B200 *In Situ* Observations during SARP and ALEGROS 2024

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NASA GSFC
AiRMAPS+ Workshop, 4 September 2024

ALEGROS and SARP 2024

SARP (Student Airborne Research Program) is a summer internship program that addresses NASA training and educational goals

ALEGROS (Associating Local Emissions of Gases with Regional Observations from Satellites) leveraged EPA support with the SARP payload to address EPA and NASA atmospheric composition needs

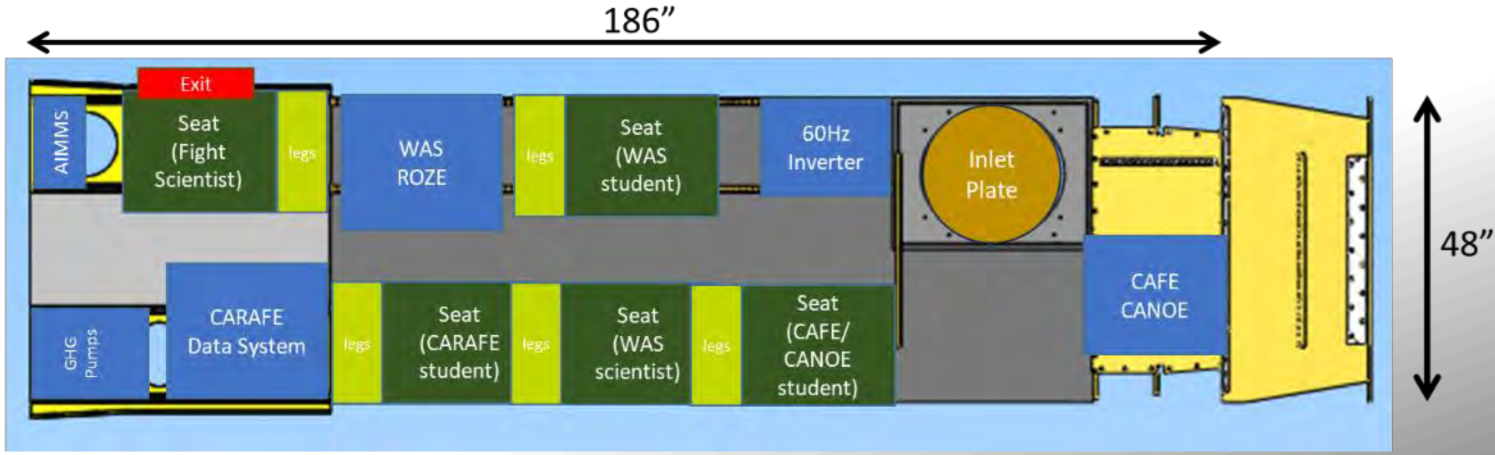
Measurement Objectives

1. Near-surface concentrations (spatially dense, diurnal cycle)
2. Eddy covariance fluxes over urban and rural areas
3. Vertical profiling over Pandora sensors

Aircraft

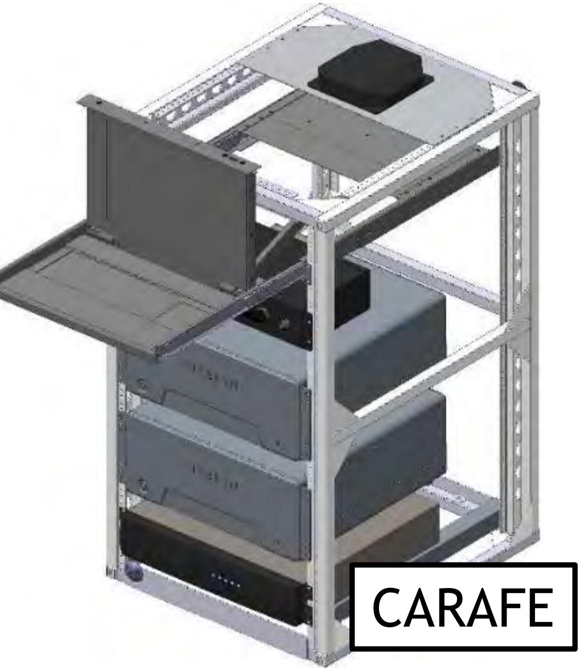
- Beechcraft King Air B200 (Tail # N46L)
- Owned and operated by Dynamic Aviation
- Max altitude 10000' (unpressurized)
- Typical science speed 150 knots (173 mph)

