The breathing of a salt marsh: learnings and challenges about carbon dynamics

Restore America's Estuaries

Rodrigo Vargas

Department of Plant and Soil Sciences

@vargaslab

University of Delaware

rvargas@udel.edu

Acknowledgements

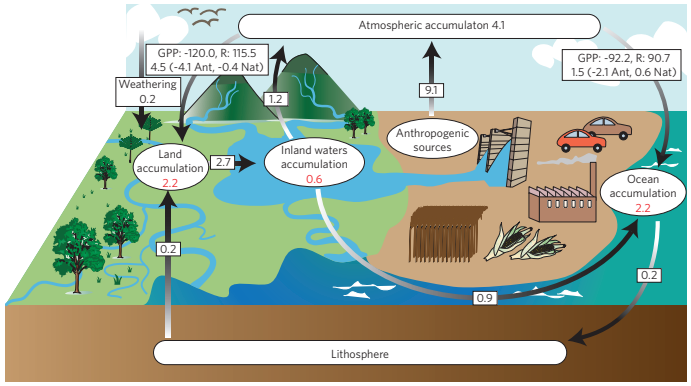
Students @VargasLab
Margaret Capooci, Andrew Hill, Branimir Trifunovic, Alma Vazquez-Lule, Jocelyn Wardrup

- Delaware National Estuarine Research Reserve (DNERR)

+ multiple co-authors and colleagues

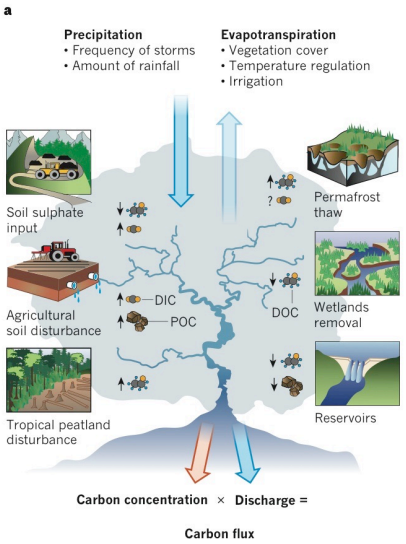
#1

“Boundless Carbon Cycle”

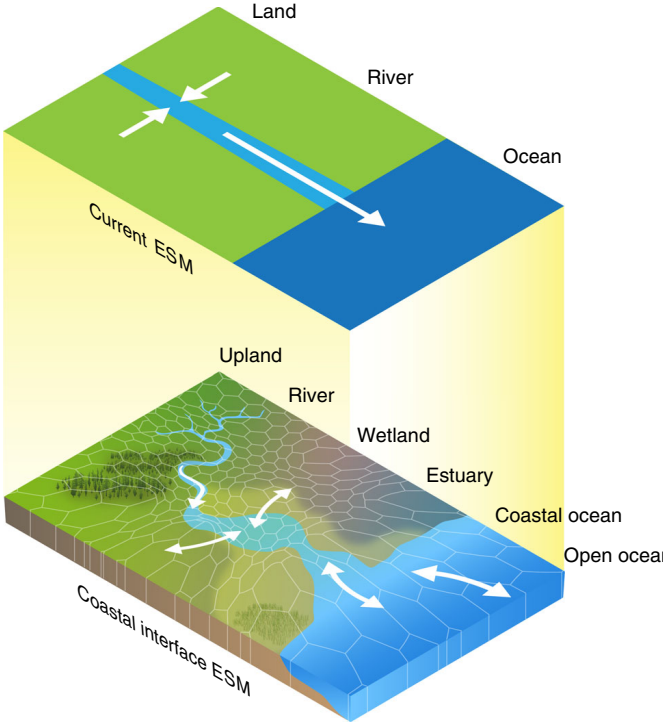


Land-ocean

(Battin et al 2009)

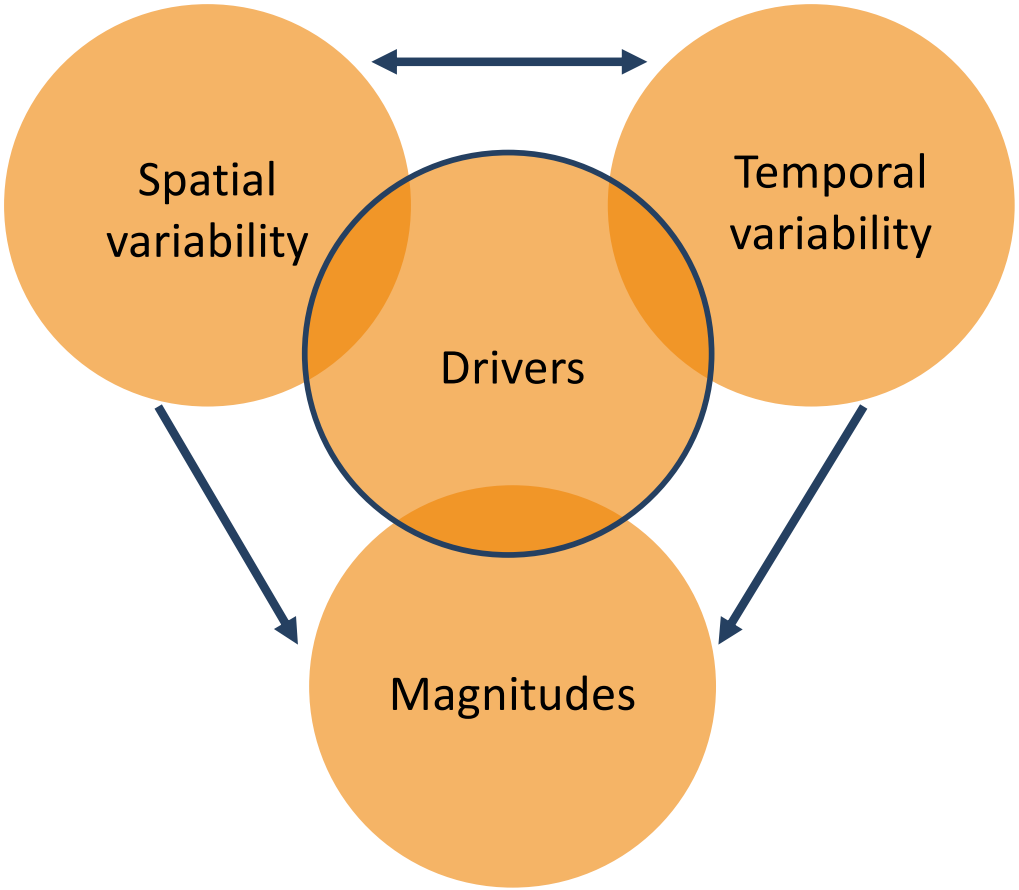


(Bauer et al 2013)



(Ward et al 2020)

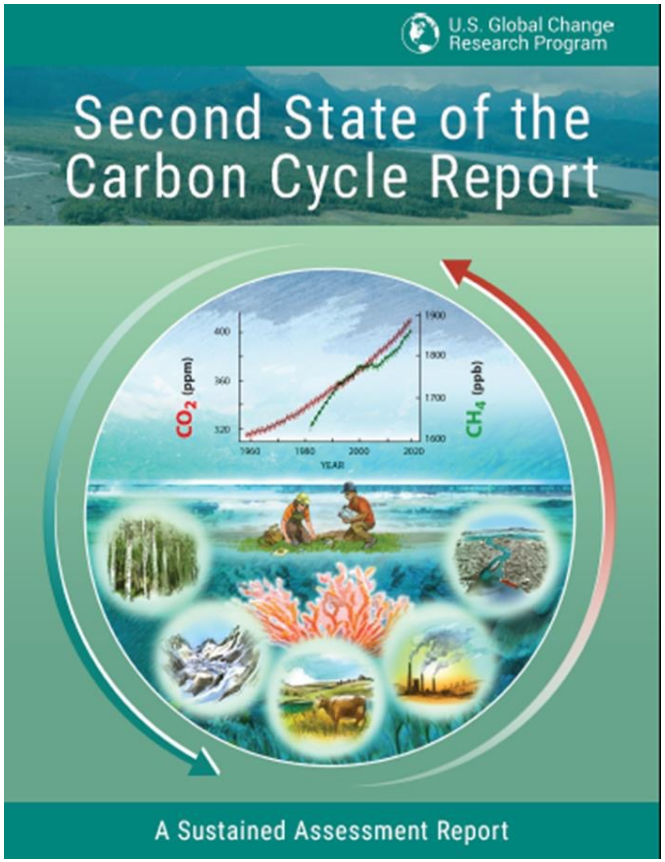
#2


Spatial variability
Temporal variability
Drivers
Magnitudes

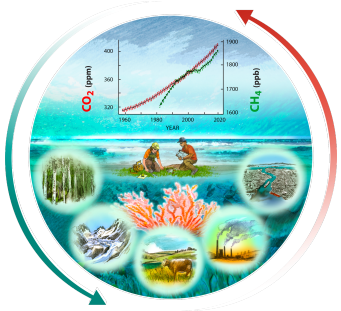
#3

"…One of the chief difficulties encountered in the work has been the development of adequate methods. From time to time, new methods have been devised, but each has left something to be desired."

