The BlueFlux Campaign: Daily Blue Carbon Flux Upscaling from Tower and Airborne Sources Reveals 20-Year History of CO_2 and CH_4 Ecosystem Fluxes in the Everglades

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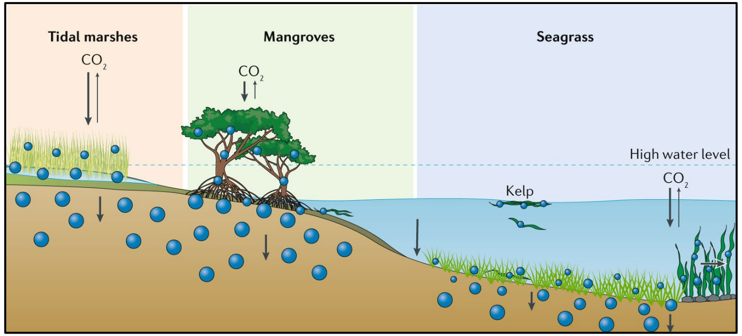
1 NASA
2 University of Maryland 1856
3 Yale
4 FIU Florida International University
5 Florida Department of Environmental Protection
6 USGS science for a changing world
7
8 Boulder
9 ECU
10 Southern Cross University
11 State

Blue carbon ecosystems (BCEs) describe the coastal vegetated habitats where carbon (C) is created as plant biomass and sequestered long-term in soils when plants decay or trap C from marine, estuarine, and riverine sources.

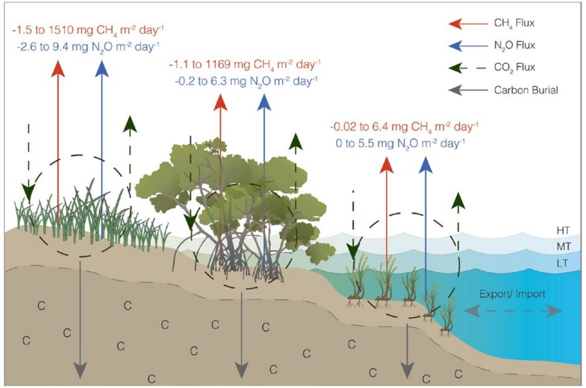
Coastal blue carbon



Macreadie et al. 2021. Blue carbon as a natural climate solution

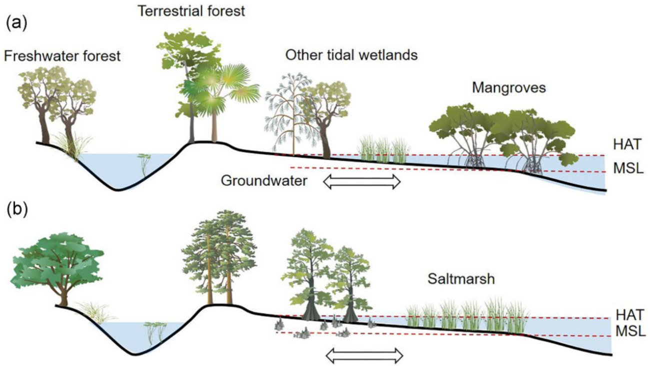
BCEs as a nature-based climate solution could offset ~3% of global emissions if properly managed, but their potential is still an uncertainty in global C budgets.

Methane Emissions



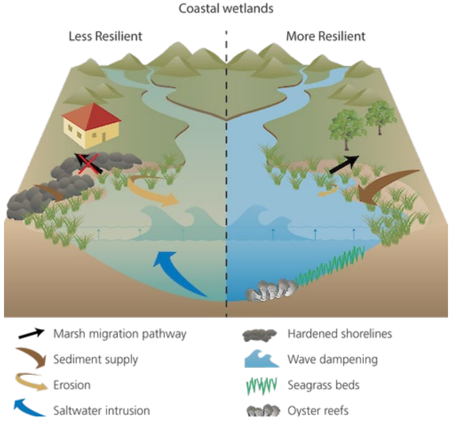
Rosentreter et al. 2021. Methane and Nitrous Oxide Emissions Complicate Coastal Blue Carbon Assessments

Tidal Freshwater blue carbon



Adame et al. 2021. All tidal wetlands are BCEs

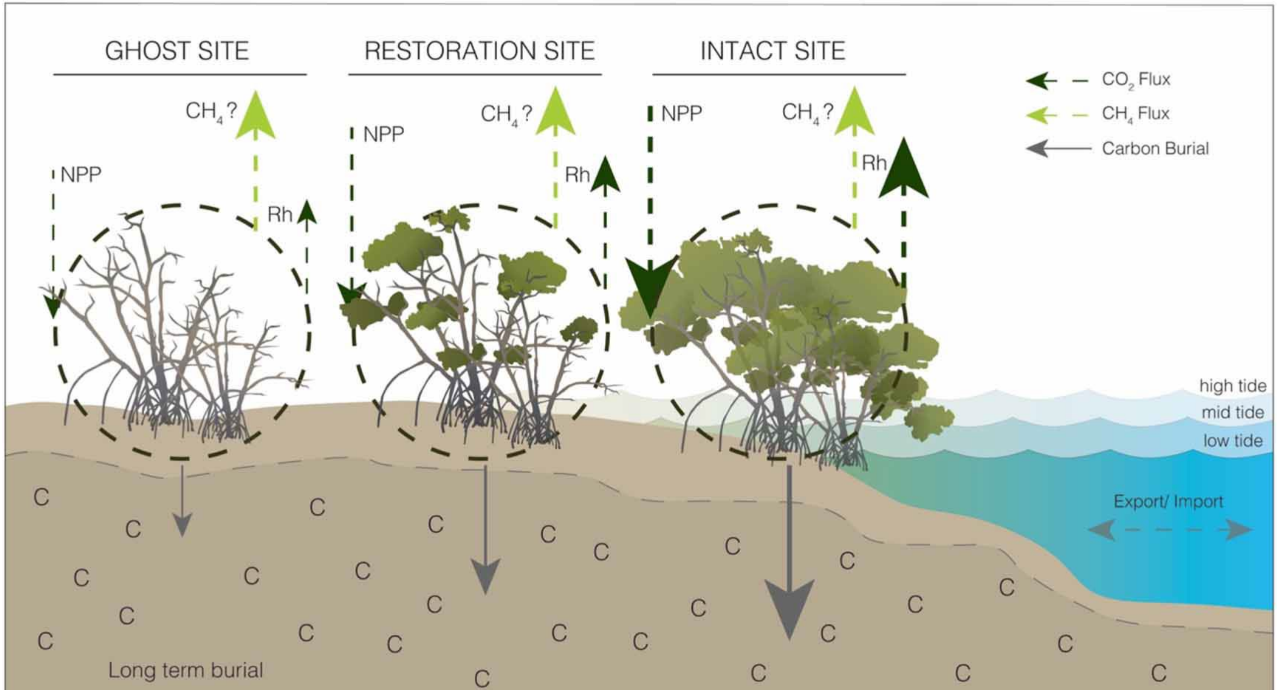
Resiliency



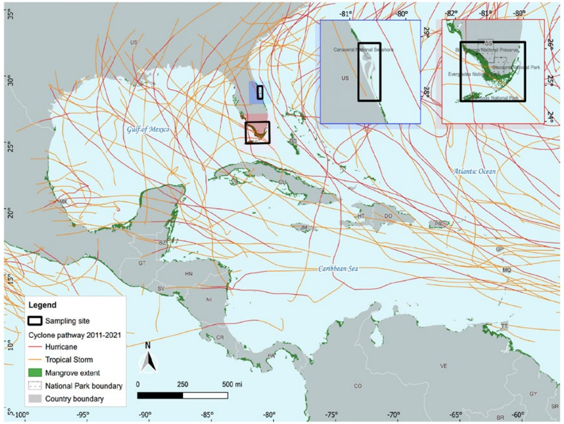
UMD Center for Environmental Science

The BlueFlux Campaign:

Our goal is to create data-driven products to inform coastal management on recent blue carbon (C) ecosystem fluxes to aid monitoring, reporting, and verification



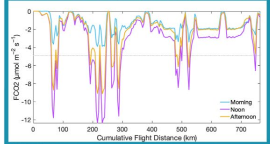
Poulter et al. 2023. Multi-scale observations of mangrove blue carbon ecosystem fluxes: The NASA CMS BlueFlux field campaign

