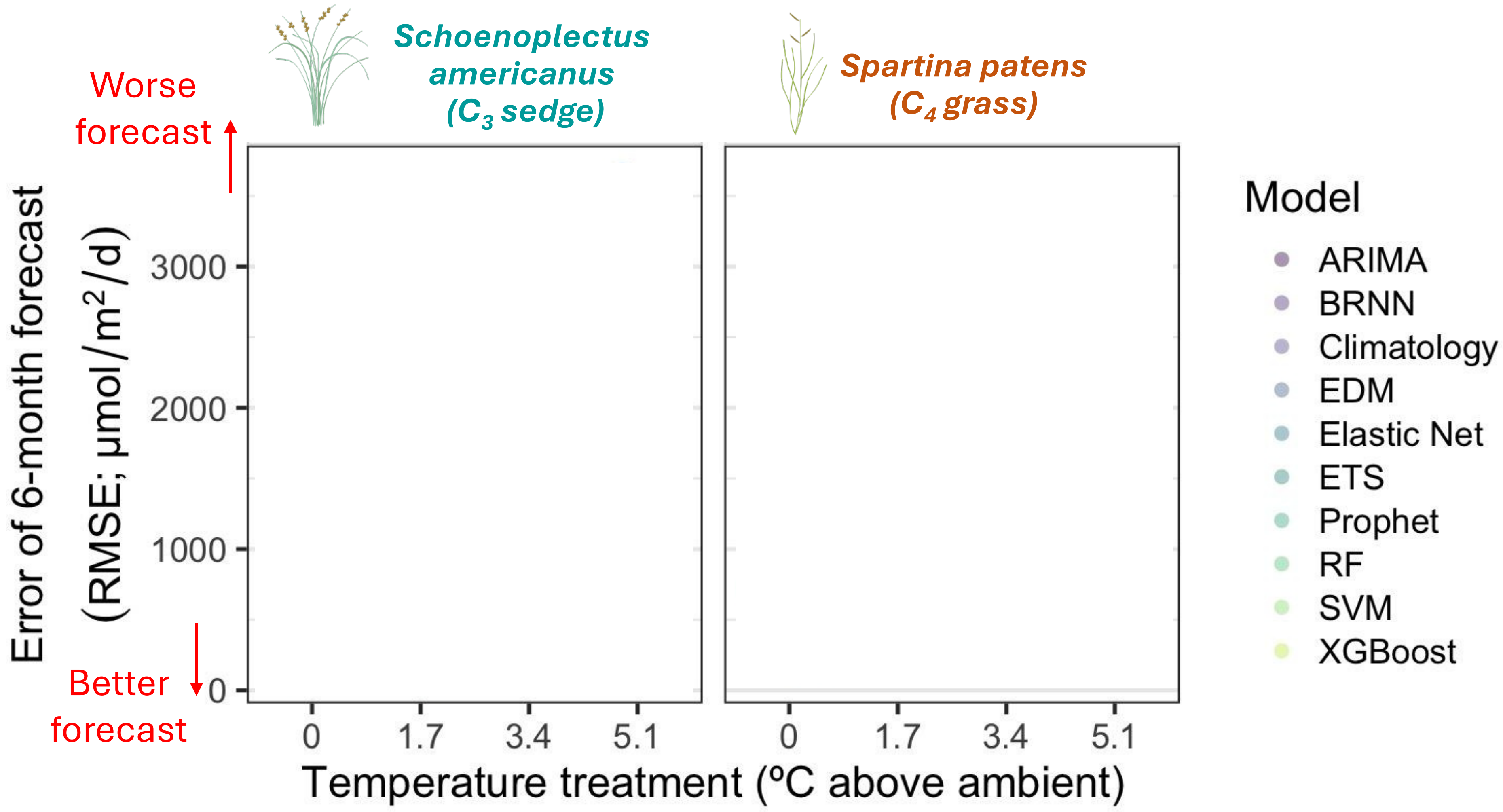
Time series models
- ARIMA
- ETS
- prophet
- EDM
- Climatology

Machine learning models (meteorological drivers)
- Random forest
- Elasticnet
- XGBoost
- Support Vector Machine
- Bayesian Regularized Neural Network

Generated and assessed six-month forecasts throughout 2024

Ability to forecast CH_4 emissions decreases in warmed plots, particularly with sedges.