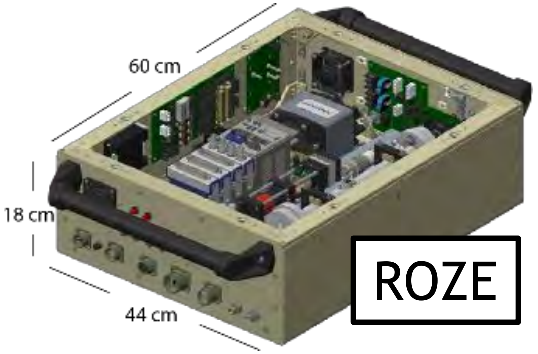

View From Cockpit

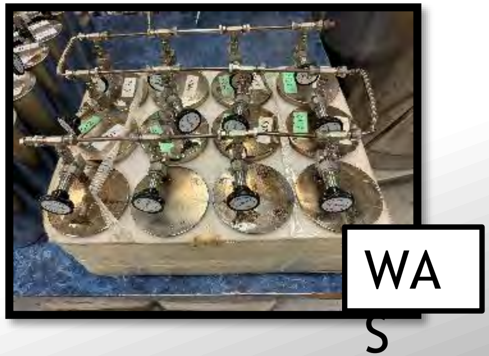


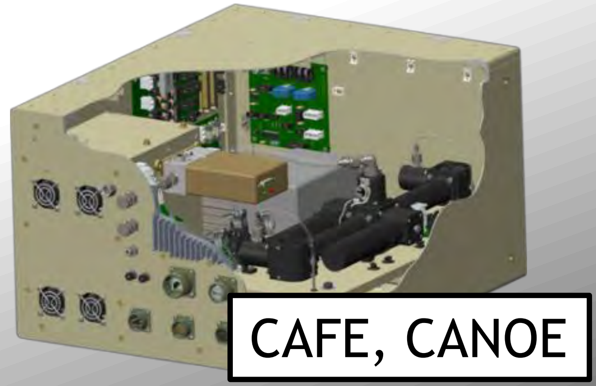
Measurement Overview

Measurement	Instrument	Institution	PI
Met, position, attitude	AIMMS-20	LaRC	Thornhill
CO (carbon monoxide) CO_2 (carbon dioxide) CH_4 (methane) H_2O (water vapor)	CARAFE	NASA GSFC	Delaria
O_3 (ozone)	ROZE	NASA GSFC	Hannun
HCHO (formaldehyde)	CAFE	NASA GSFC	St. Clair
NO_2 (nitrogen dioxide)	CANOE	NASA GSFC	St. Clair
VOC (volatile organic compounds)	WAS	UCI	Blake



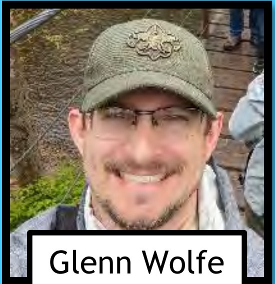


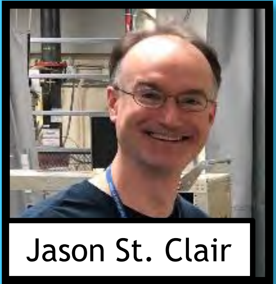




B200 In Situ Science Team

NASA Goddard and Friends
CARAFE, ROZE, CAFE, CANOE


Glenn Wolfe


Jason St. Clair


Erin Delaria


Tom Hanisco

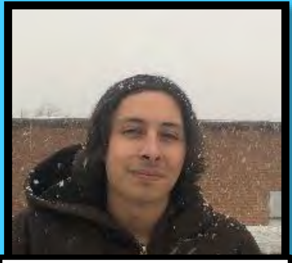

Reem Hannun


Apoorva Pandey


Bryan Place


Jin Liao


Jay Tomlin


Steven Rosesmith


Andrew Swanson

UC Irvine, Whole Air Sampler (WAS)