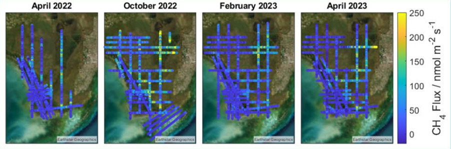


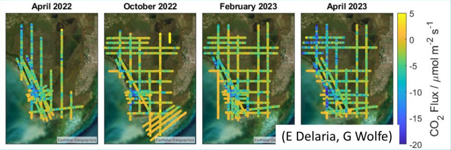
The BlueFlux Campaign:

Our team collected a combination of novel and available ground and airborne flux observations across multiple scales to inform a data-driven bottom-up approach

Objective 1: Collect airborne flux data using the NASA CArbon Airborne Flux Experiment payload (CARAFE)

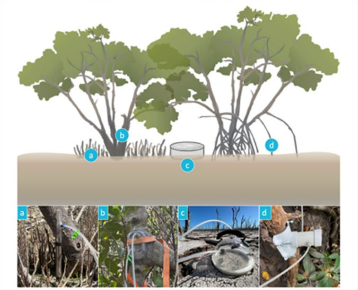




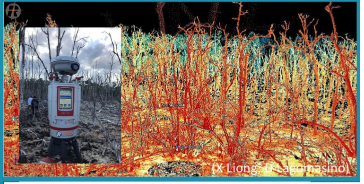


(E Delaria, G Wolfe)

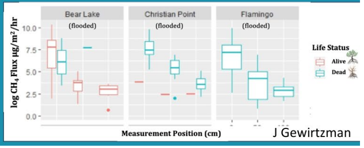
Objective 2a: Collect field data to understand partitioning of fluxes to above and belowground storage pools



(Poulter et al., 2022)

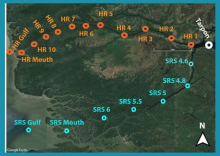


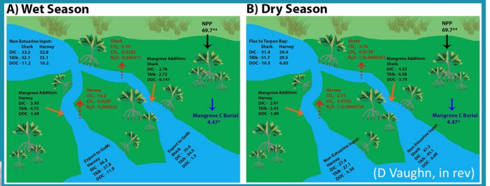
(X Liang, D Lagomasino)



J Gewirtzman

Objective 2b: Collect aquatic carbon fluxes fluxes to portioning short and long-term carbon sequestration in sediments and correct top-down NEE flux





(D Vaughn, in rev)

- TD net-ecosystem exchange from aircraft and towers includes large lateral fluxes of carbon
- Mangroves along the tidal rivers contributed 8.10-9.31% of DIC and 1.25-36.2% of DOC to the total river export
- Seasonality drives different directional flows in/out of the wetlands

Delaria et al. 2023. Assessment of Landscape-Scale Fluxes of Carbon Dioxide and Methane in Subtropical Coastal Wetlands of South FL

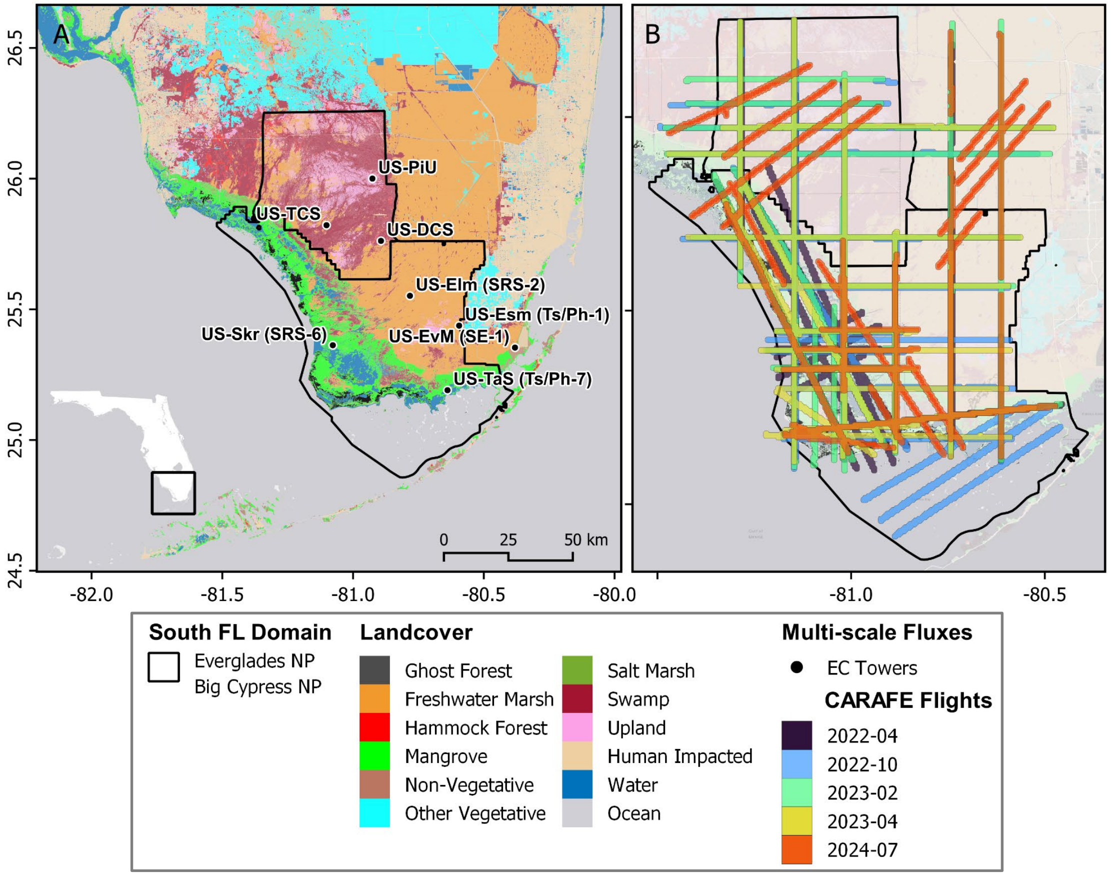
Delaria, et al. 2024. Dataset: BlueFlux Airborne Trace Gases, Fluxes, and Mixing Ratios, Southern Florida, 2022-2023.

* *Gewirtzman et al. In prep*

* *Vaughn et al. In review. Seasonal Variability of Lateral Dissolved Carbon and Water-Air Greenhouse Gas Fluxes from Mangrove-Fringed Rivers in the Florida Everglades*

*BlueFlux-2

We leverage CO_2 and CH_4 fluxes from 8 eddy covariance (EC) towers (2004–2023) and 5 airborne deployments of the Carbon Airborne Flux Experiment (CARAFE) instrument



- Airborne EC measured an additional 8% of landscape variability in daily CH_4 fluxes
- EC towers captured 6% more of the temporal variability in daily CO_2 flux
- Multi-scale observations capture a wider range of fluxes across S Florida's expansive Everglades ecosystem

Our data-driven approach to upscale daily fluxes using satellite reflectance

EC tower half-hourly turbulent flux samples

CARAFE instantaneous EC measurements

Data Processing

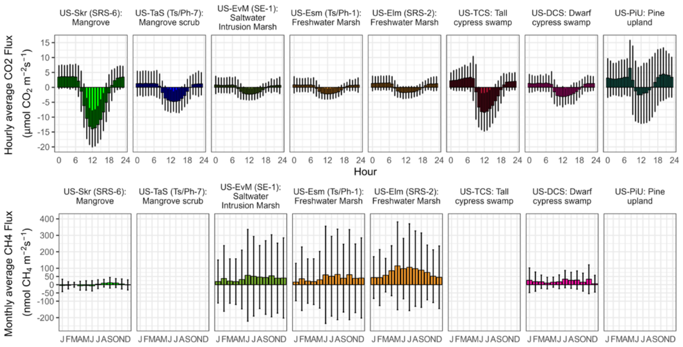
- Daily integrated average fluxes: sampled from towers and scaled for CARAFE
- Resampled to a 500-m grid by location

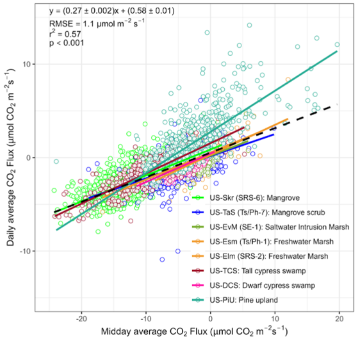
Training Data

Daily fluxes matched by date and location to reflectance from MODIS NBAR bands (B, G, R, NIR, SWIR1, SWIR2)