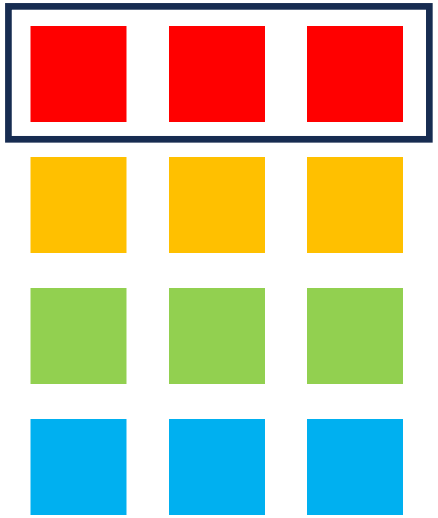
Abby Lewis



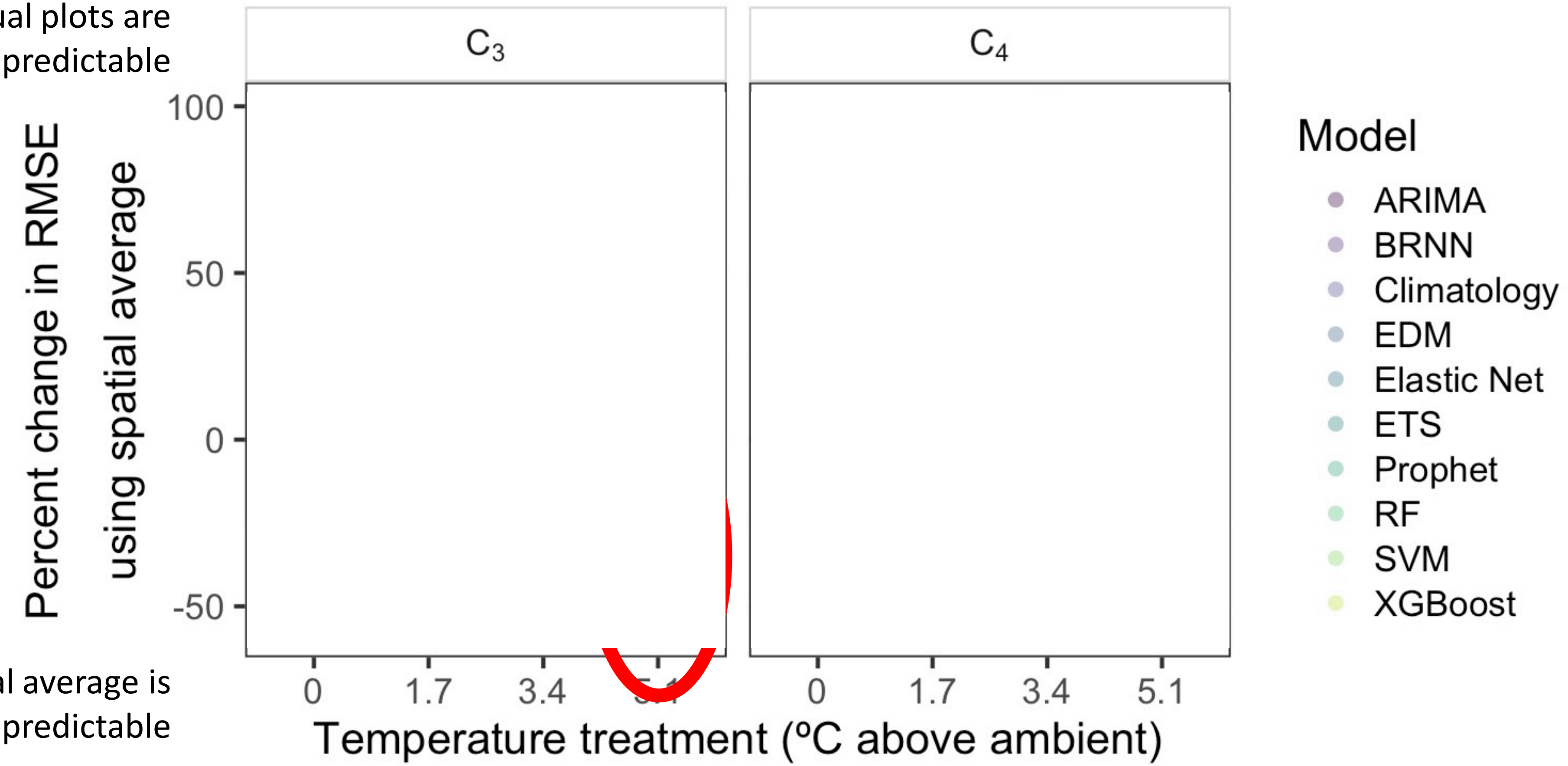
Lewis et al., *under review*

Can we improve predictability with spatial averaging?