Don Blake


Barbara Barletta


Tai Chen


Katherine Paredero

Meteorology, Data System


Lee Thornhill
LaRC


Dave Van Gilst
NSRC


Pat Finch
NSRC

Forecasting

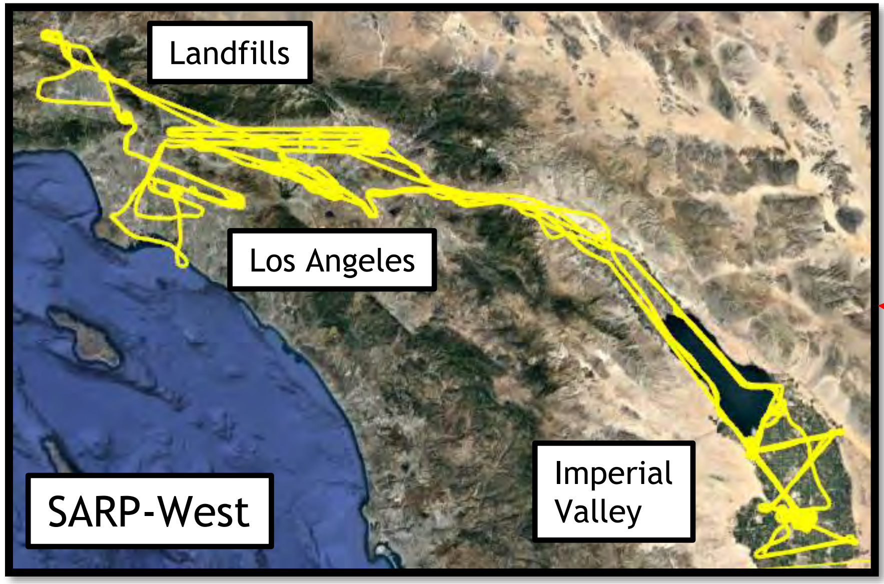

Bennett Erdman

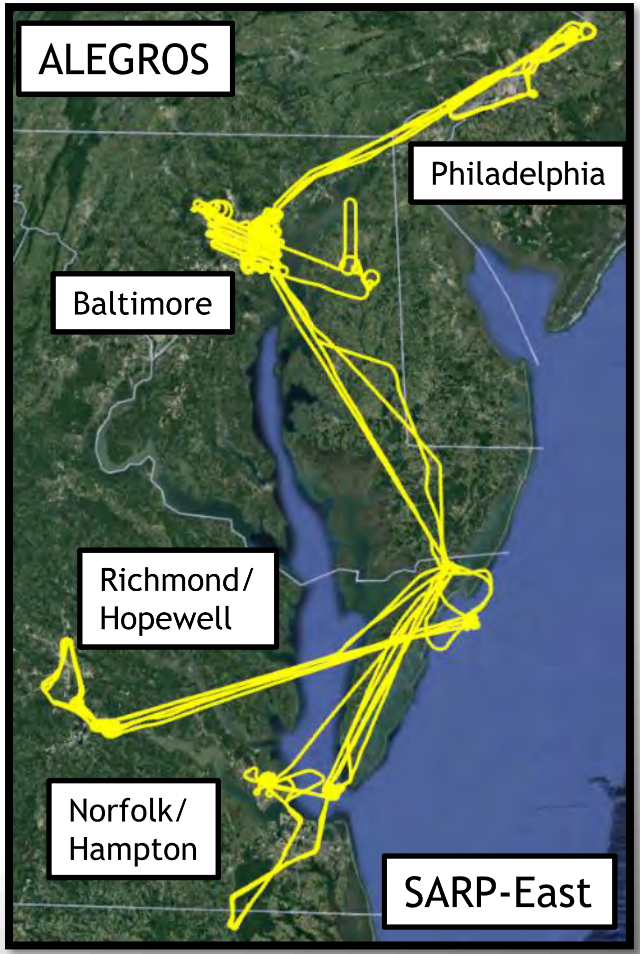
Logistics (ESPO)