Smith and Brown, 1931 Agronomy Journal



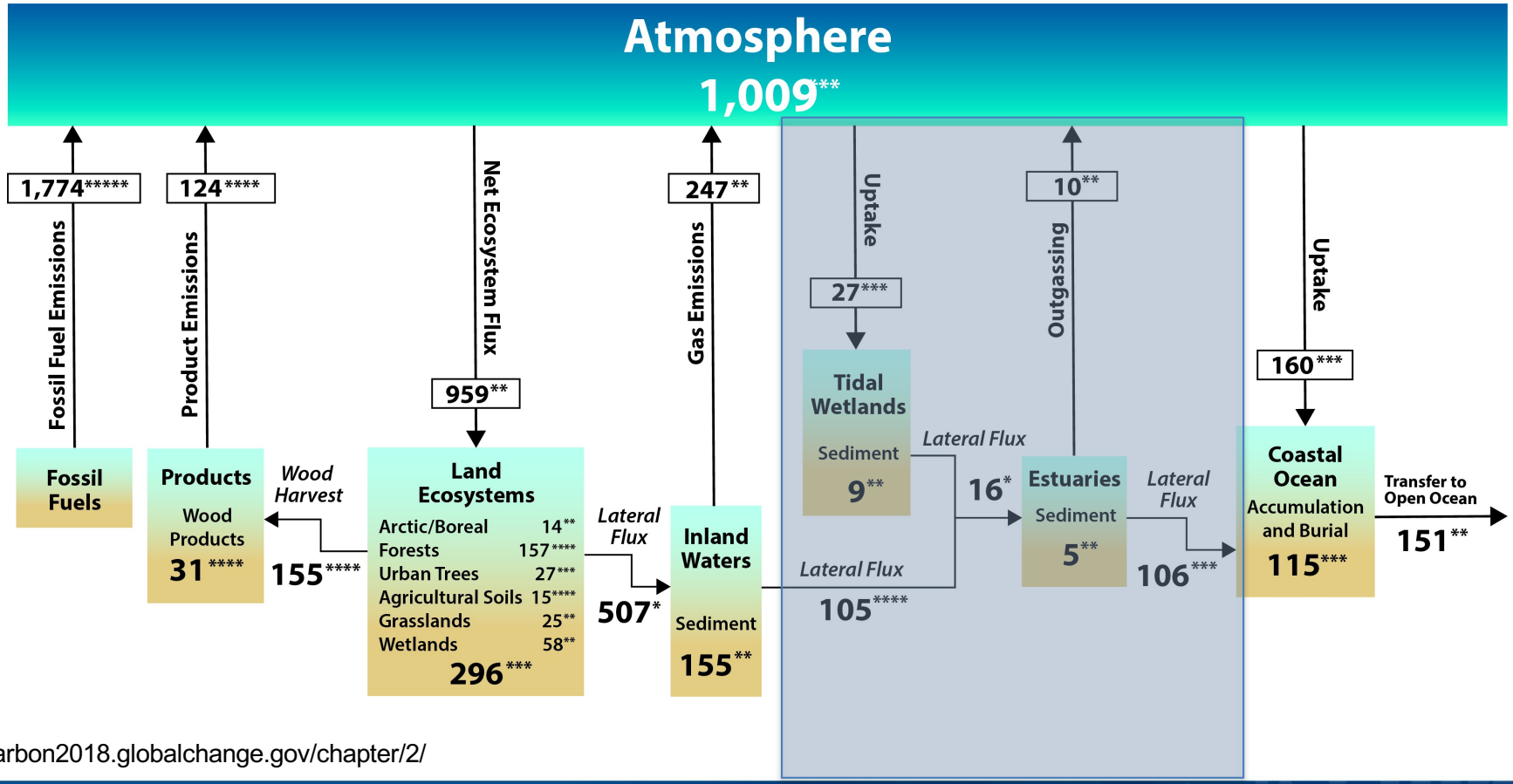
USGCRP, 2018: Second State of the Carbon Cycle Report (SOCCR2): A Sustained Assessment Report [Cavallaro, N., G. Shrestha, R . Birdsey, M. A. Mayes, R . G. Najjar, S. C. Reed, P. Romero-Lankao, and Z. Zhu (eds.)]. U.S. Global Change Research Program, Washington, D.C., USA, 878 pp., https://doi.org/10.7930/SOCCR2.2018.



The *Second State of the Carbon Cycle Report* (SOCCR2) provided a current state-of-the-science assessment of the carbon cycle in North America (i.e., the United States, Canada, and Mexico) and its connection to climate and society.

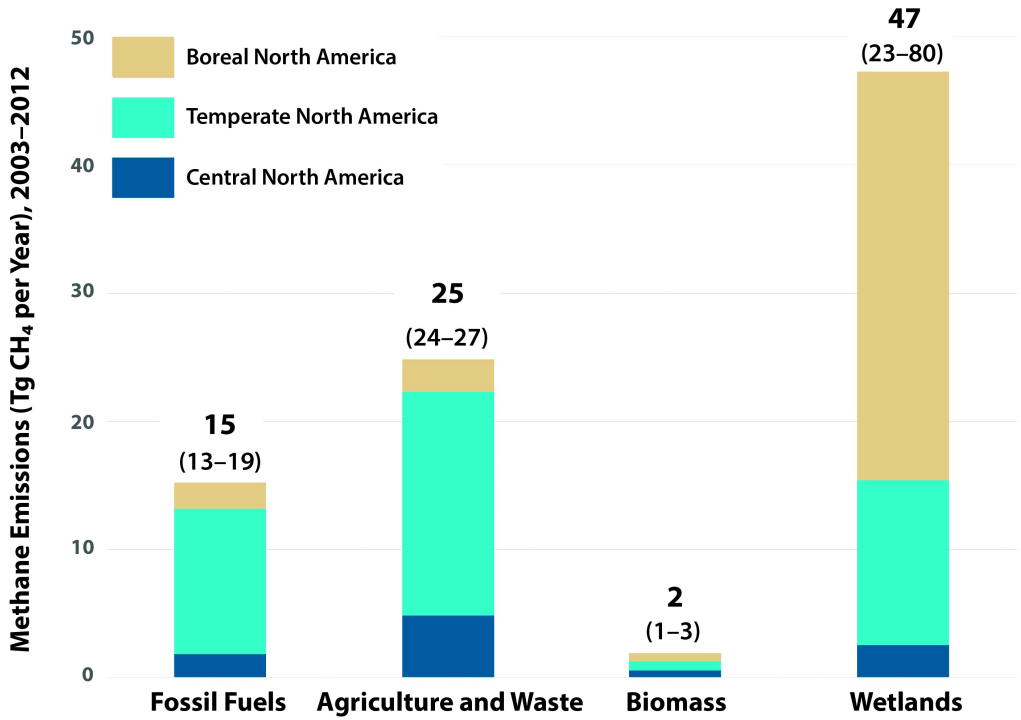
These findings were based on multidisciplinary research that includes experimental, observational, and modeling studies from the last decade.

It was intended for a diverse audience that includes scientists, decision makers in the public and private sectors, and communities across the United States, North America, and the world,



https://carbon2018.globalchange.gov/chapter/2/

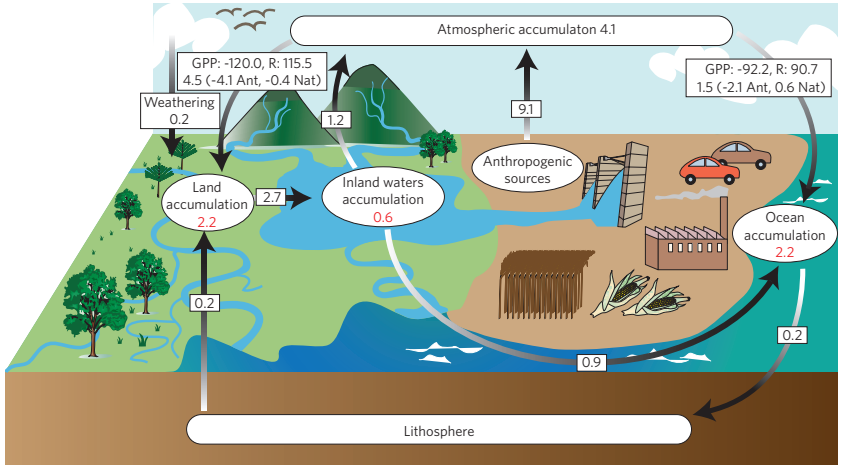
Sources of Methane (CH_4) Emissions Estimated from Bottom-Up Methods for Three Regions of North America from 2003 to 2012



But…

https://carbon2018.globalchange.gov/chapter/2/

Challenges 1-3



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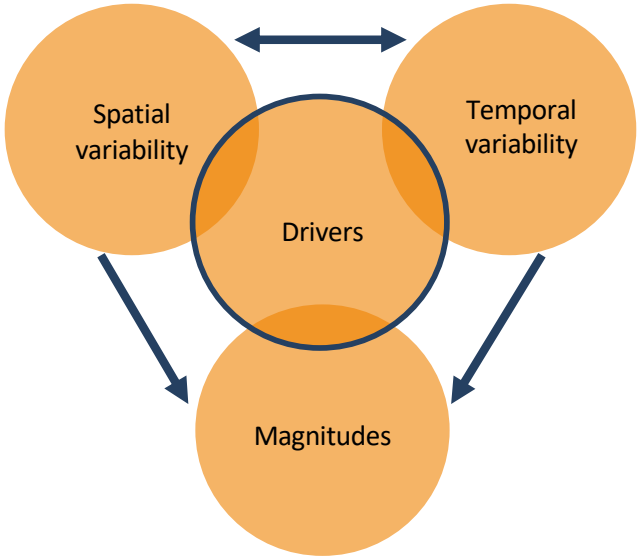
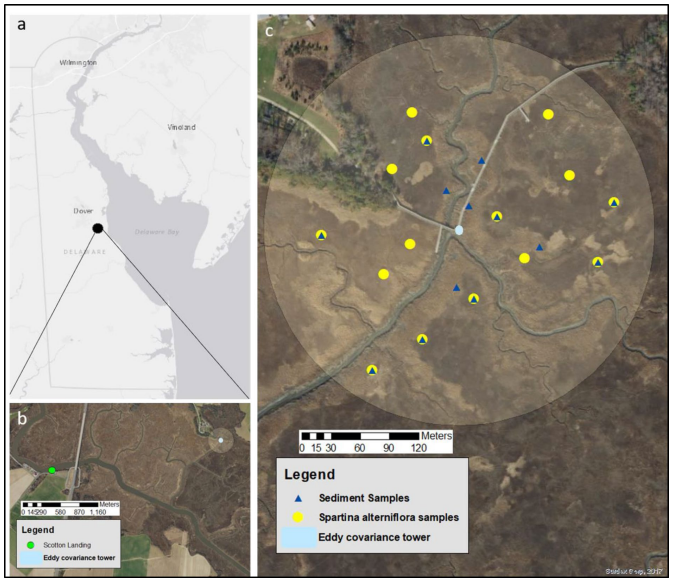
Smith and Brown, 1931 Agronomy Journal



How?