Abby Lewis

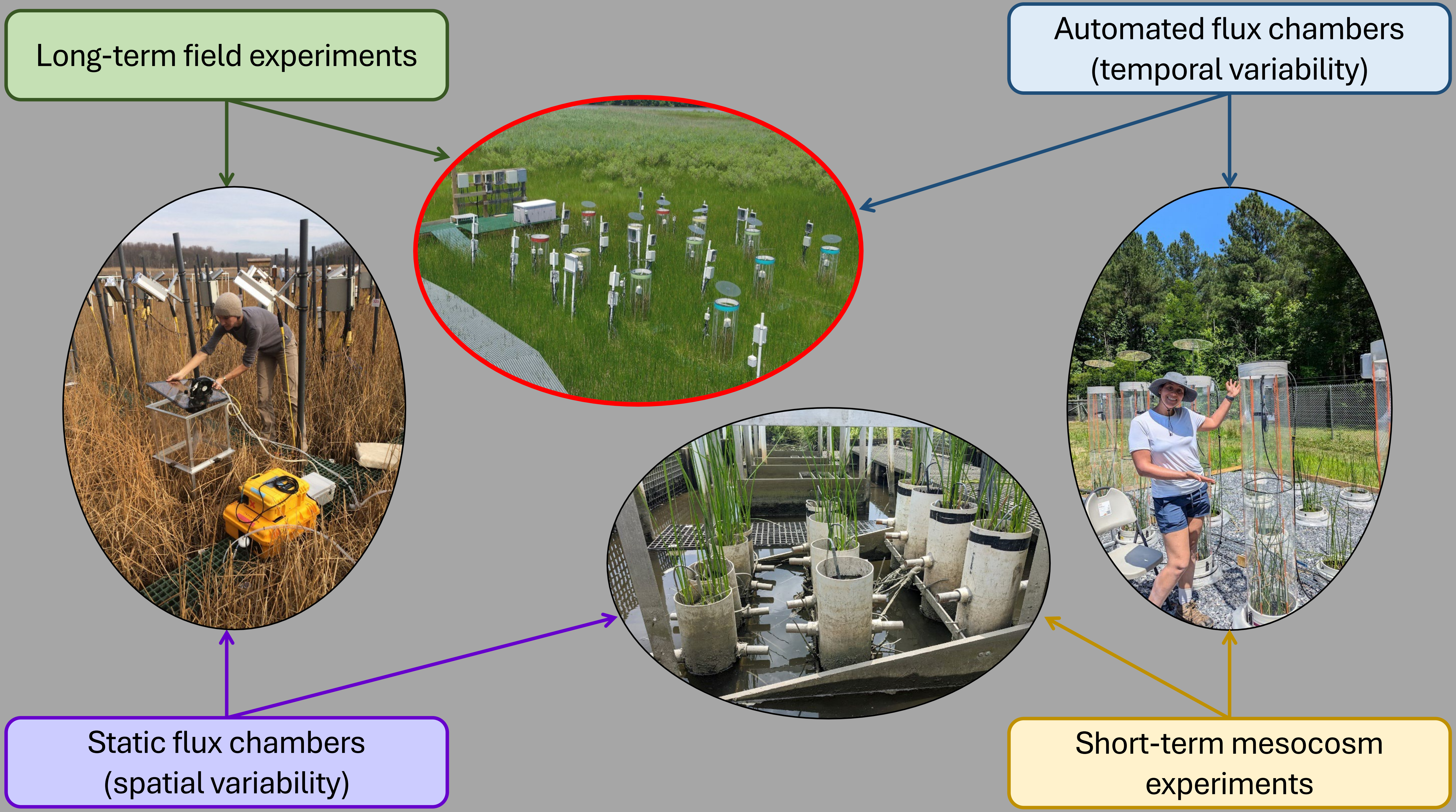


Individual plots are more predictable



Spatial average is more predictable

Lewis et al., *under review*