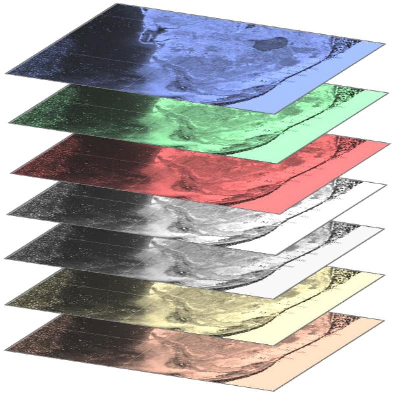
Upscale Modeling

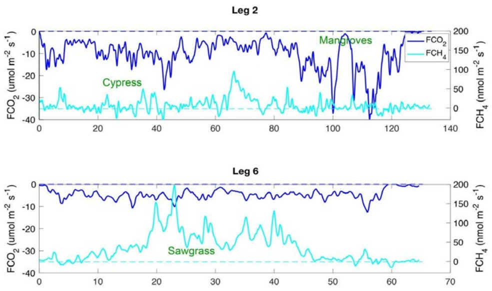
Ensemble Random Forest models were developed to predict fluxes based on surface reflectance

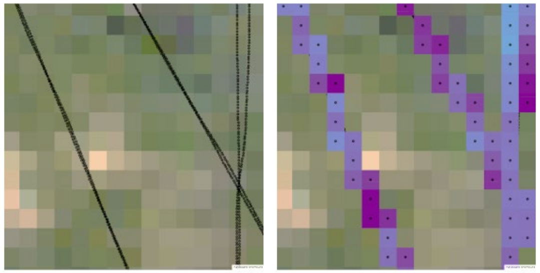


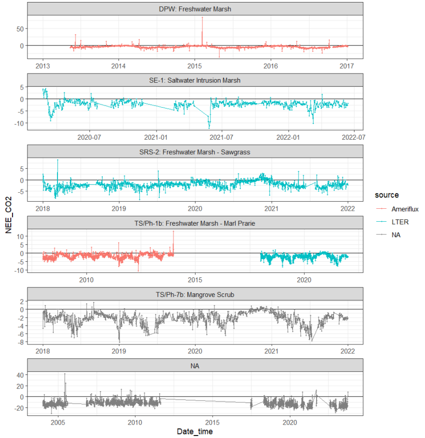


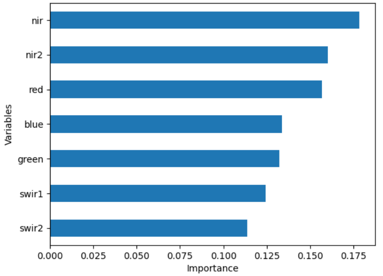
n	CO_2	CH_4
CARAFE	10,924	10,919
EC towers	7,210	3,903











At the daily scale, upscaling models predicted 65% of variance in daily CO_2 flux and 47% of variance in daily CH_4 flux

Capturing the inherently high level of variability of vertical ecosystem fluxes of CO_2 and CH_4 across a gradient of wetland vegetation and environmental conditions is made possible by multi-scale data

	Model	r^2	RMSE	MAE
Daily mean CO_2 flux ($\mu mol\ m^{-2}\ s^{-1}$)	CARAFE + TOWERS (n=18,134)	0.65	0.80	0.91
Daily mean CH_4 flux ($nmol\ m^{-2}\ s^{-1}$)	CARAFE + TOWERS (n=14,822)	0.47	27.7	29.8

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NASA

BlueFlux: Modeled Daily CO2 and CH4 Wetland Fluxes, Southern Florida, 2000-2024

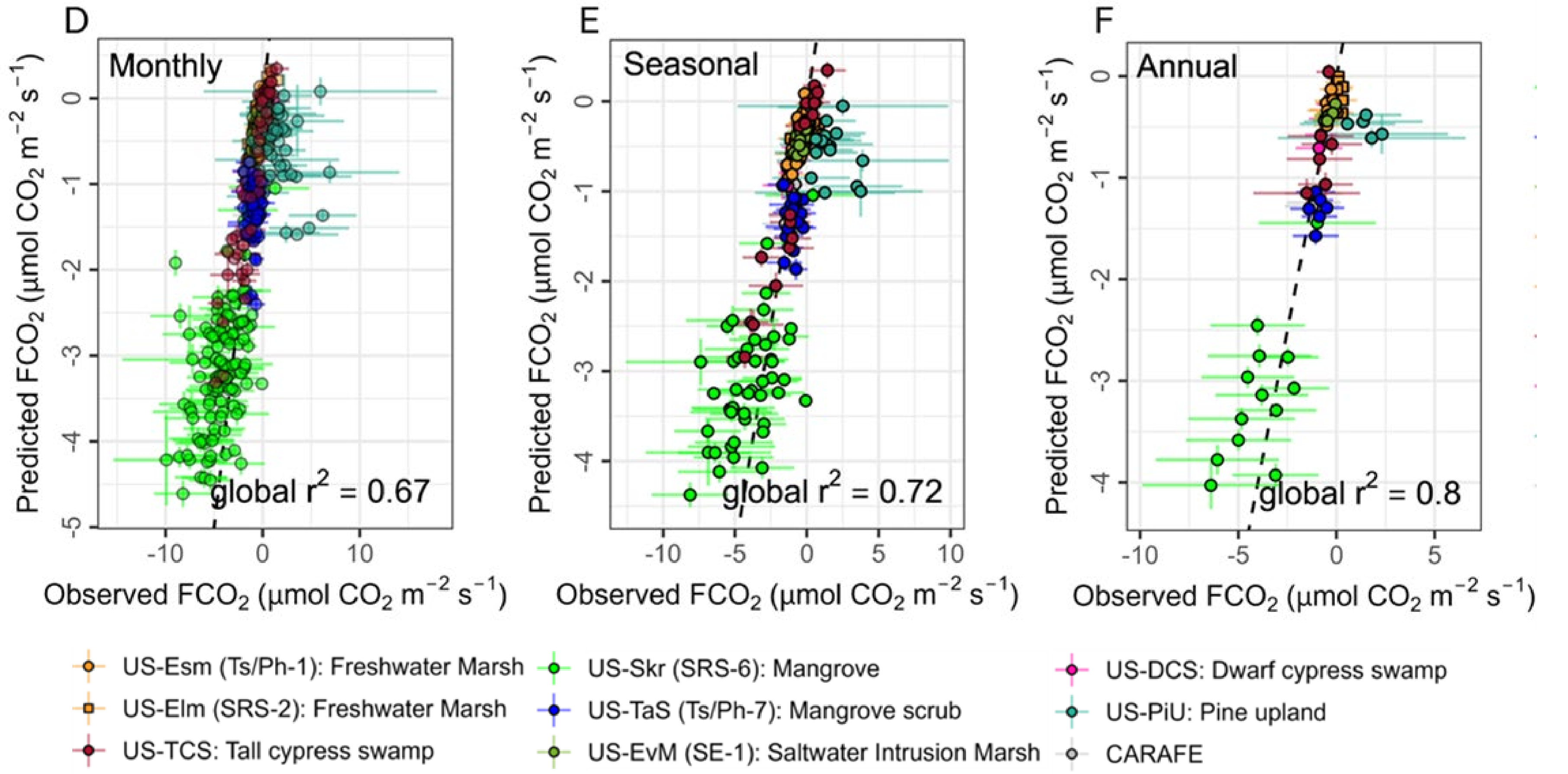
Overview

DOI	https://doi.org/10.3334/ORNLDAAC/2404
Version	1
Projects	CMS BlueFlux
Published	2025-04-16
Usage	4 downloads