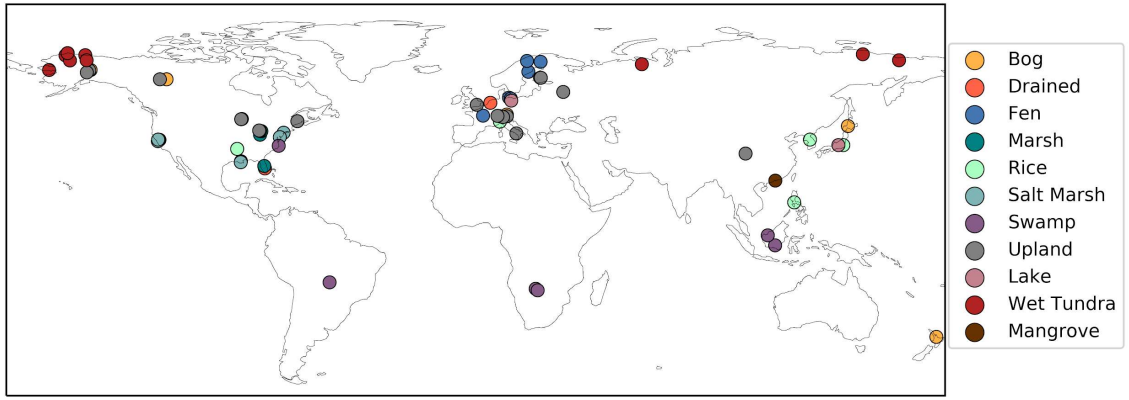
https://coast.noaa.gov/nerrs/

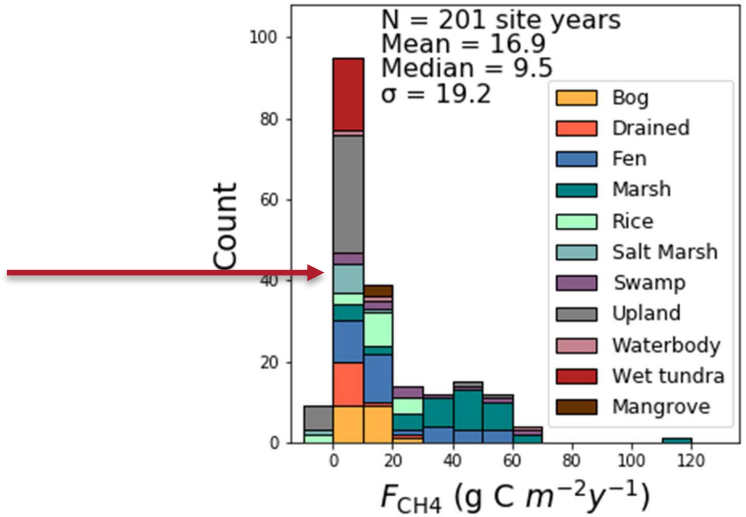


Lichiheb et al. 2021

St Jones Reserve (salt marsh)…. dominated by *S. alterniflora*

FLUXNET-CH4





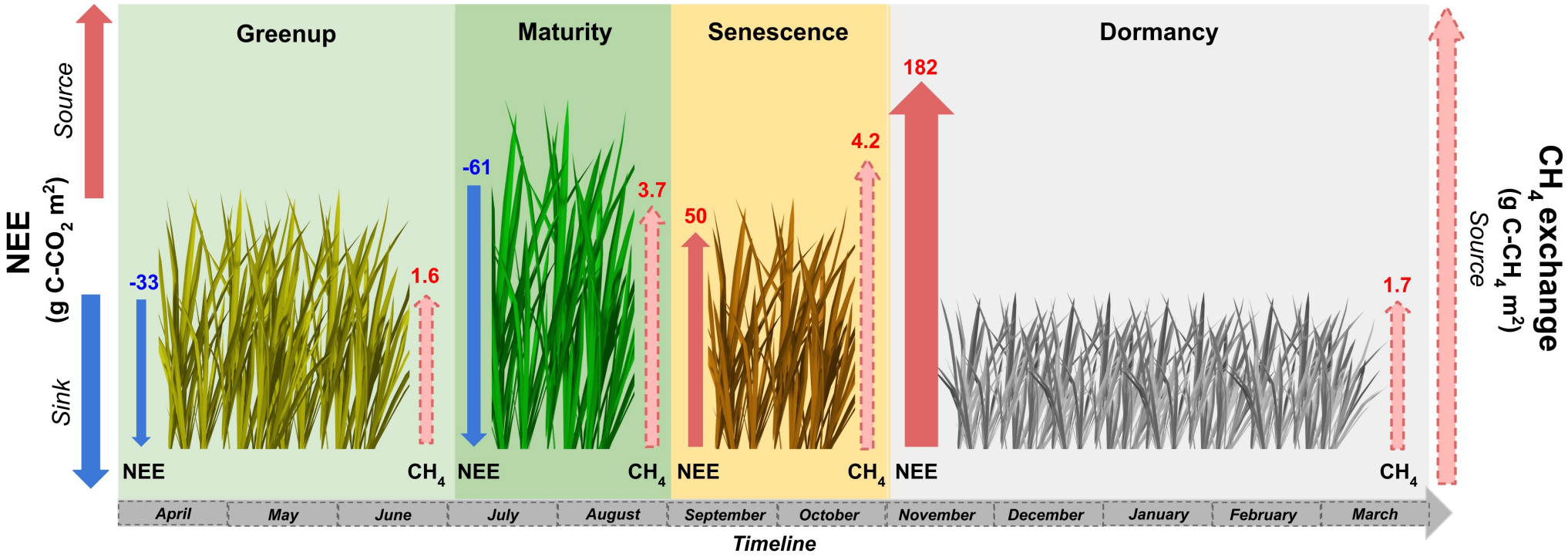
(Delwiche et al 2021)

5 Salt Marshes
10 site-years

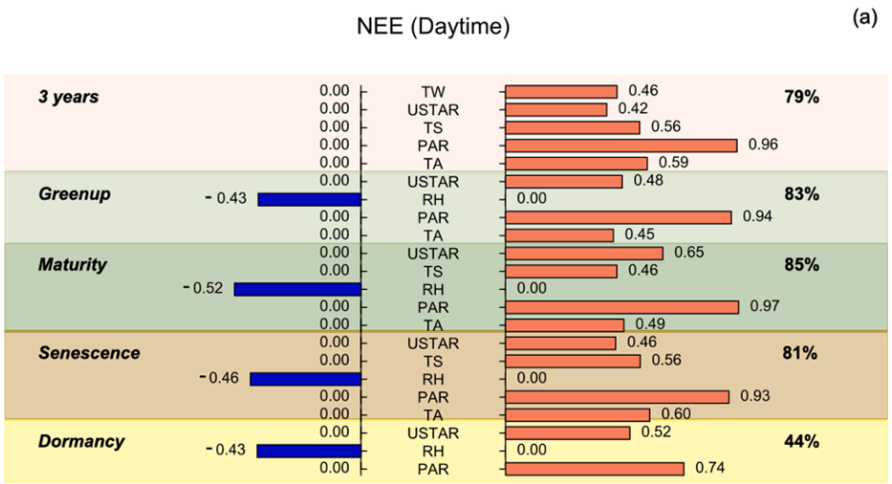
(out of 79 sites)

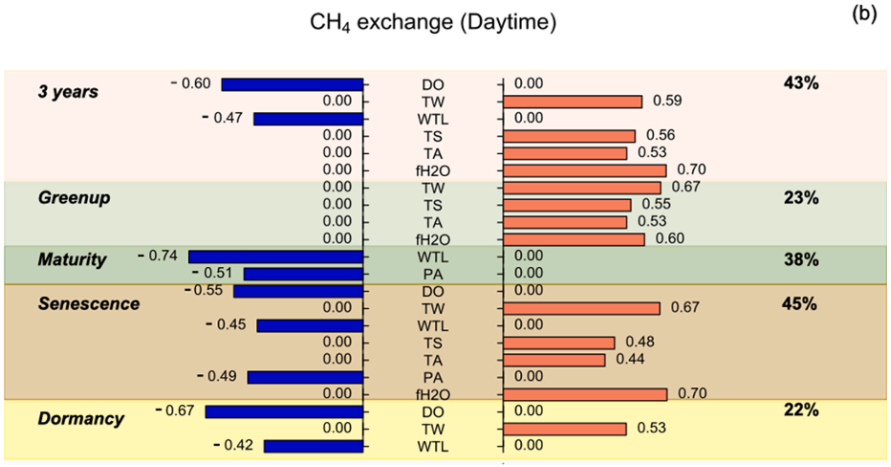
Net source of C to the atmosphere with annual emissions of:

- 13-201 g C-CO_2 m^{-2} yr^{-1}
- 8.5-15.2 g C-CH_4 m^{-2} yr^{-1}



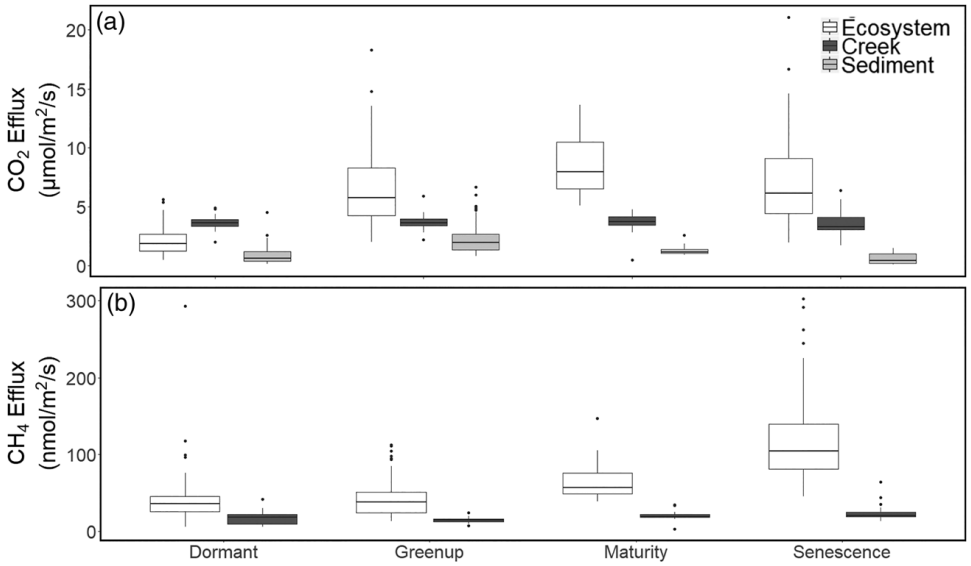
(Vazquez-Lule and Vargas et al 2021)

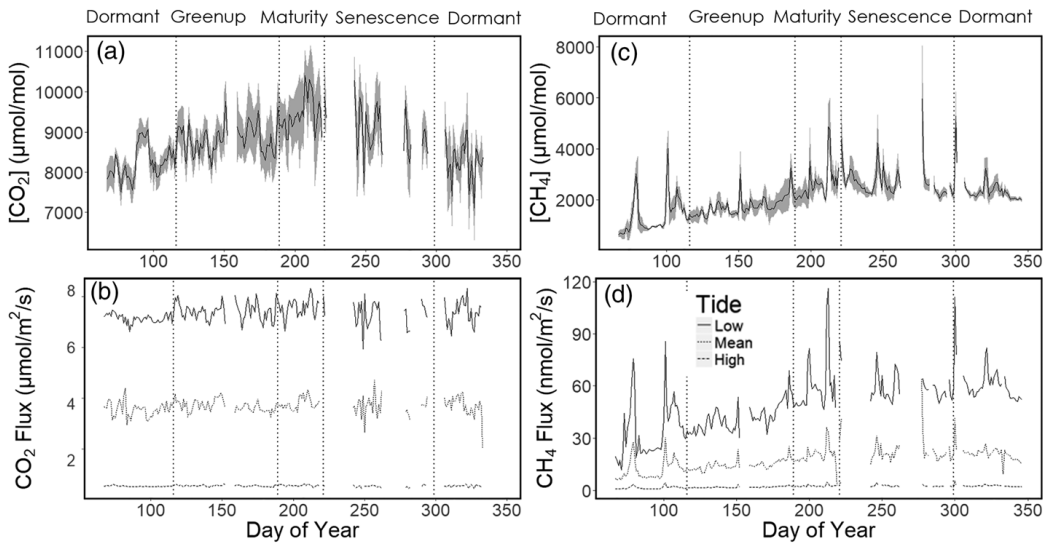




(Vazquez-Lule and Vargas et al 2021)