Long-term field experiments
Automated flux chambers
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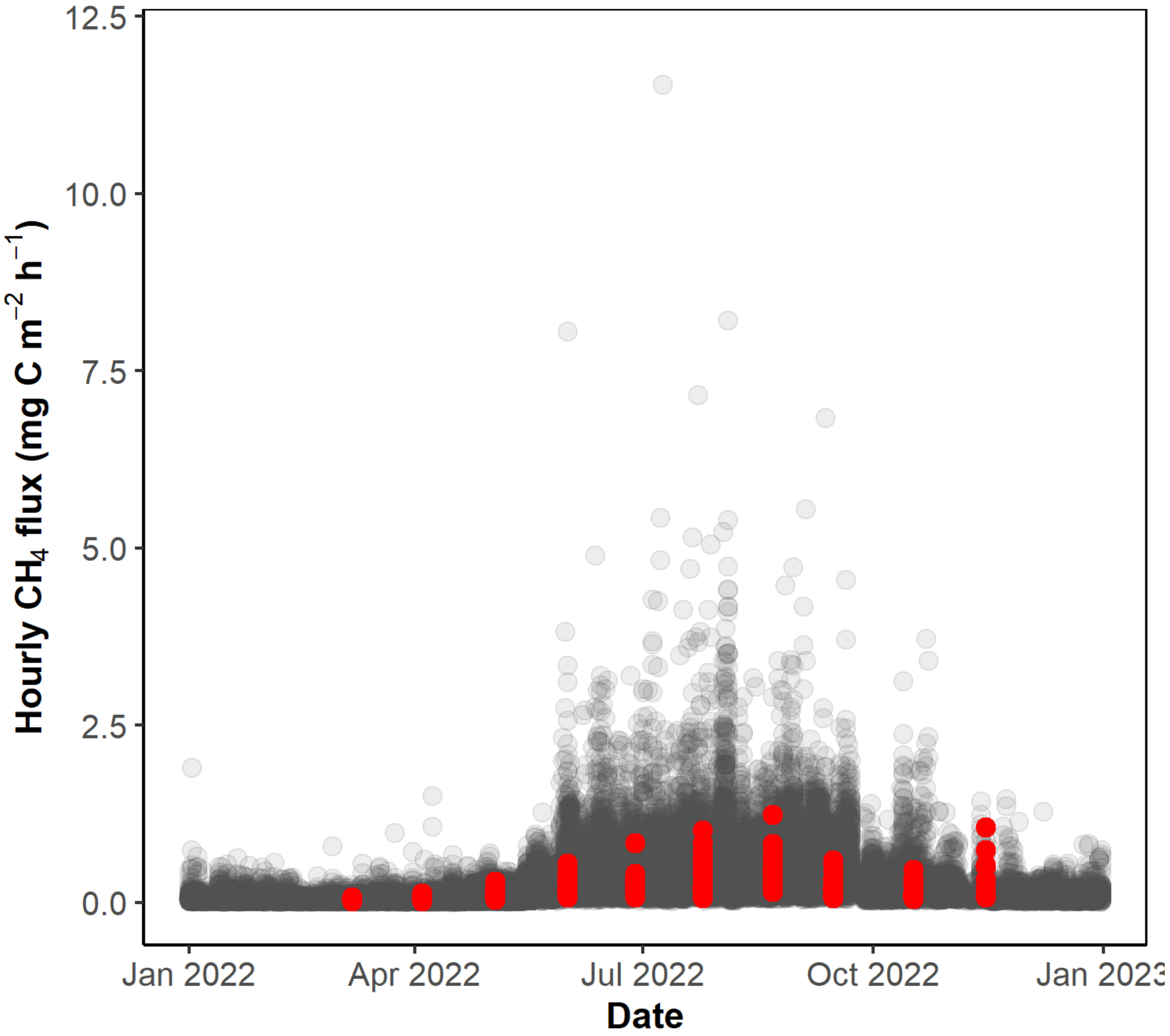