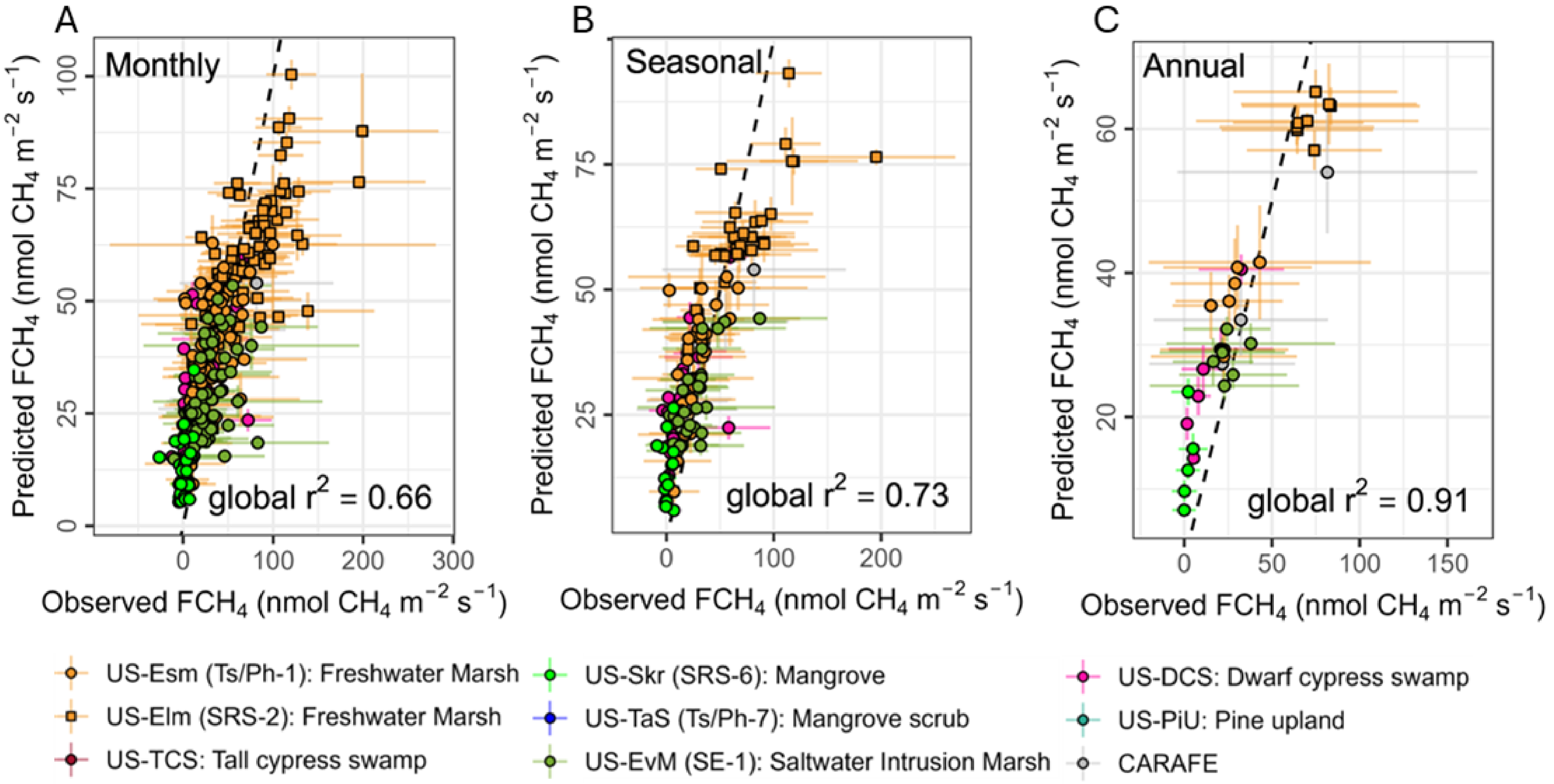
Download Data 10.8 GB

User Guide

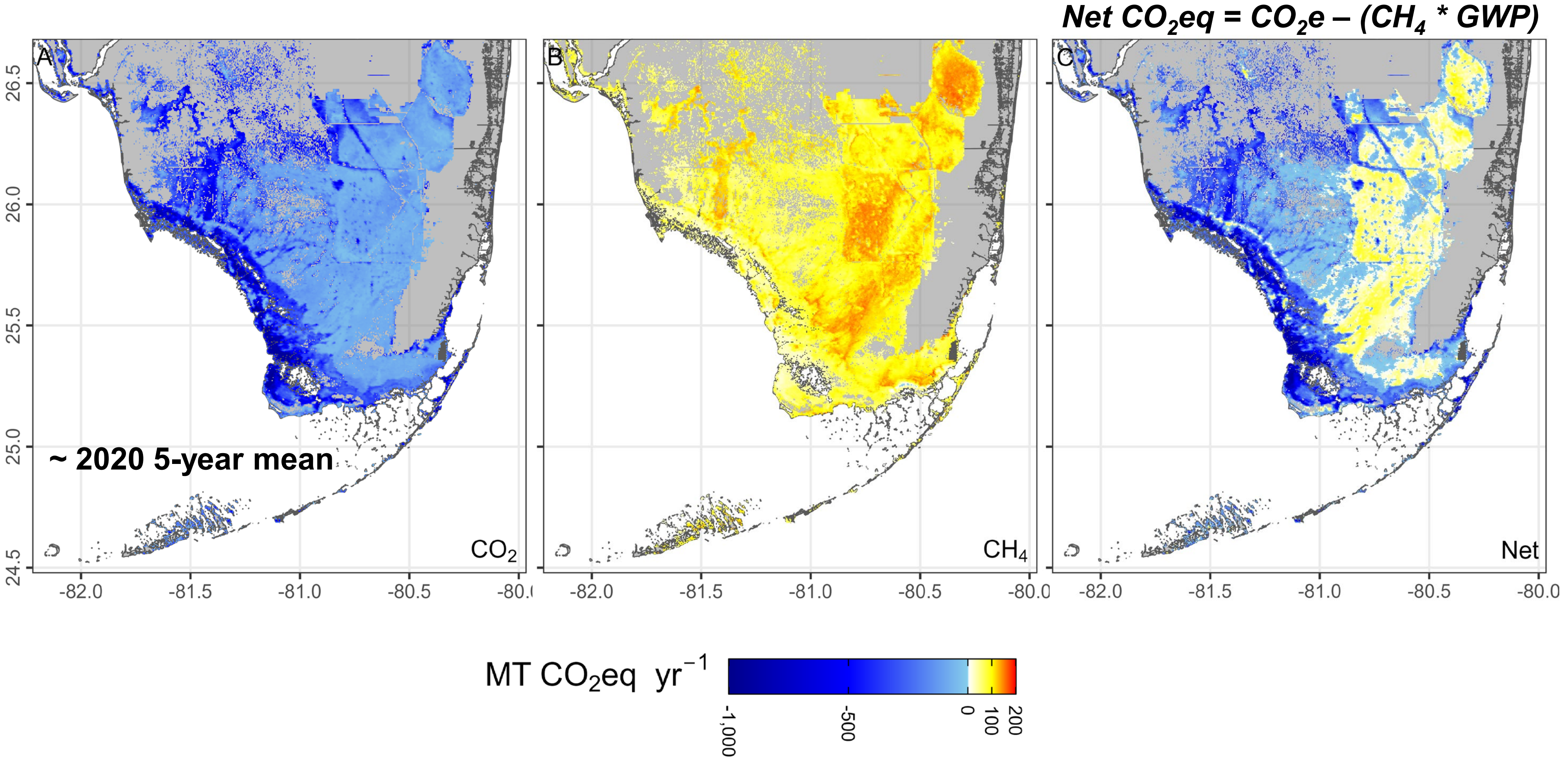
At the monthly, seasonal, and annual scales, predicted CO_2 fluxes captured 67 – 80% variance of observed fluxes across the landscape



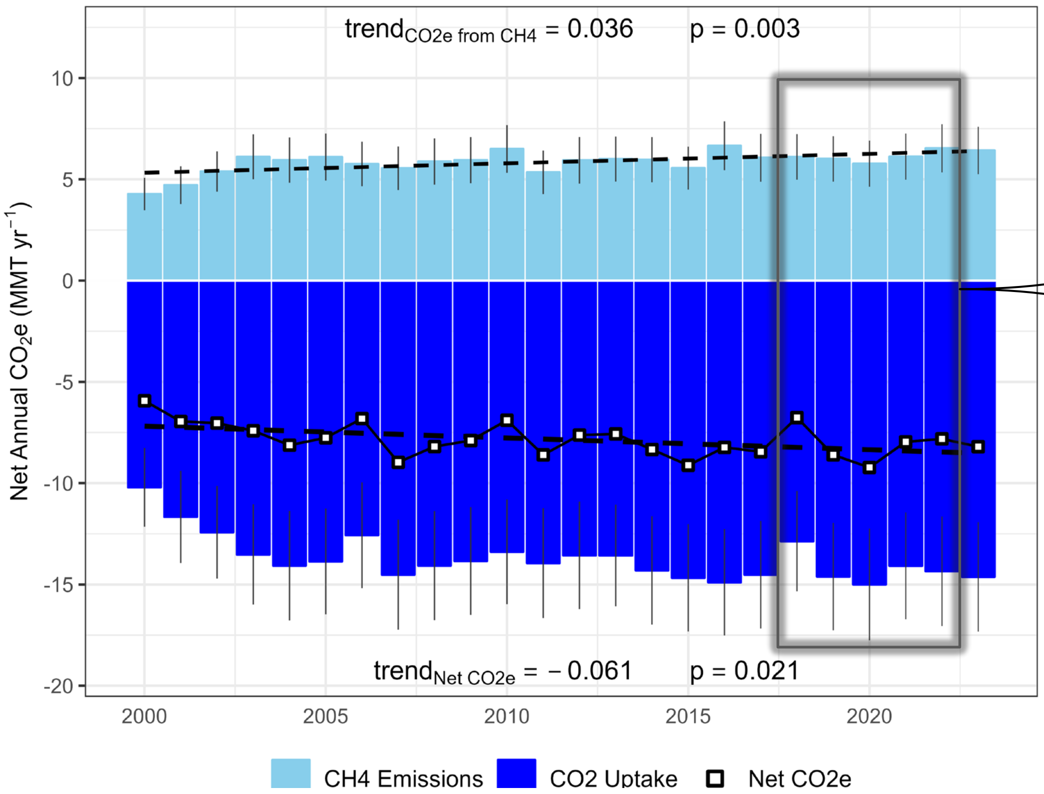
At the monthly, seasonal, and annual scales, predicted CH_4 fluxes captured 66 – 91% variance of observed fluxes across the landscape