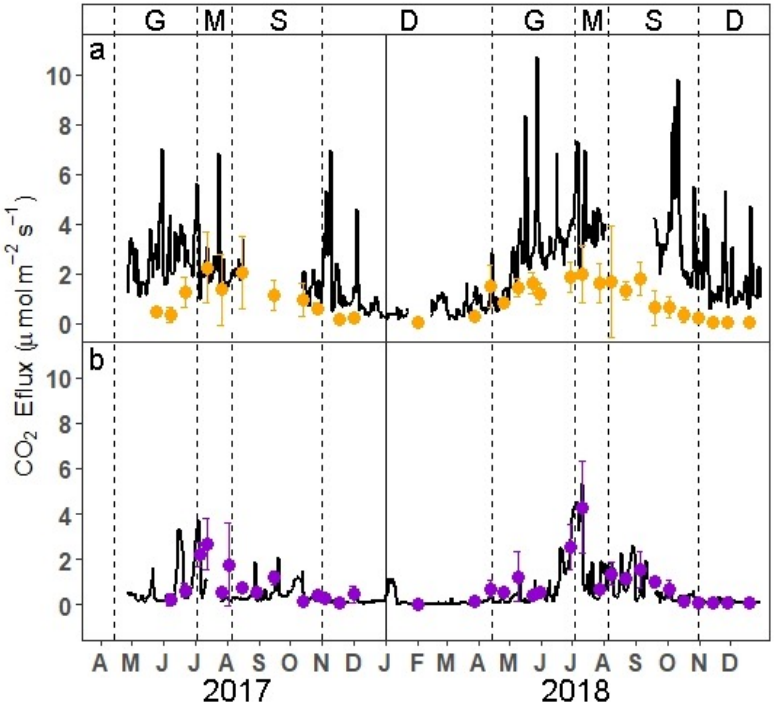
Water fluxes (creek)

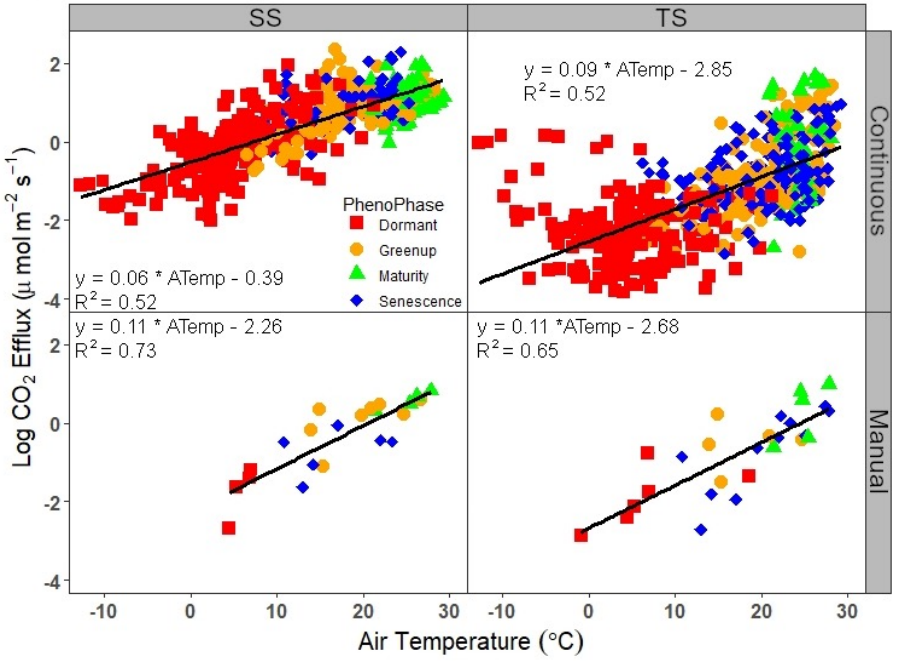




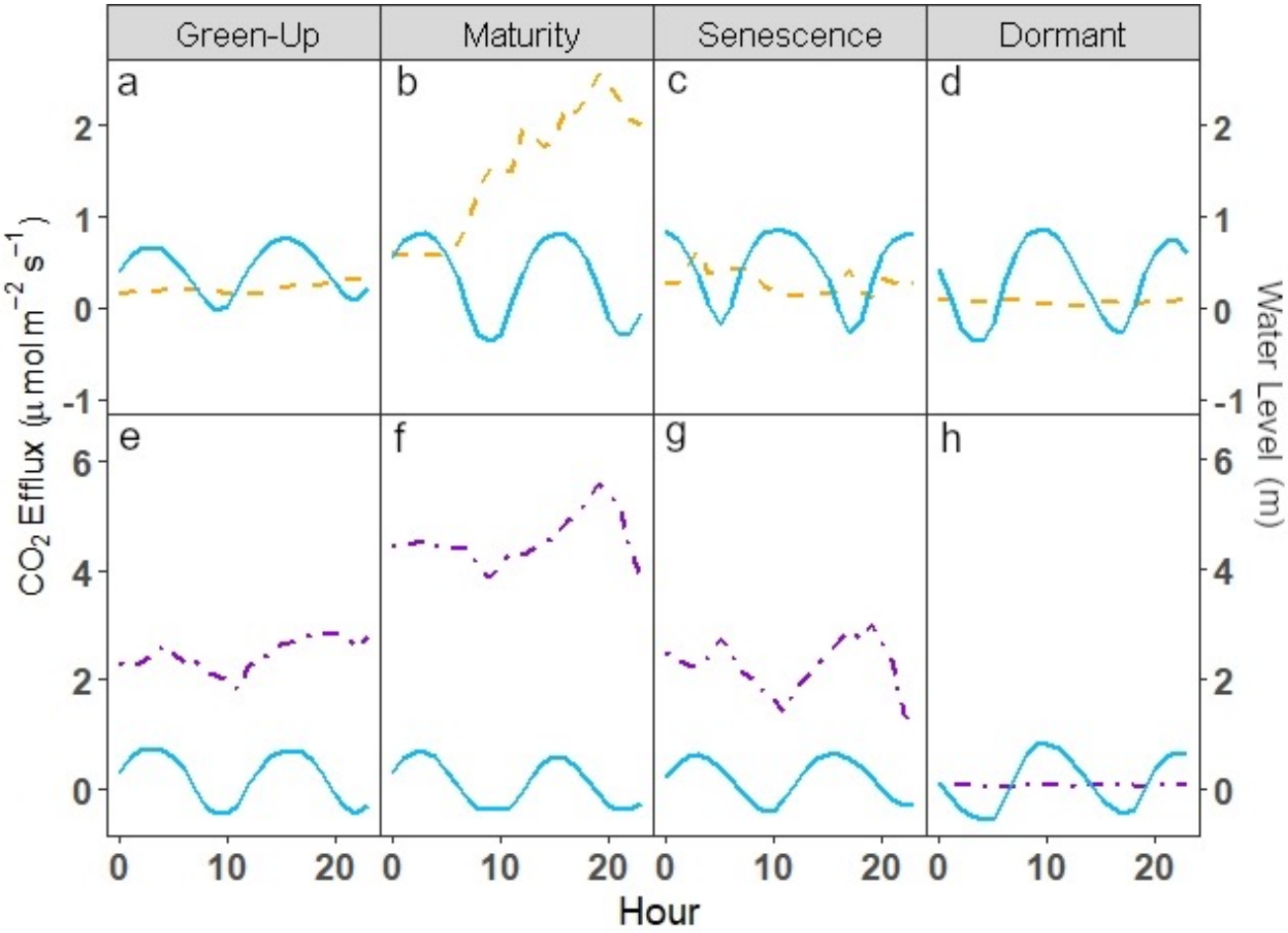
(Trifunovic et al 2020)

Manual vs Automated measurements
(soil CO_2 efflux)





(Capooci and Vargas [in review])



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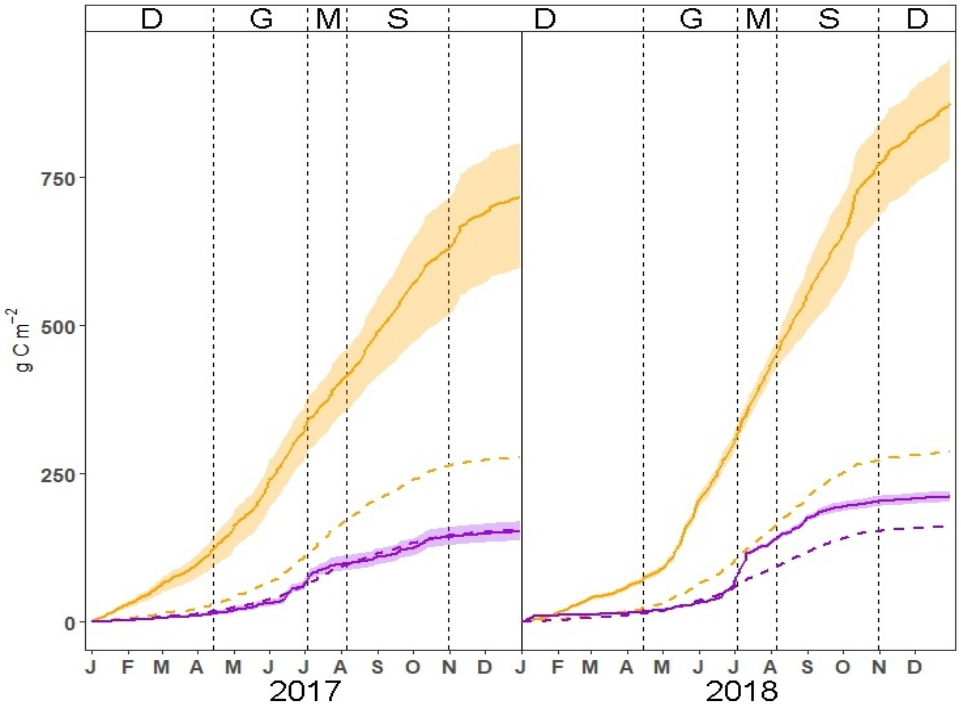
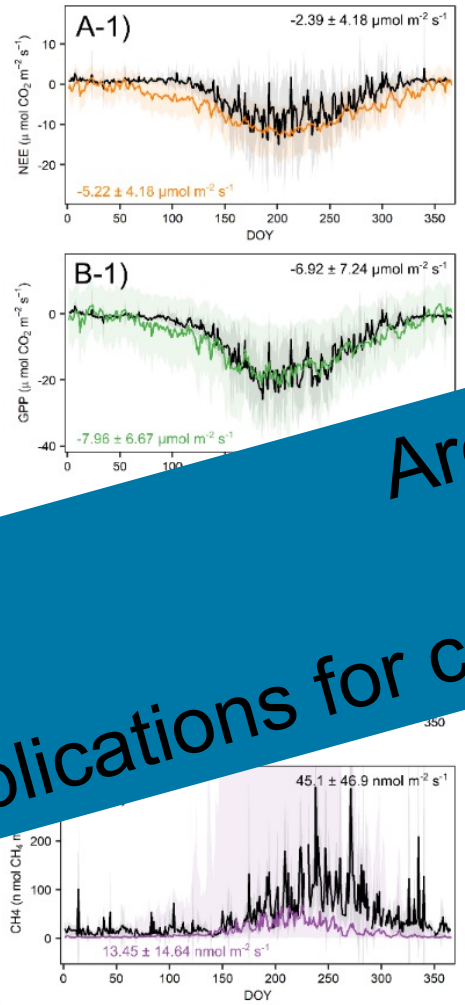