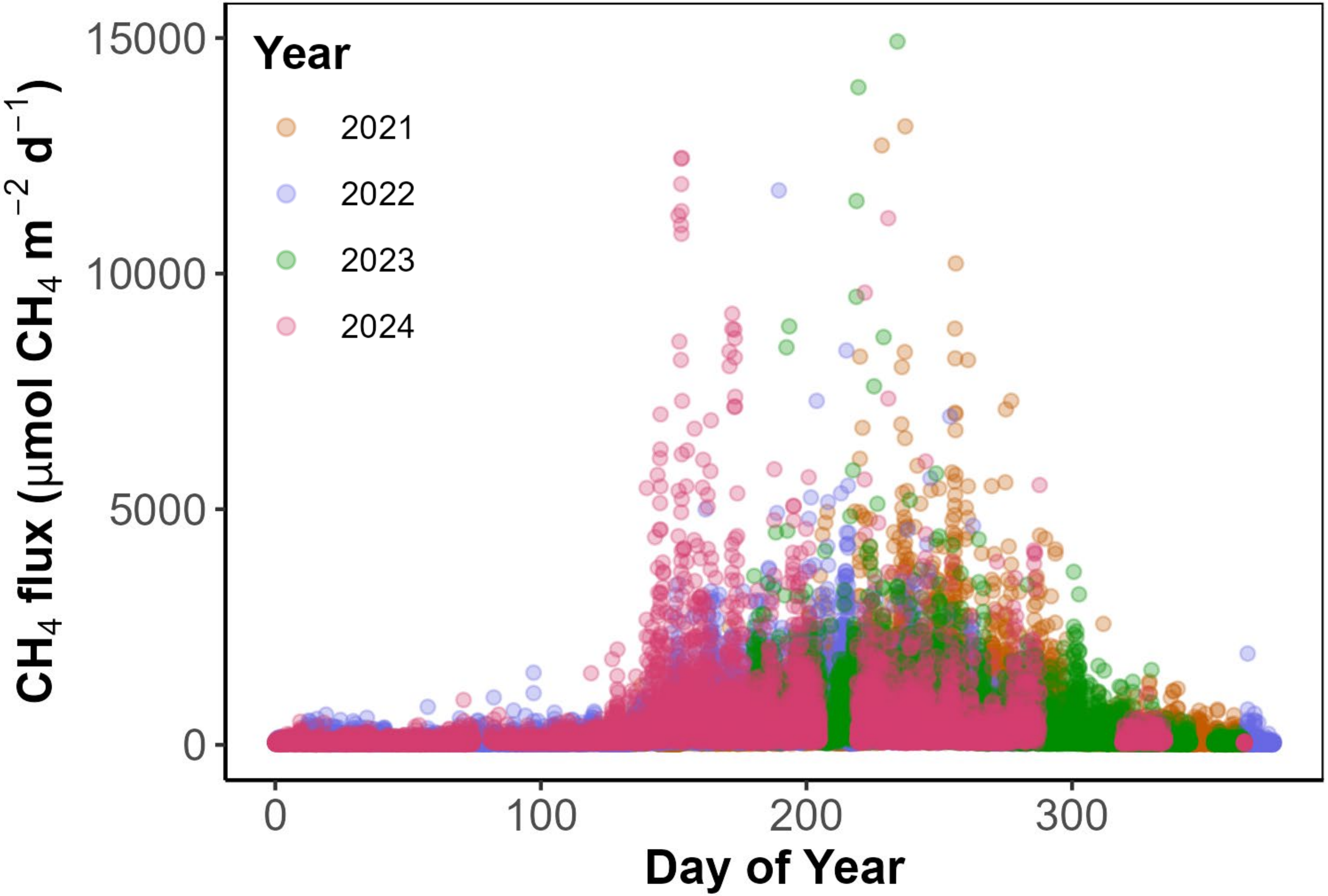
Static chambers also capture seasonal and interannual variability, but they miss the high-temporal variability picked up by **autochambers**.