Roy Johnson


Vidal Salazar

Schedule & Locations



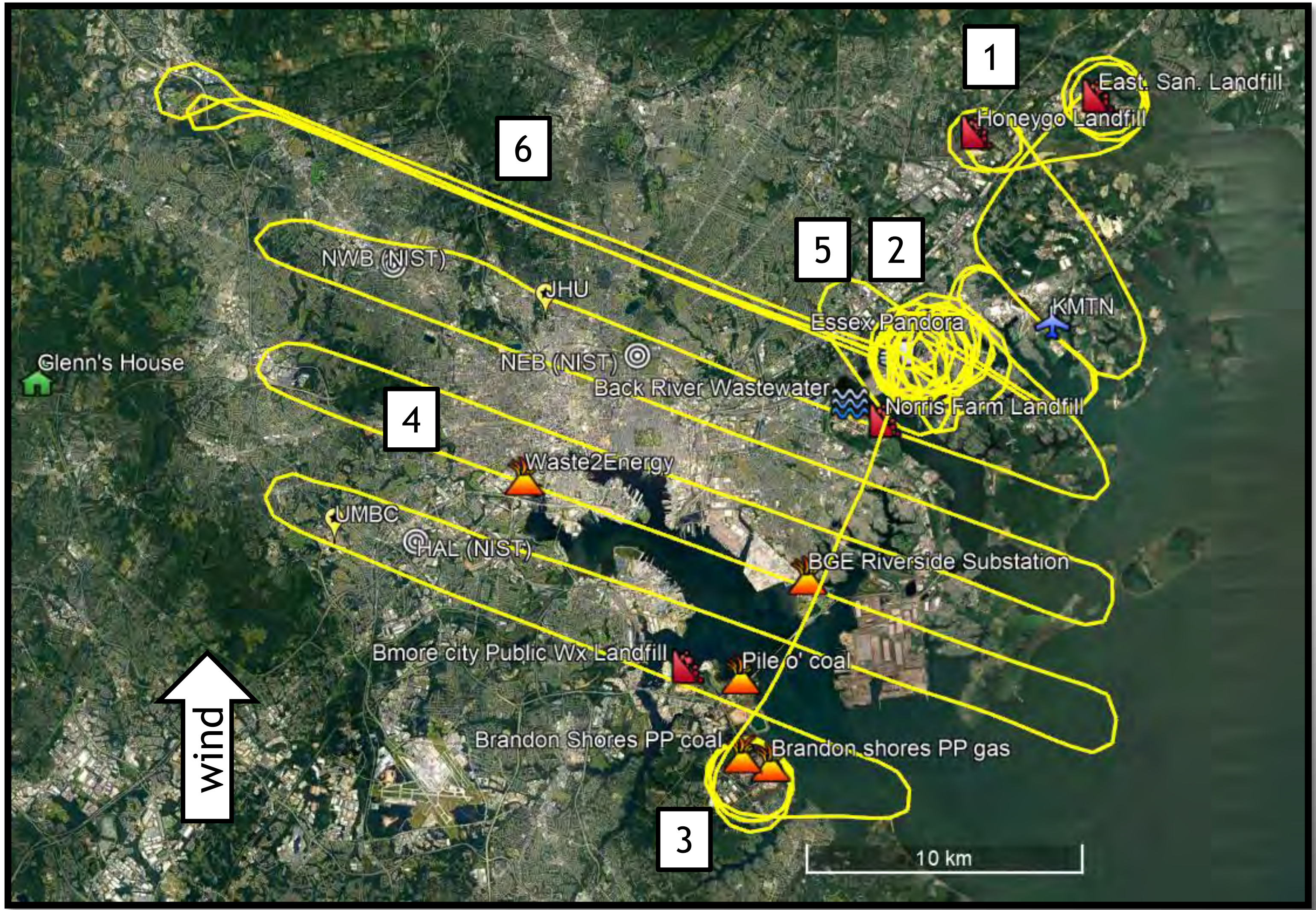


ALEGROS	June 17 – 22	
30 hours		
SARP-East	June 24 – 26	21 hours
SARP-West	June 29 – 32	21 hours

Baltimore Flights

1. Circle around landfills (north) and power plant (south)
2. Missed approach @ MTN and spiral @ Essex Pandora to 10000’