Manual measurements underestimated the annual flux between <23% and <67%.

(Capooci and Vargas [in review])



Annual Sum

R^2 = 0.87 → Overestimate by ~100%

R^2 → Underestimate by ~14%

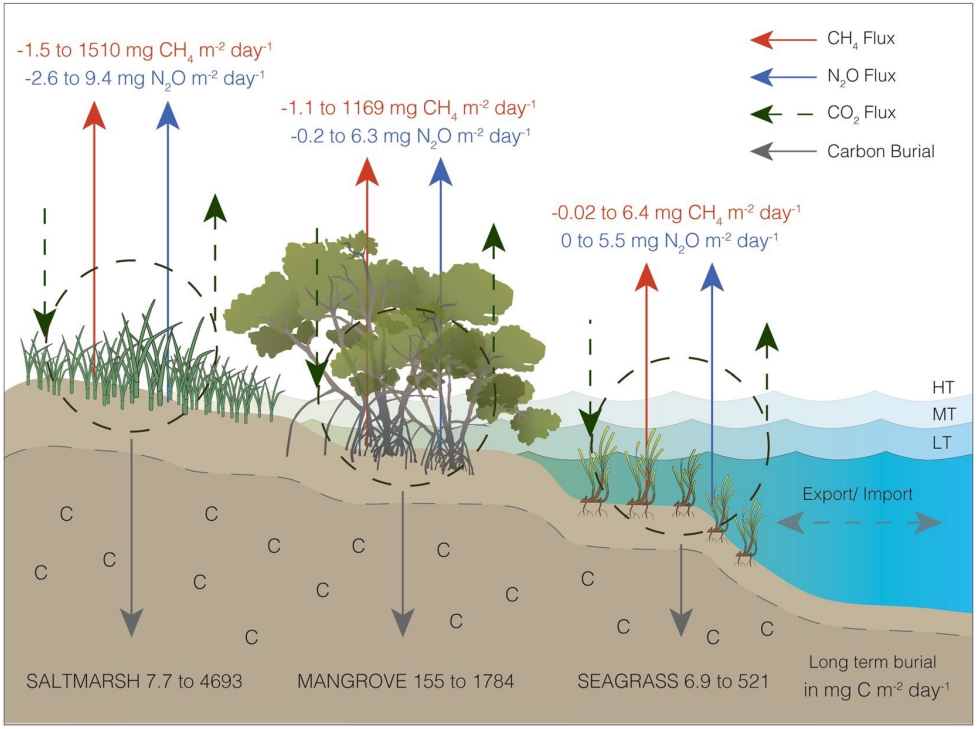
R^2 = 0.66 → Underestimate by ~70%

Are we there yet?

Implications for carbon modeling and accounting?

(Hill et al [unpublished])

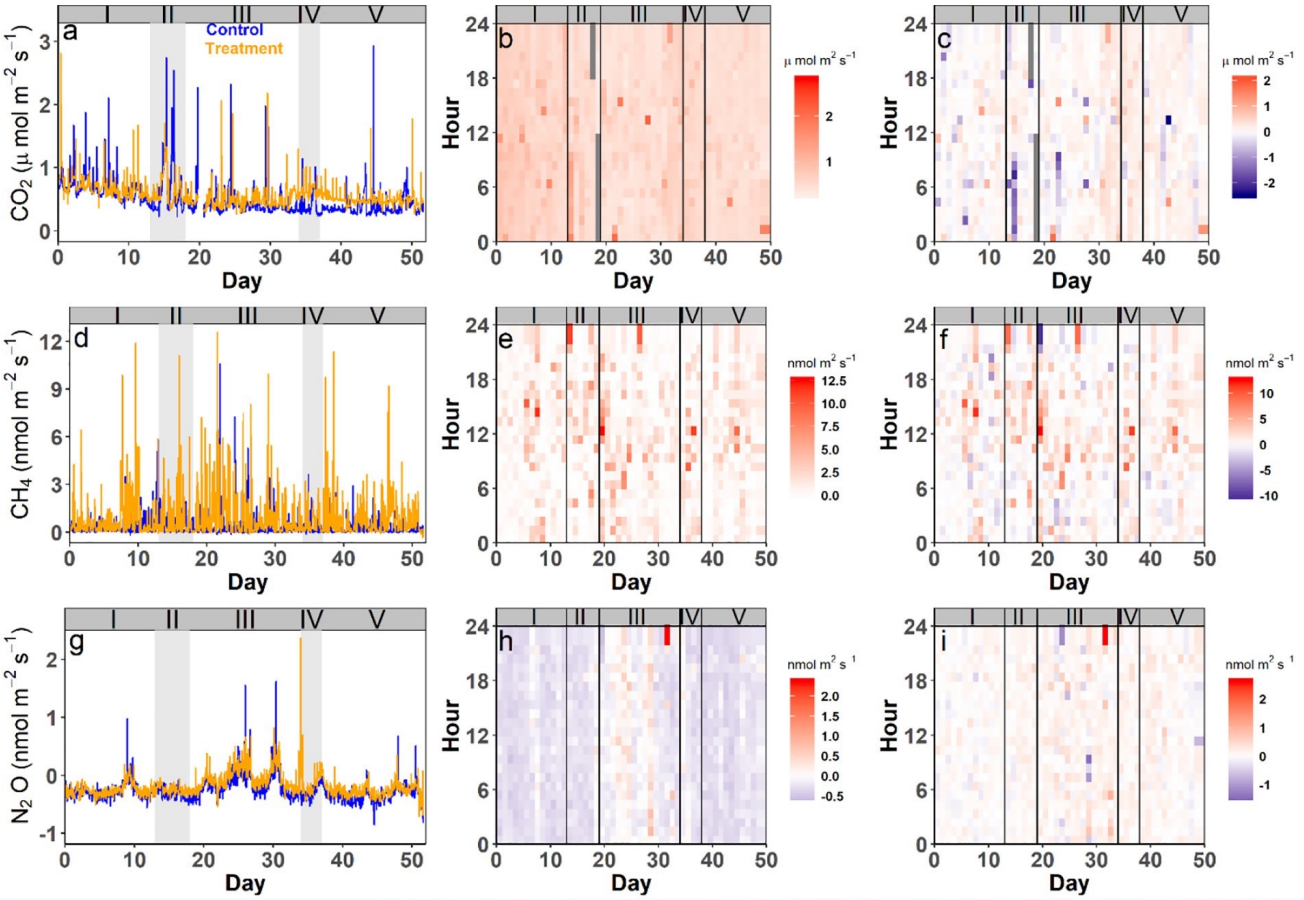
…methane and nitrous oxide emissions complicate coastal blue carbon assessments



(Rosentreter et al 2021)

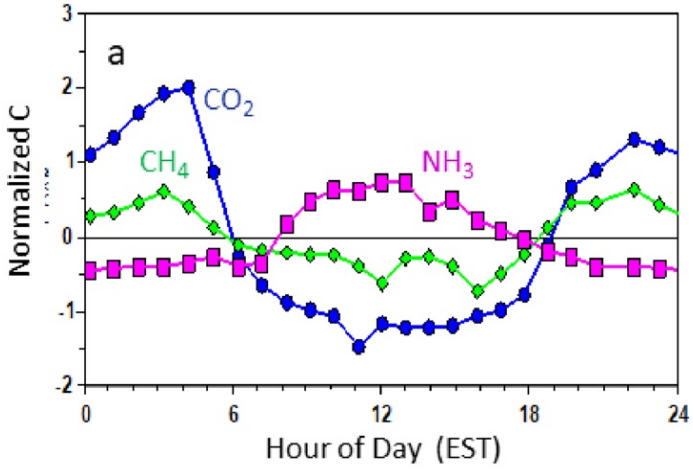
Heat map of fluxes treatment

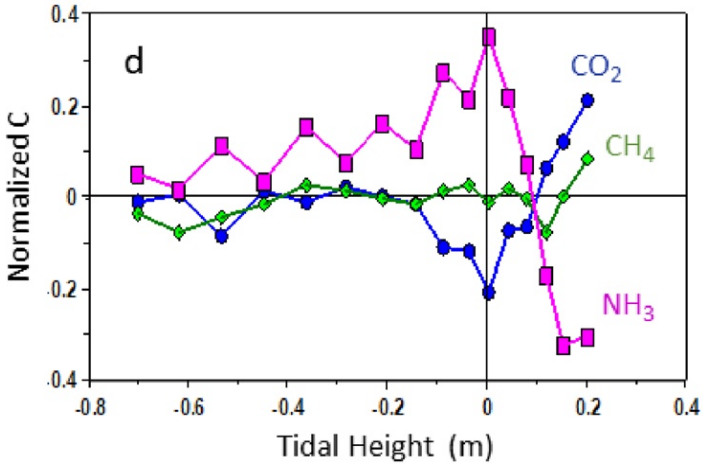
Heat map of differenced between treatment and control



(Capooci et al 2019)