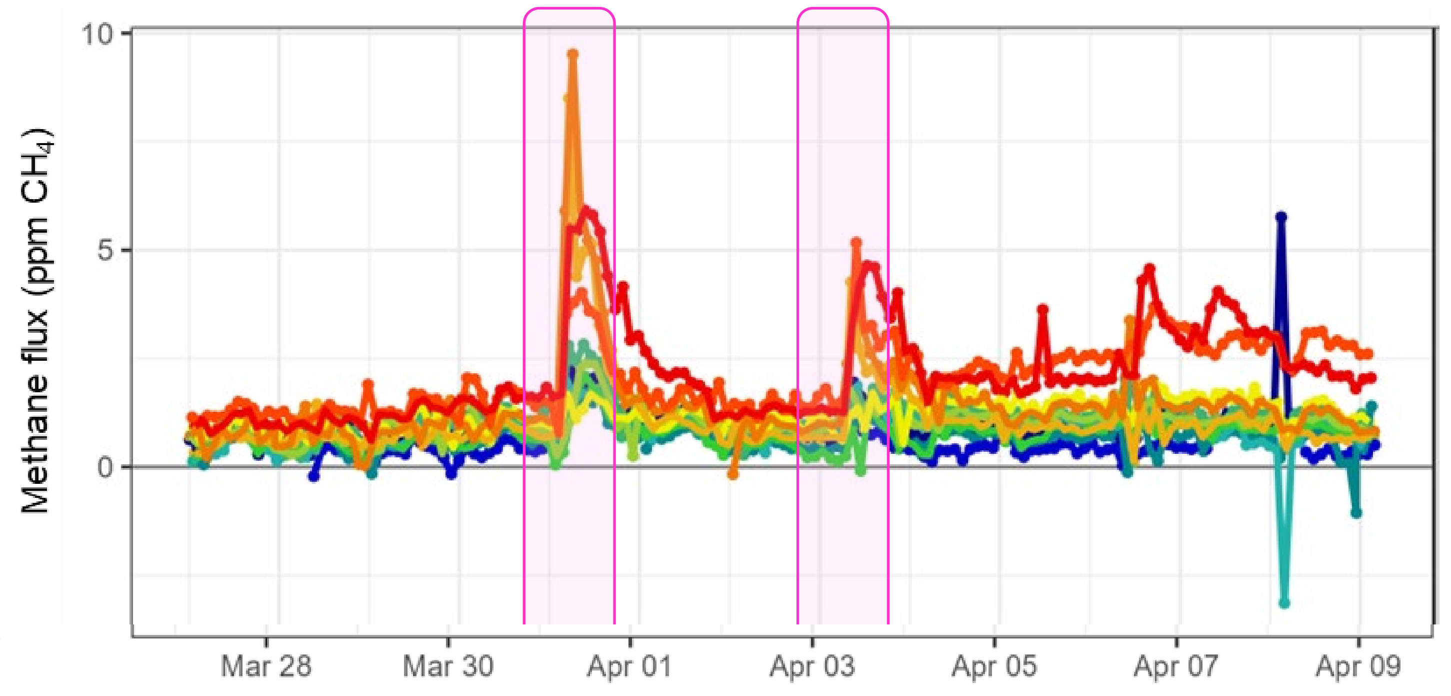


Patterns in CH_4 emissions are highly variable across years, likely driven by shifting temperature and salinity