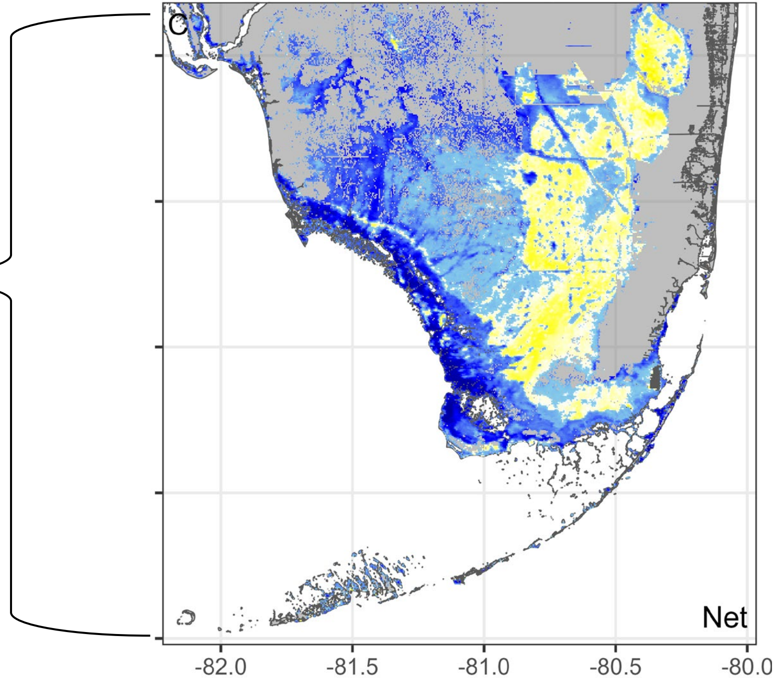


Daily predicted CO_2 and CH_4 fluxes at the 500-m scale capture long-term regional CO_2eq emissions needed for GHG reporting

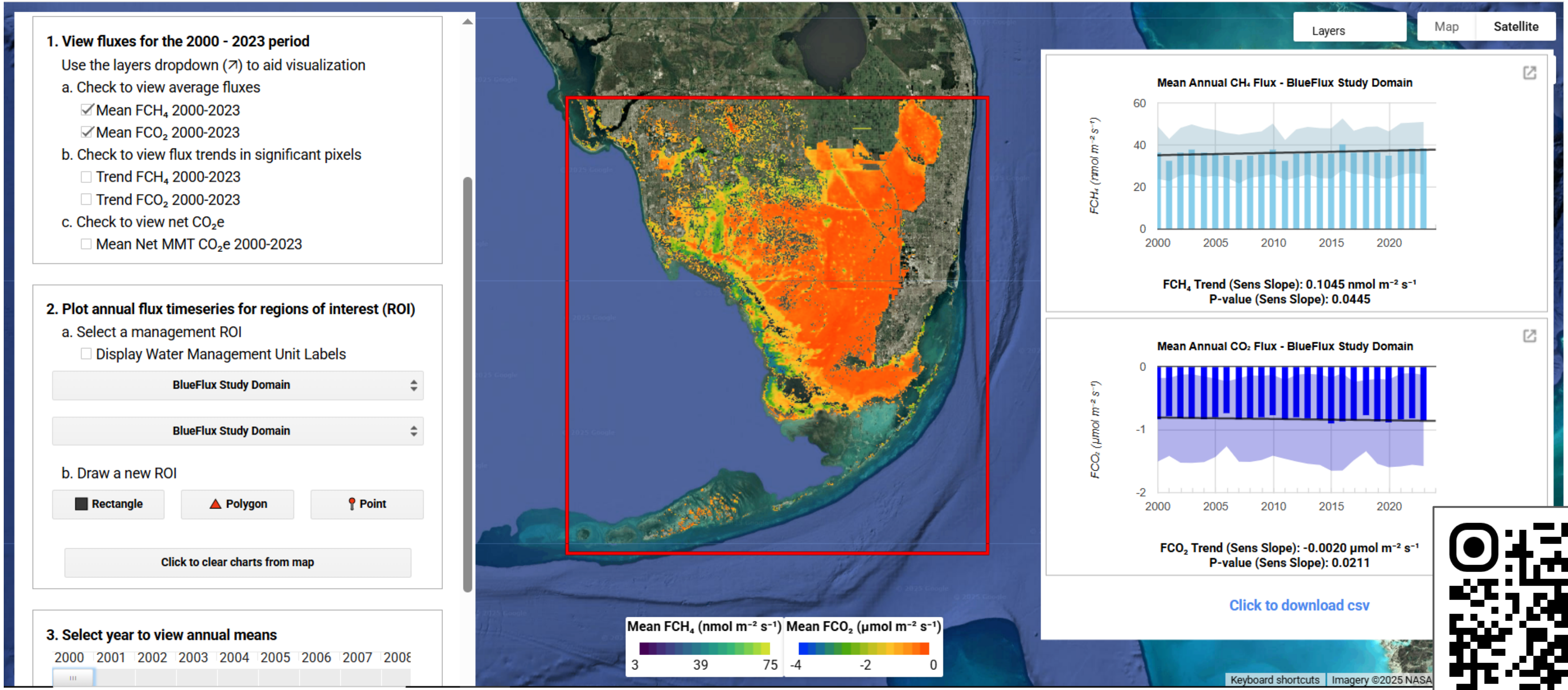


Regional CO_2eq over time highlights interannual variability and long-term trends





We developed an interactive approach to explore CO_2 and CH_4 fluxes and long-term trends across the Everglades ecosystem



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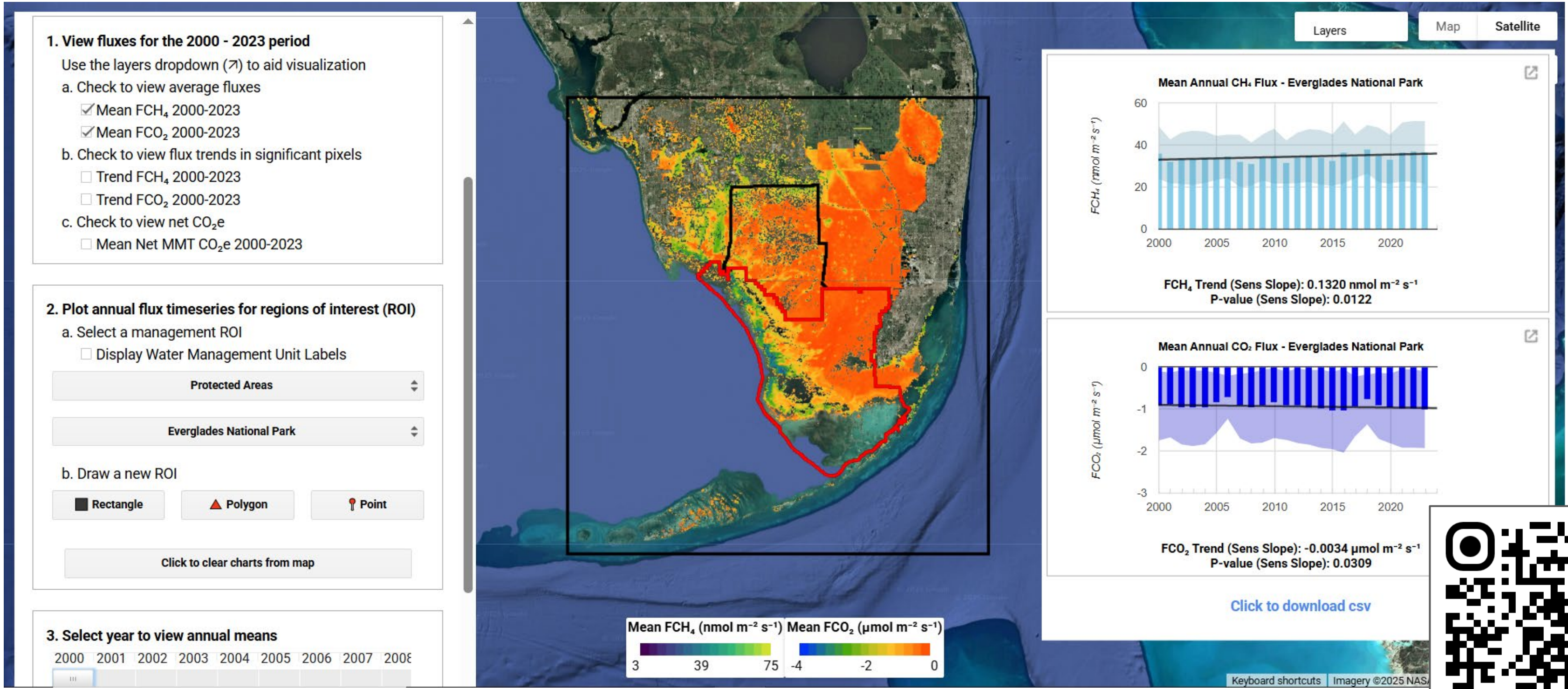