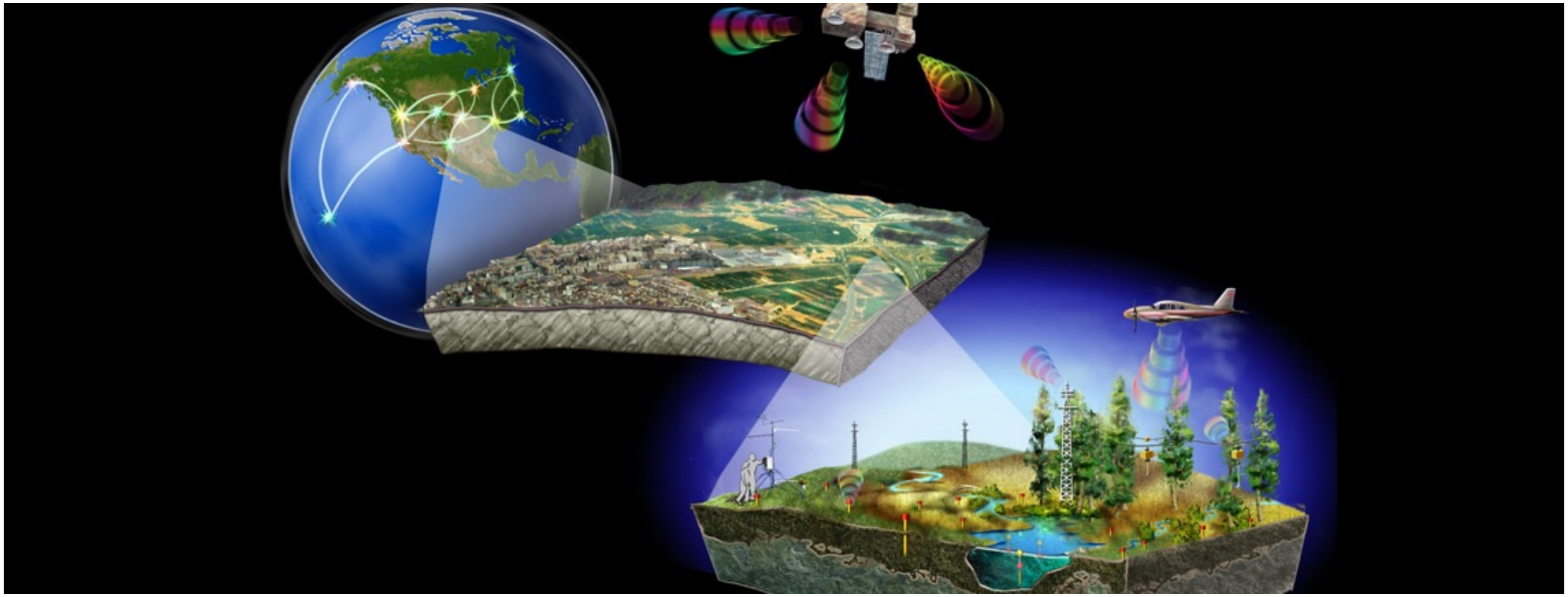
….what about ammonia?



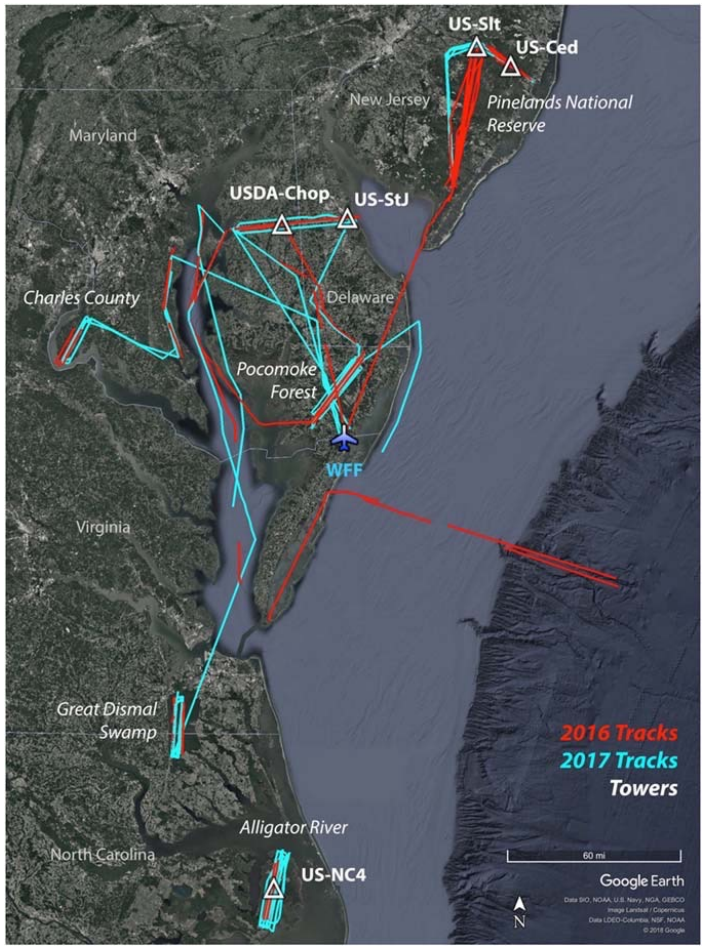


(Lichiheb et al 2021)

Multi-sensor remote sensing?



https://www.nsf.gov/news/special_reports/neon/



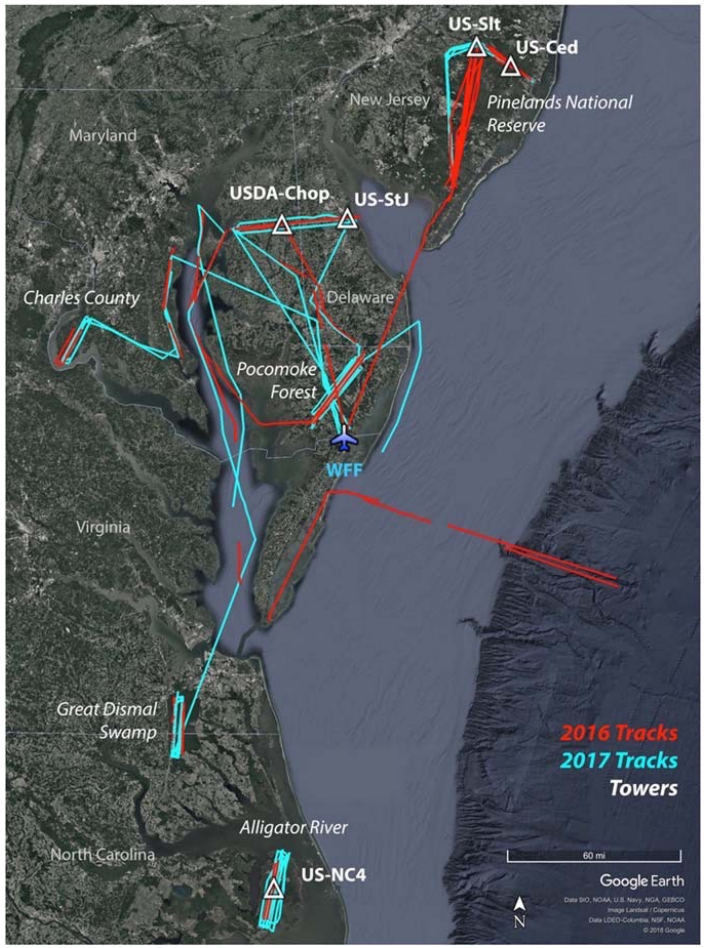
NASA Carbon Airborne Flux Experiment (CARAFE) platform

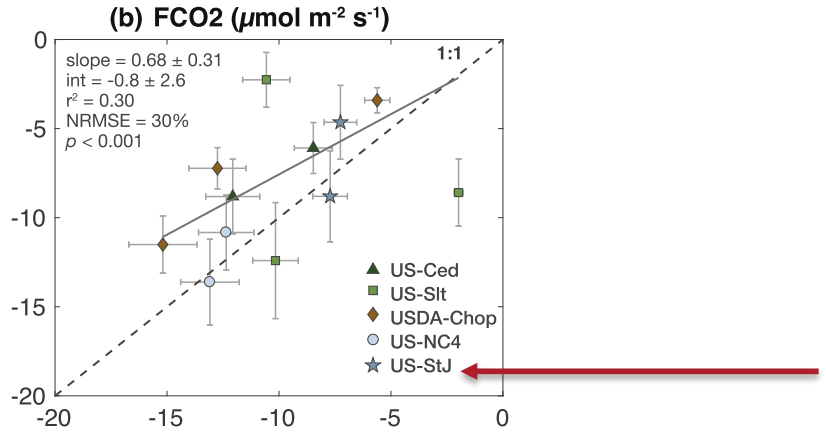
Airborne eddy covariance

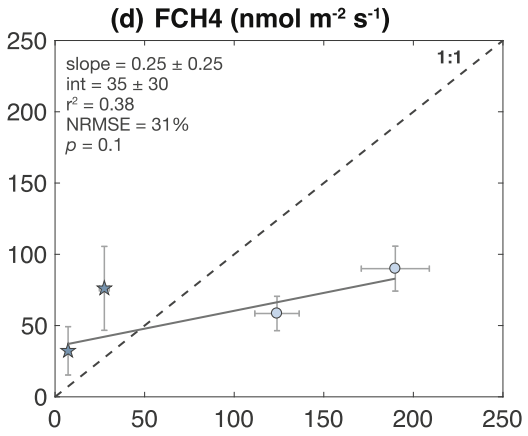
NASA CARAFE flux transects from September 2016 (red) and May 2017 (cyan)

EC flux towers along the flight path capture ~30%–75% of the regional variability in ecosystem fluxes

(Hannun et al 2020)