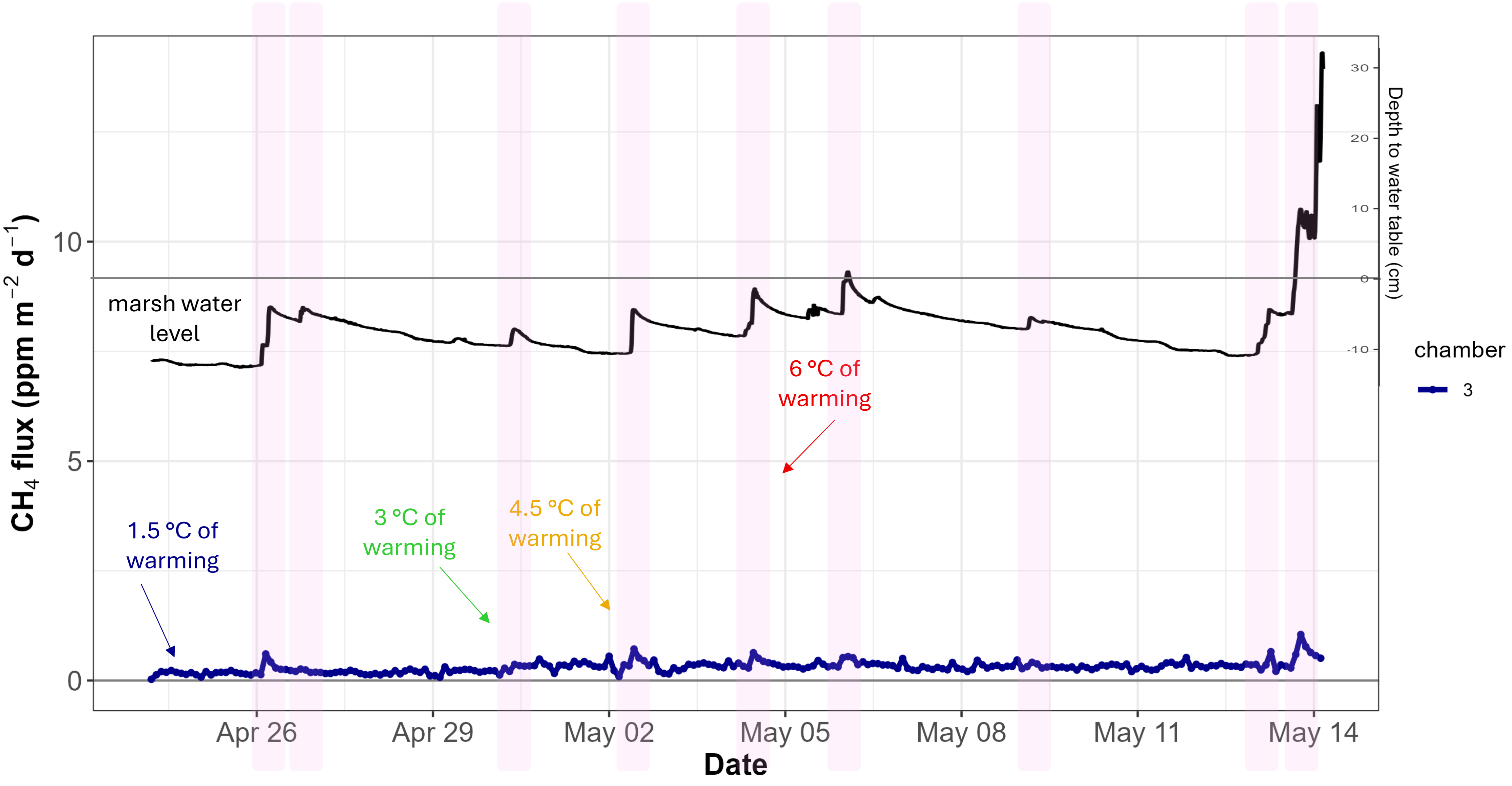


- Warm spring in 2024 led to unusually high fluxes early in the year, but lower throughout the summer and fall
- Higher salinity in 2022 and 2023 suppressed fall fluxes compared to 2021

Pulses of high CH_4 are potentially linked to high water events.



Pulses of high CH_4 are more frequent and more intense under warming.



Next steps: trying to stimulate “hot moments” experimentally to determine the underlying mechanisms

Alia Al-Haj

What do we know (and what *don't* we know)?

- Variability in magnitude and timing of CH_4 fluxes from coastal wetlands can be attributed to shifts in flooding, salinity, temperature, and vegetation
- Warming increases CH_4 emissions, but also increases variability, decreasing our ability to predict CH_4 dynamics
  - We can improve predictions with more spatial data
- Magnitude and predictability of CH_4 emissions vary across plant communities
  - CH_4 emissions are higher from grasses but more variable from sedges
- Hot moments of CH_4 emissions are linked to rising water level and increase in frequency and intensity under warming
  - Still need to determine underlying mechanisms

Thanks to numerous technicians, postdocs, volunteers, and interns in SERC's Global Change Ecology, Biogeochemistry, and Technology in Ecology Labs for data collection and experiment maintenance!

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Photo: S. Voss

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