Patterns in BCE uptake of CO_2eq over time varied among AHED water management units

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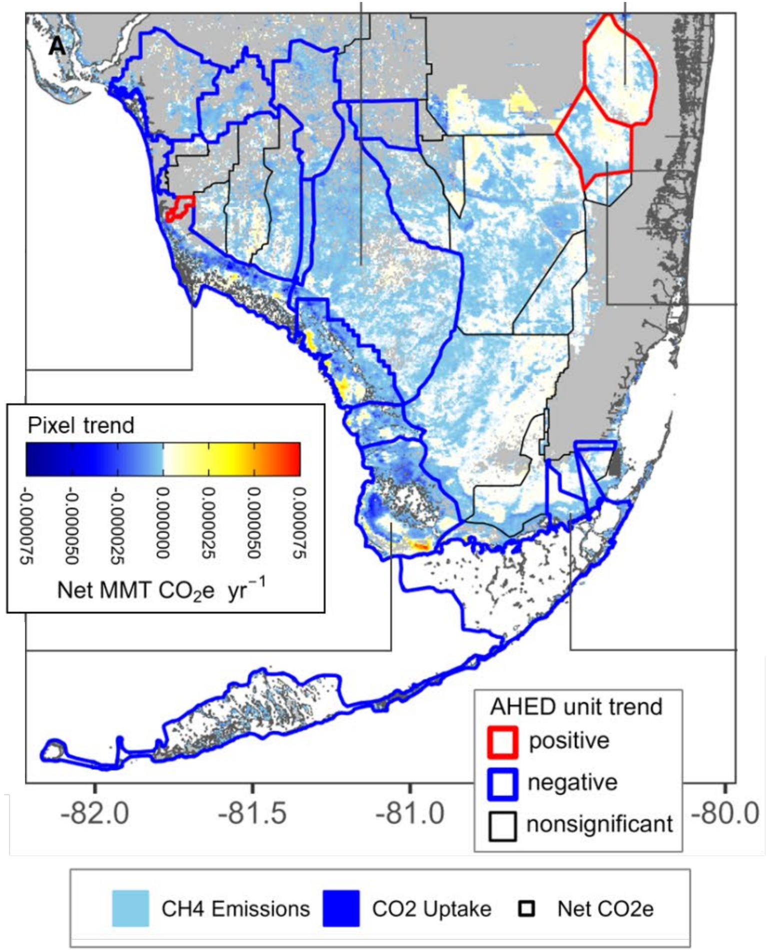
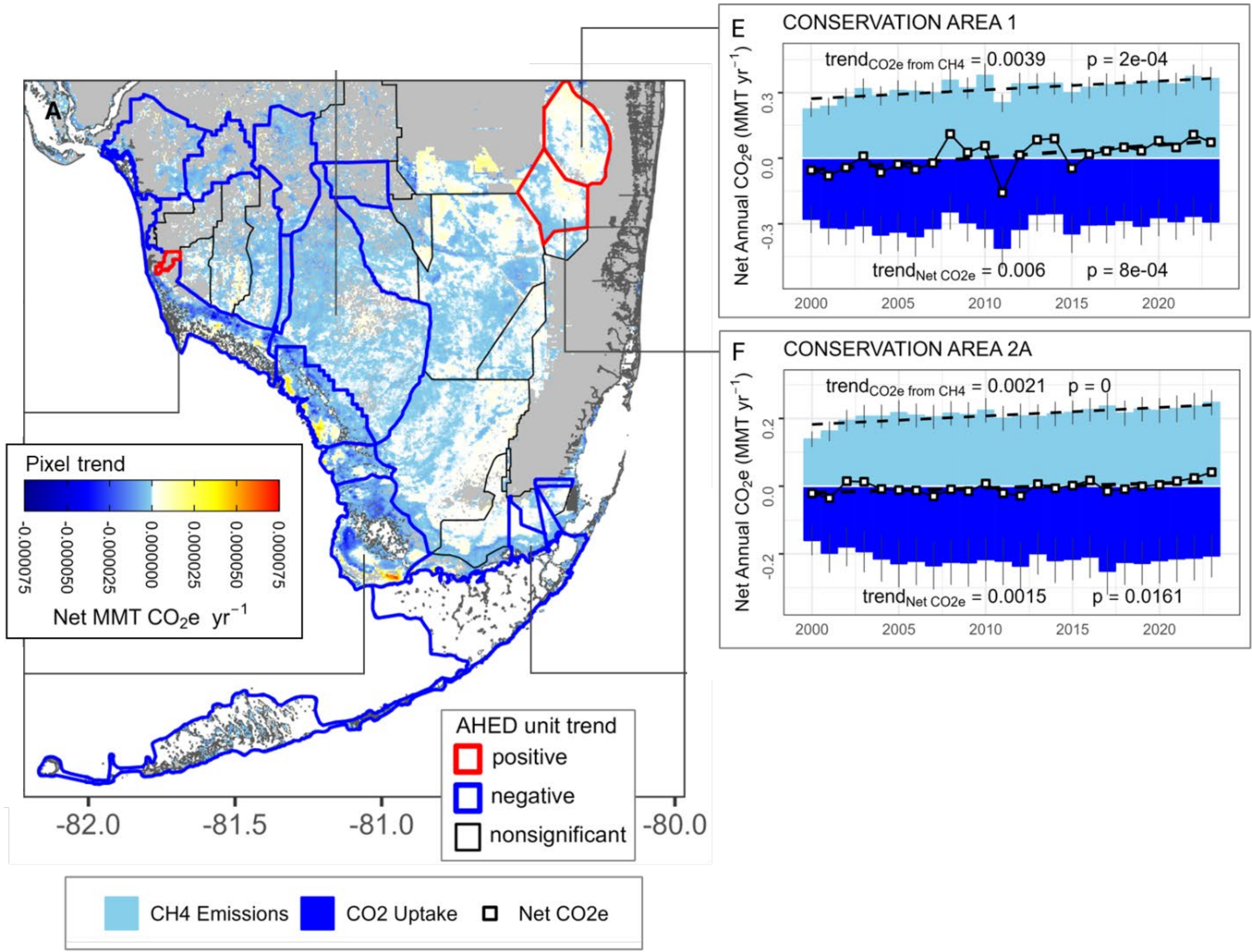
part of CERP efforts to restore and protect South Florida's diverse ecosystems while balancing human-related needs for water supply and flood protection