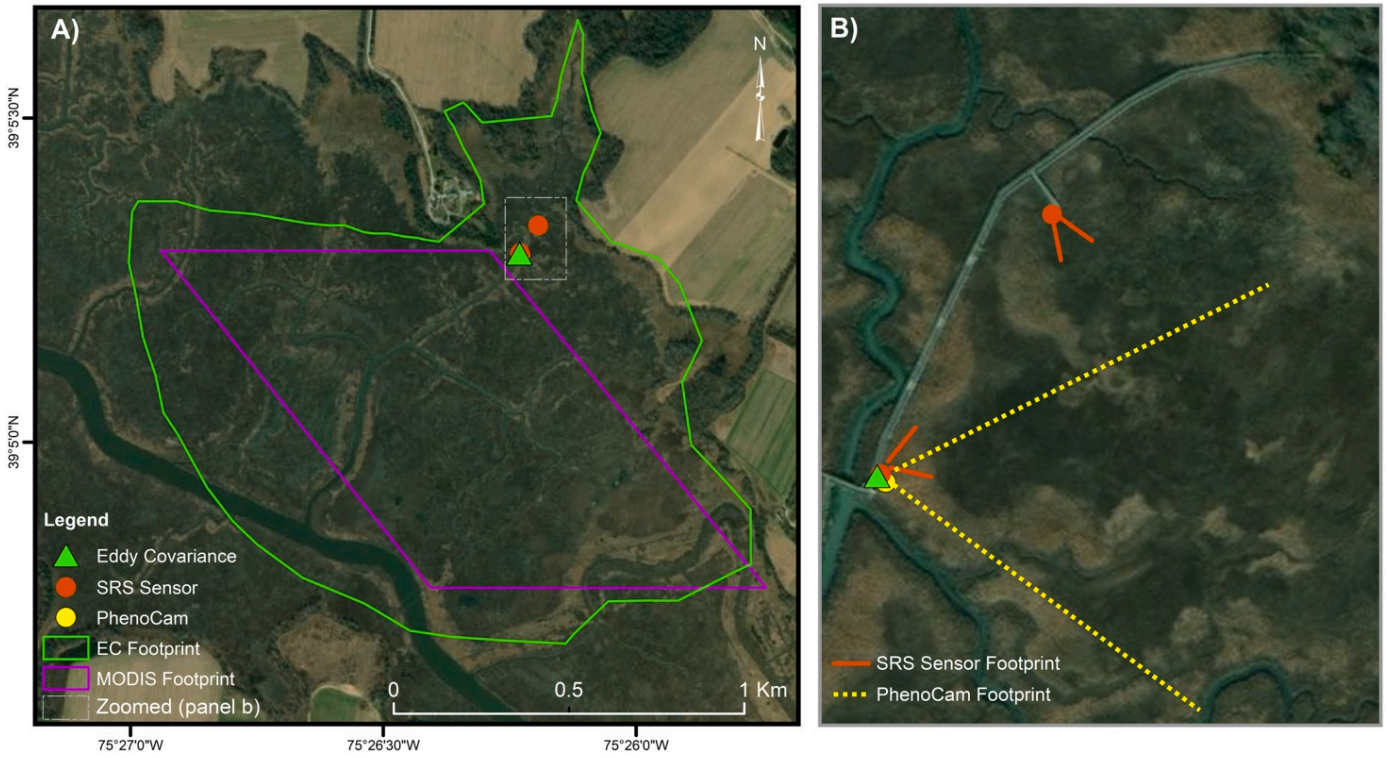


(Hannun et al 2020)

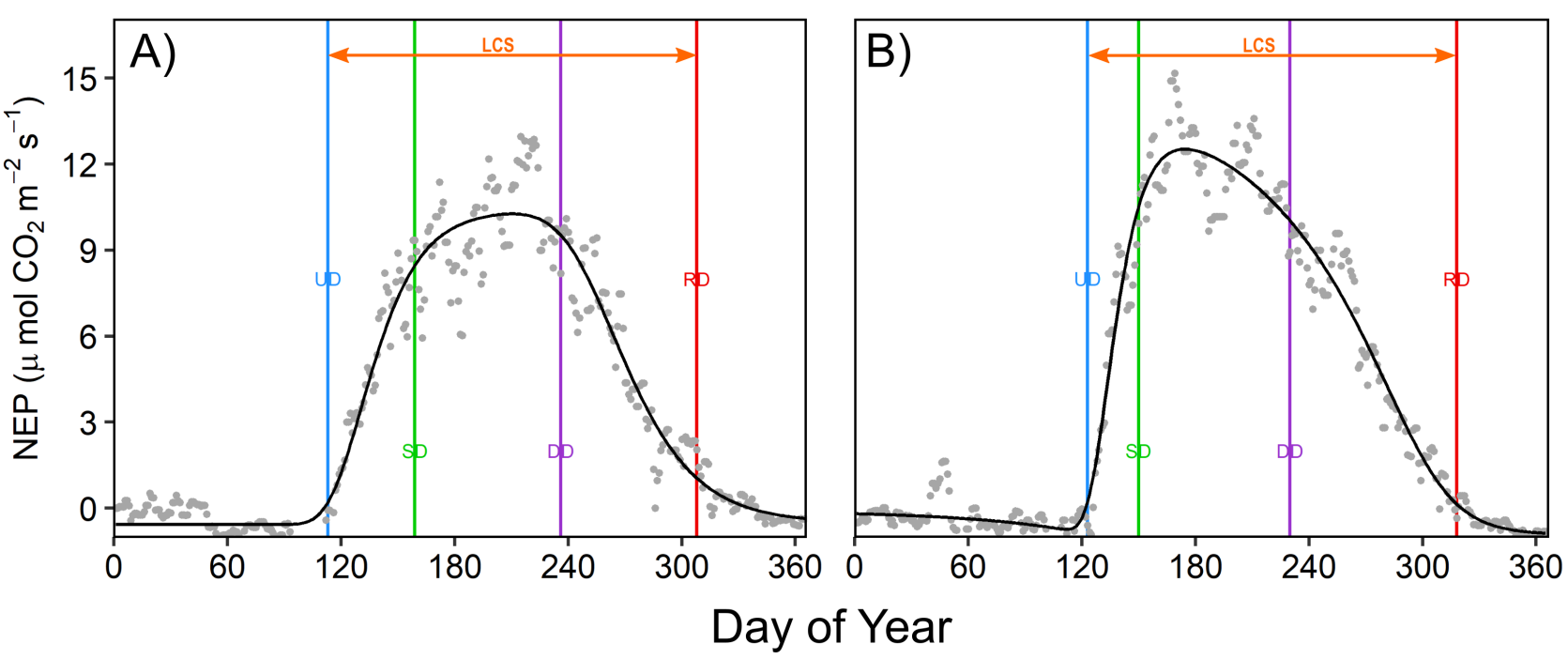
PhenoCam

AN ECOSYSTEM PHENOLOGY CAMERA NETWORK

https://phenocam.sr.unh.edu/webcam/sites/stjones/



(Hill et al 2021)



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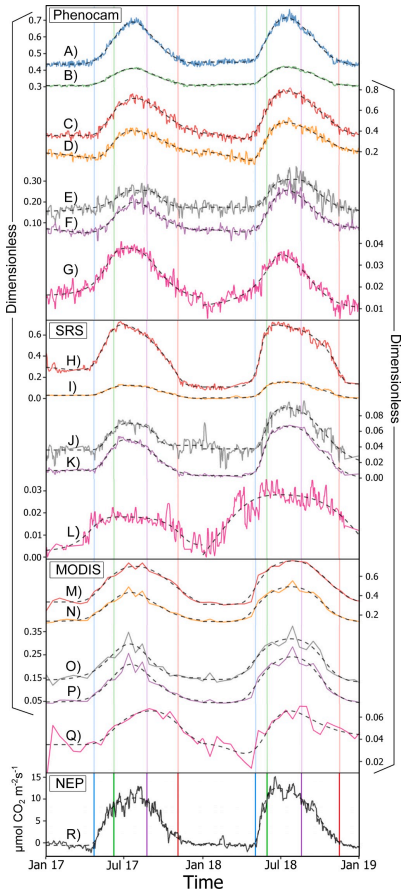
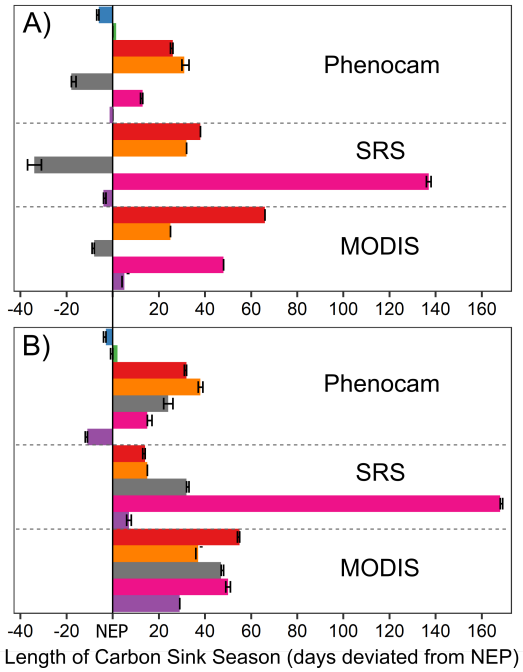
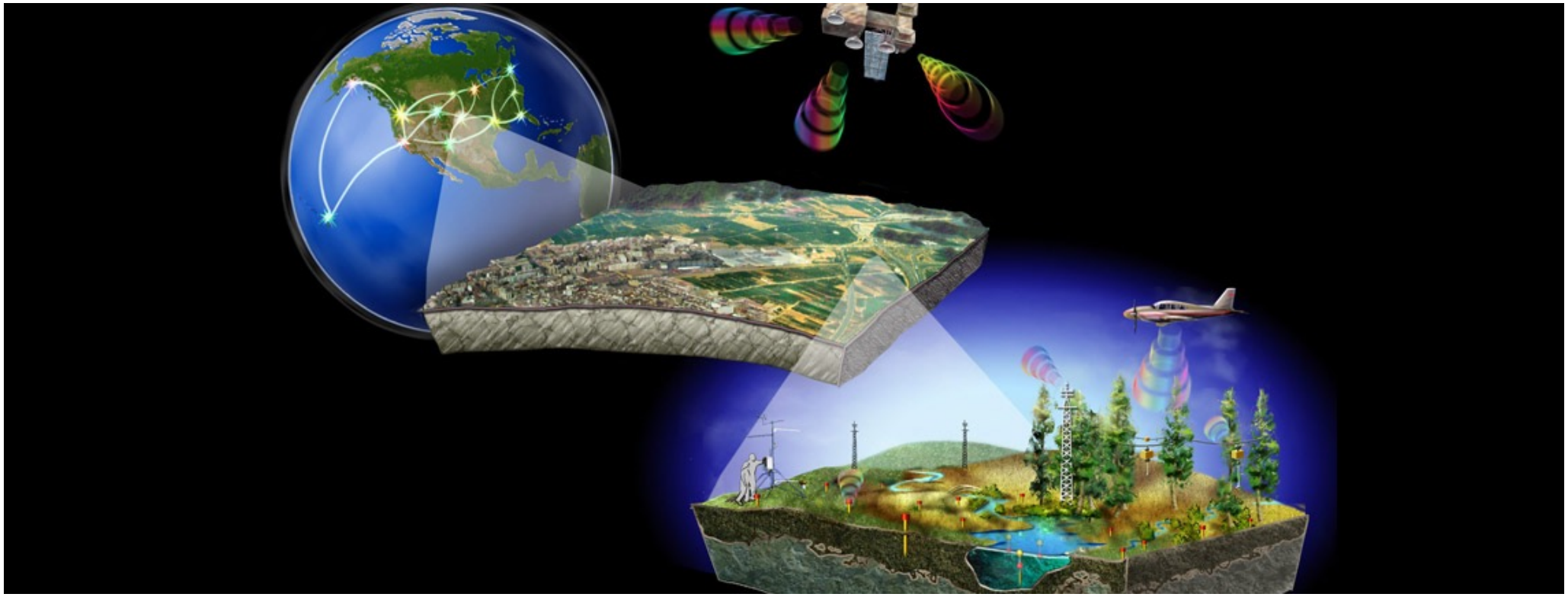




- NDVI and EVI suffer considerable discrepancies in start and end season date predictions.
- The phenocam provided the best monitoring approach by providing information on structure (via NDVI) and function (via visible wavelengths indices).

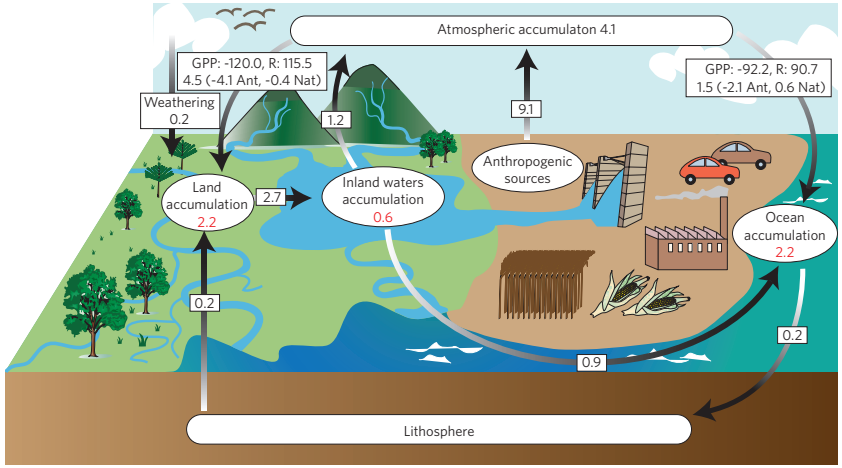
(Hill et al 2021)

Towards a Coastal Observatory?



https://www.nsf.gov/news/special_reports/neon/

Challenges 1-3



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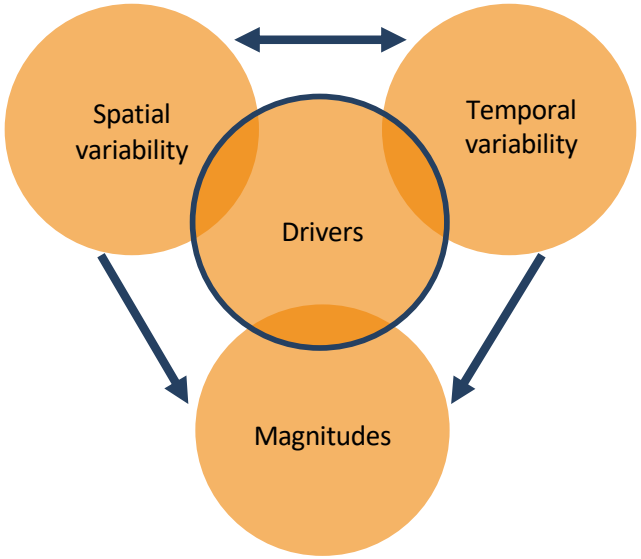
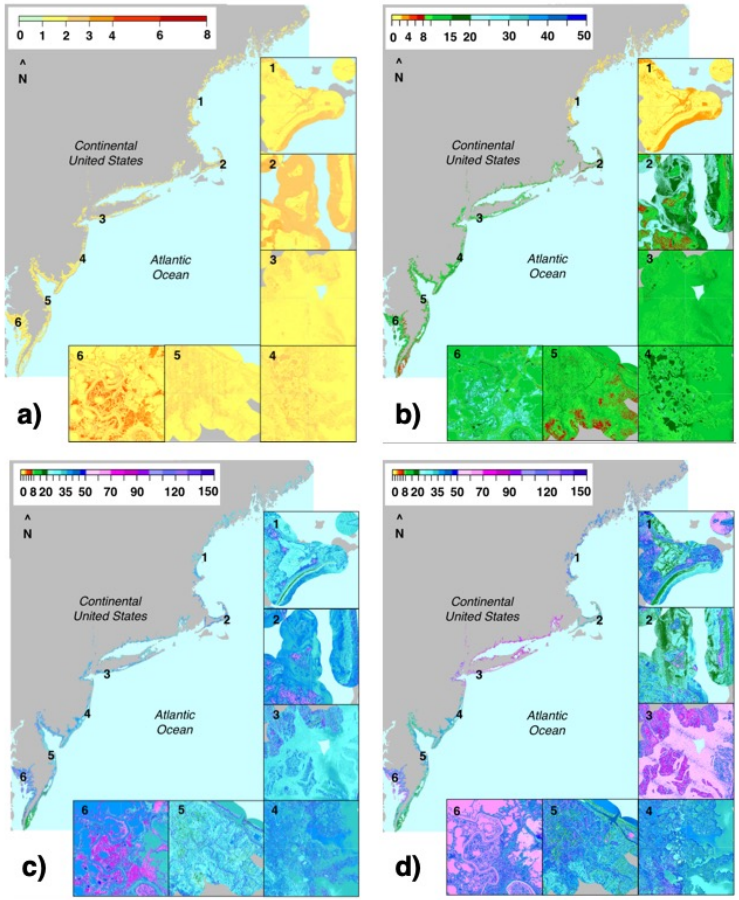
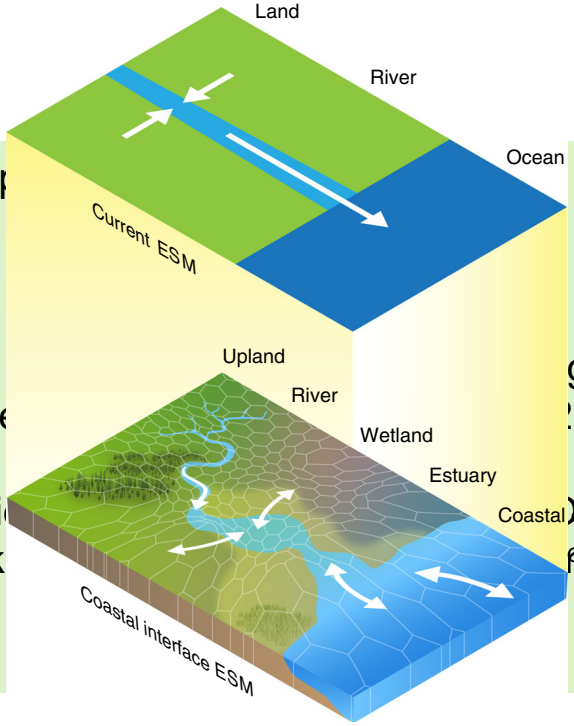


How?

Hyper-resolution for carbon management?

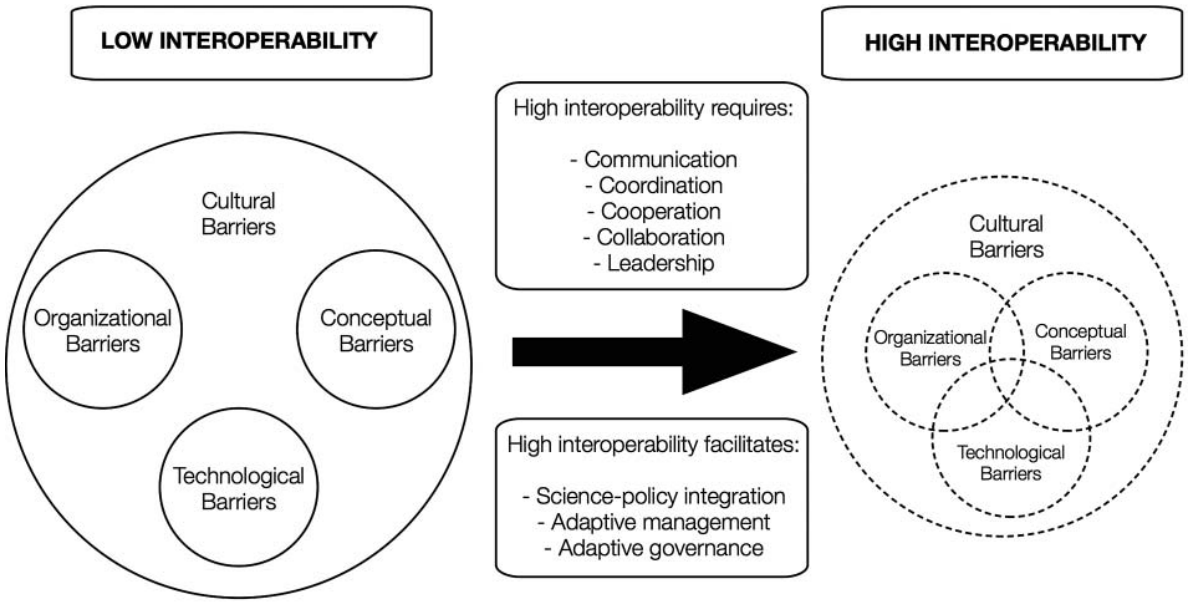


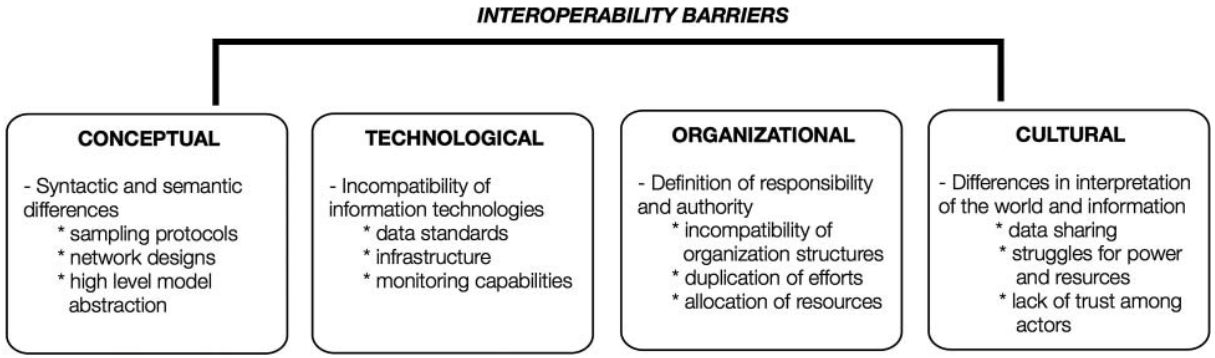
- 3m sp
- High
- Total cm de g (0-5 00 cm)
- Previ stock 77%. OC m by



(Ward et al 2020)

(Wardrup et al [unpublished])





(Vargas et al 2017)

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