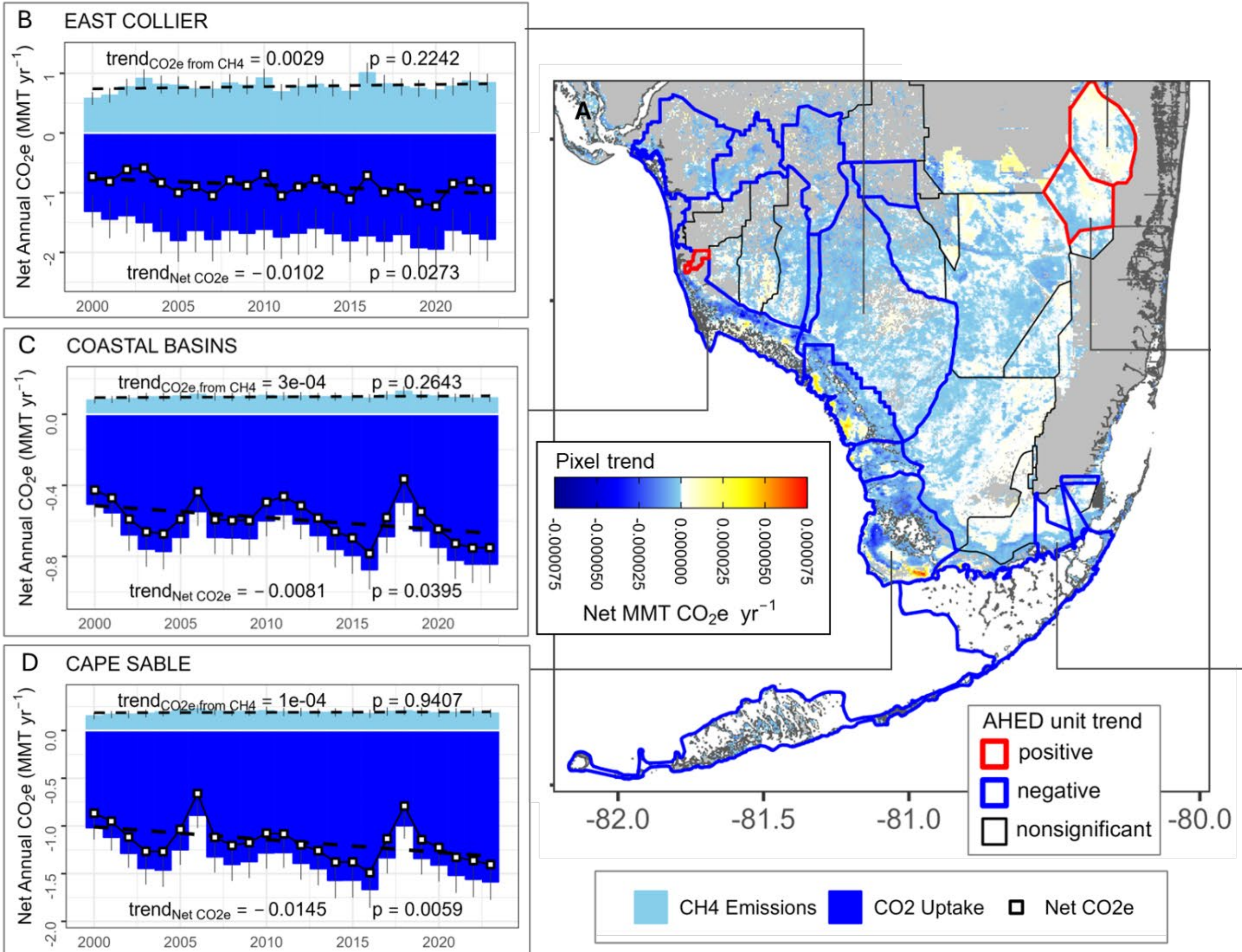


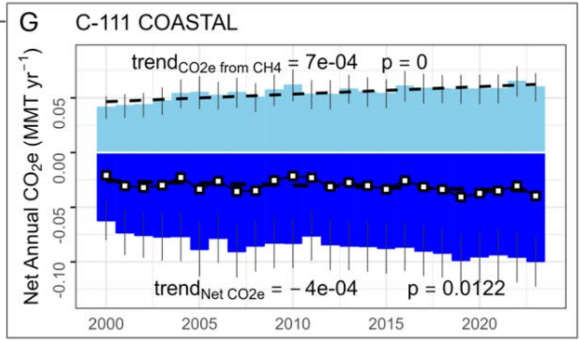
- Water Conservation Areas 1 and 2A showcase where net CO_2eq trends 2000-2023 were positive

- Abrupt and gradual conversion of C sinks to sources over time due to disturbance and increased contributions of CH_4 to net CO_2eq emissions in areas of freshwater marsh

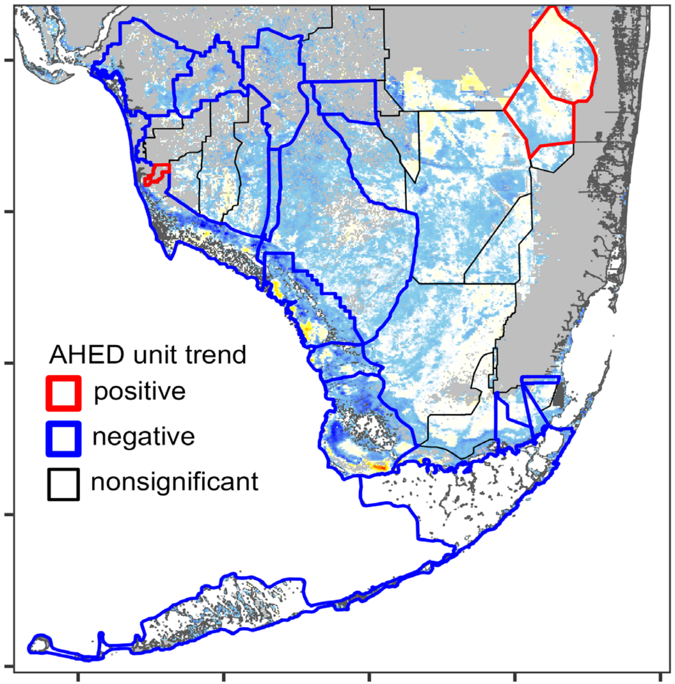


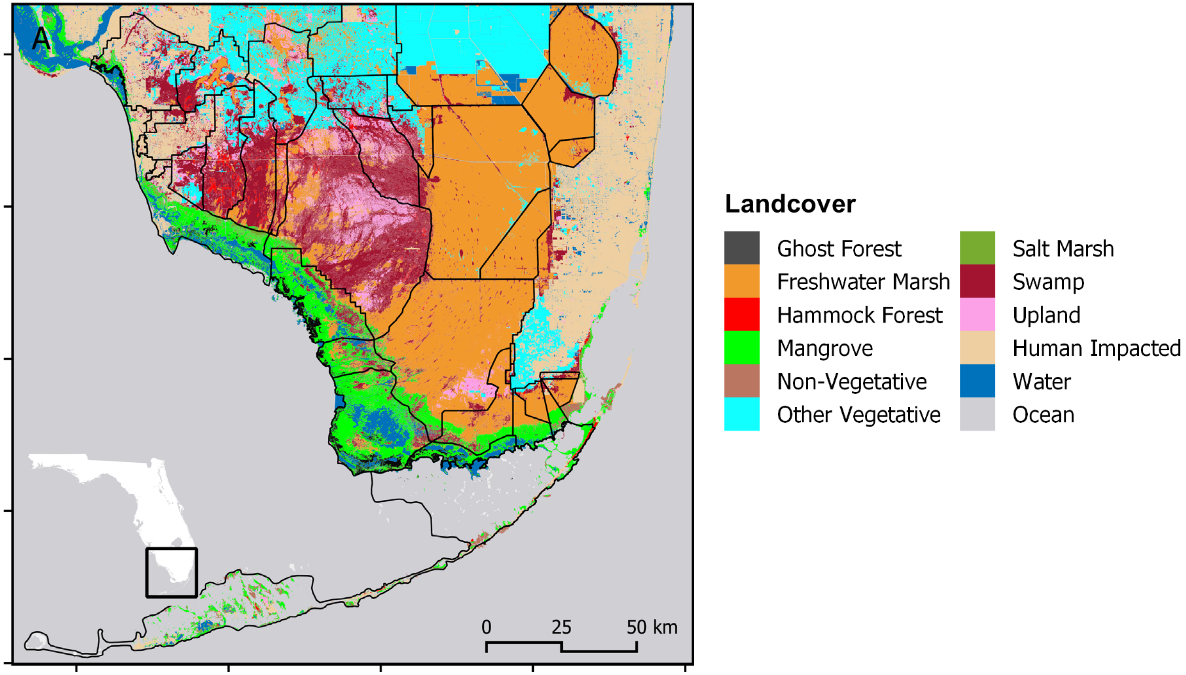
- Negative trends in net CO_2eq found in several water management units where CO_2 uptake outweighed CH_4 emissions
  - interannual CO_2 drawdown fluctuates
  - CH_4 fluxes outpace CO_2 fluxes
  - environmental disturbances to specific BCEs impact their capacity to sequester CO_2



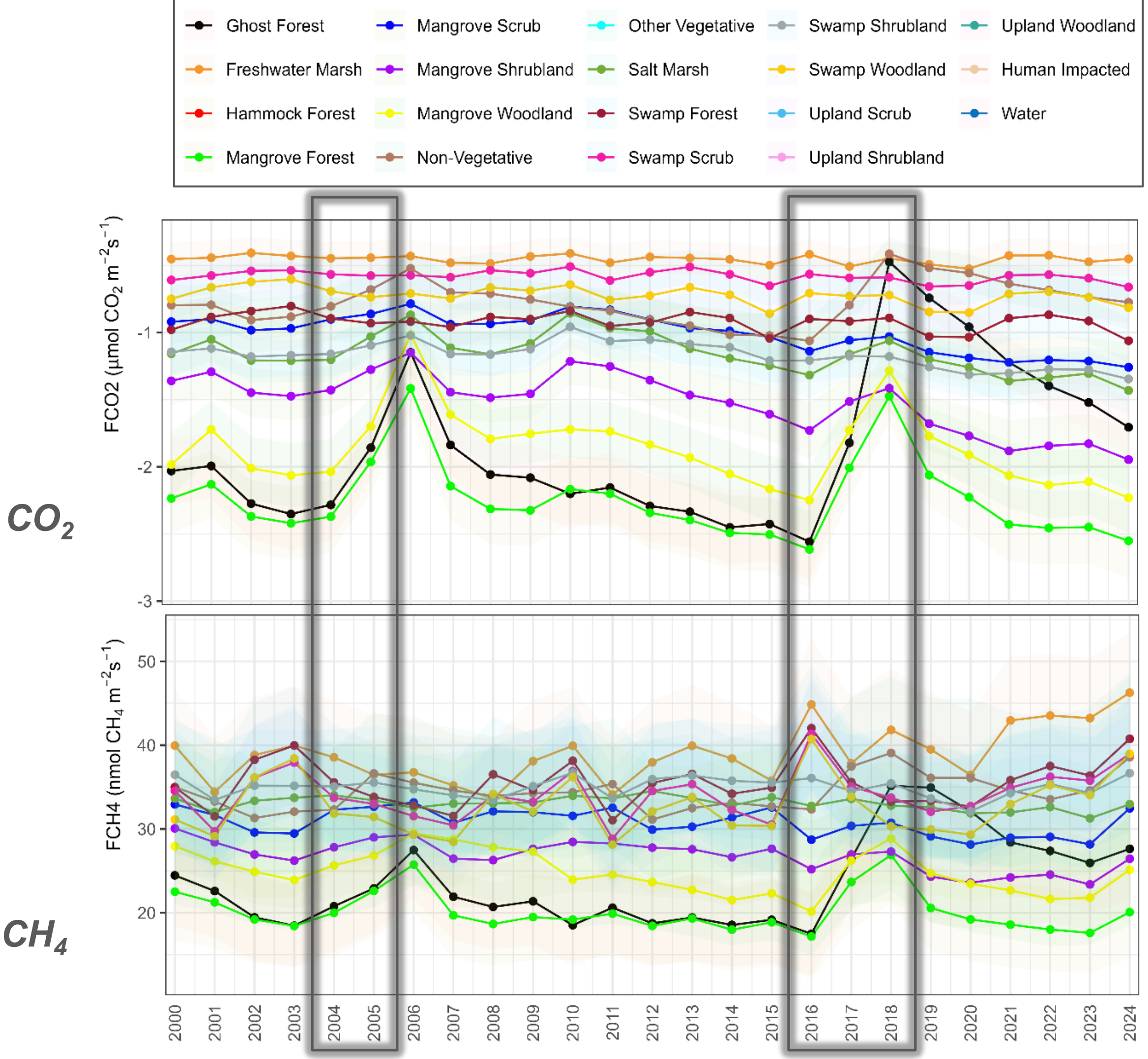


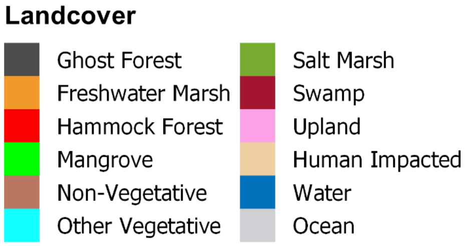
Net CO_2eq uptake varied among BCEs and each faces specific environmental disturbances that impact their capacity to sequester CO_2





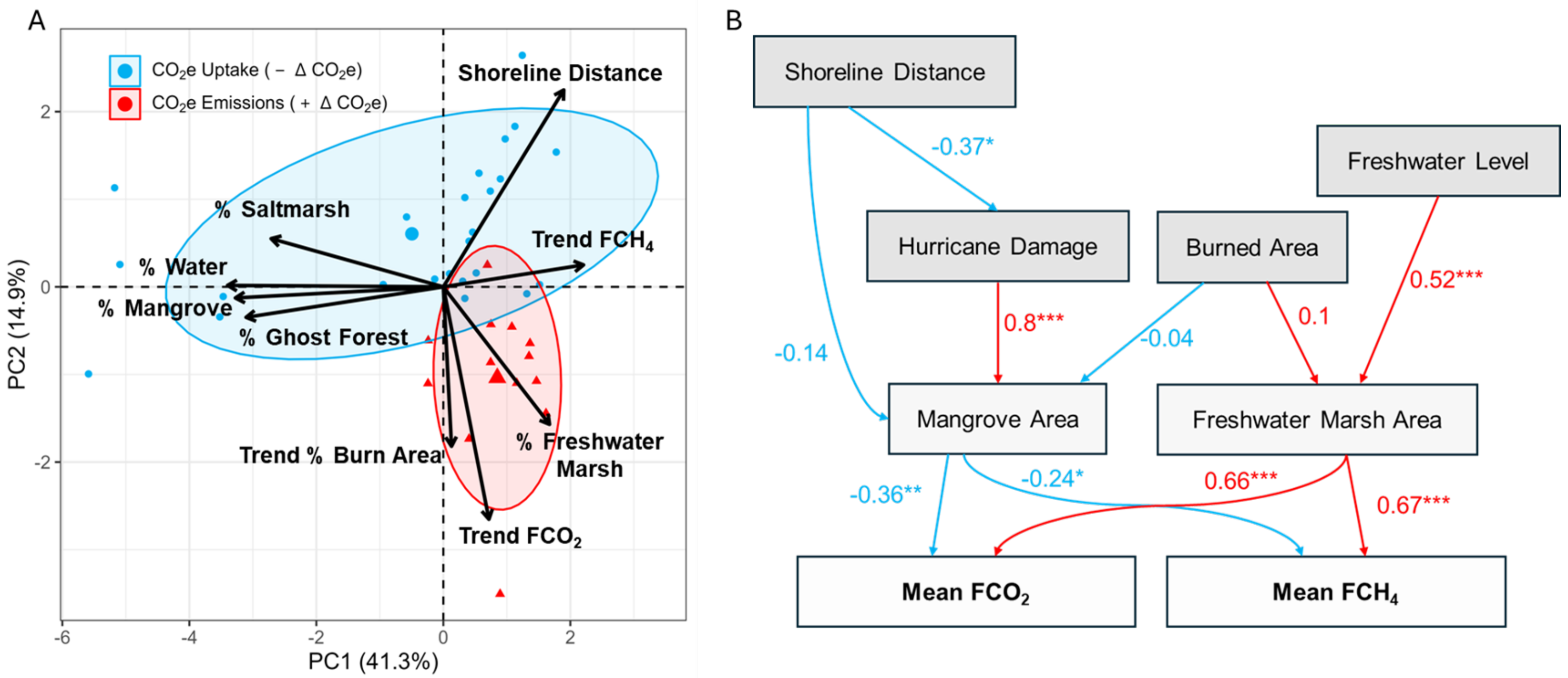
Net CO_2eq uptake varied among BCEs and each faces specific environmental disturbances that impact fluxes





Major Hurricanes (> Cat 3)	
Idalia 2023	H4
Nicole 2022	H1
Ian 2022	H5
Elsa 2021	H1
Eta 2020	H4
Sally 2020	H2
Michael 2018	H5
Irma 2017	H5
Matthew 2016	H5
Hermine 2016	H1
Wilma 2005	H5
Rita 2005	H5
Katrina 2005	H5
Dennis 2005	H4
Jeanne 2004	H3
Ivan 2004	H5
Frances 2004	H4
Charley 2004	H4
Gordon 2000	H1

Adaptive management of environmental conditions can mitigate flux emissions in BCEs



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CORESCAM Coastal Biodiversity Resilience to Increasing Extreme Events in Central America

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Thank you!

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