3. Circle power plant
4. Raster over city for TEMPO and eddy covariance @ 1000’ AGL
5. Missed approach @ MTN and spiral @ Essex Pandora
6. Flux divergence legs @ north end (level legs at 1500’, 2000’ AGL)

Date	Morning	Midday	Afternoon
6/17	x	x	
6/18	x	x	x
6/21	x	x	
6/22	x		
6/24		x	x

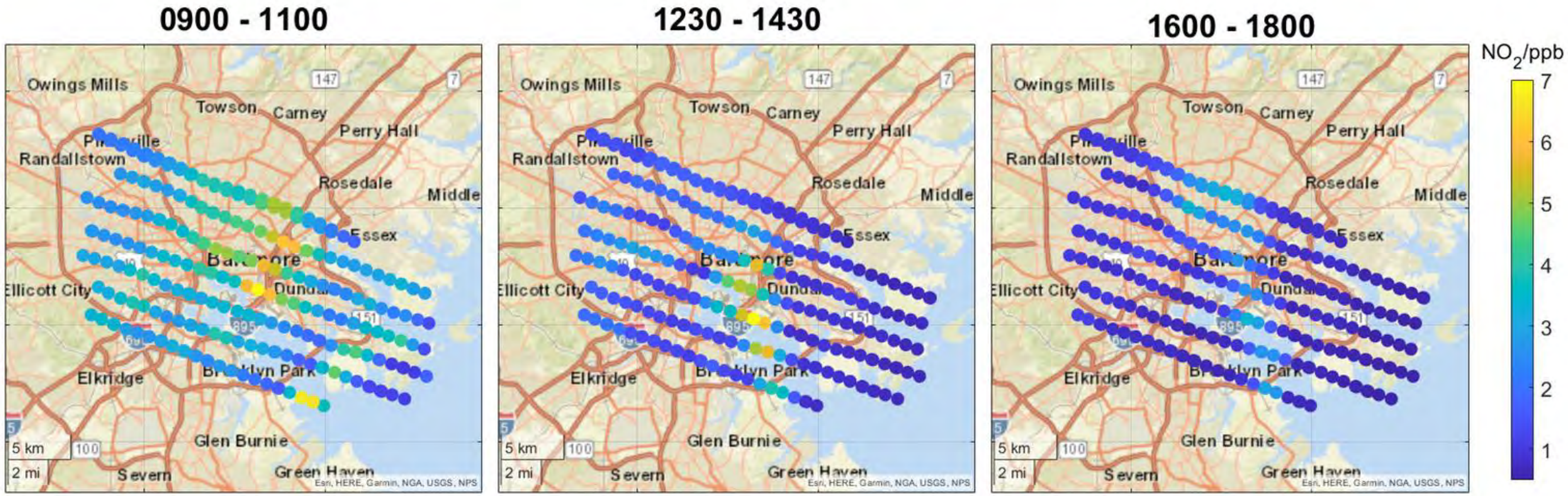


Lessons Learned

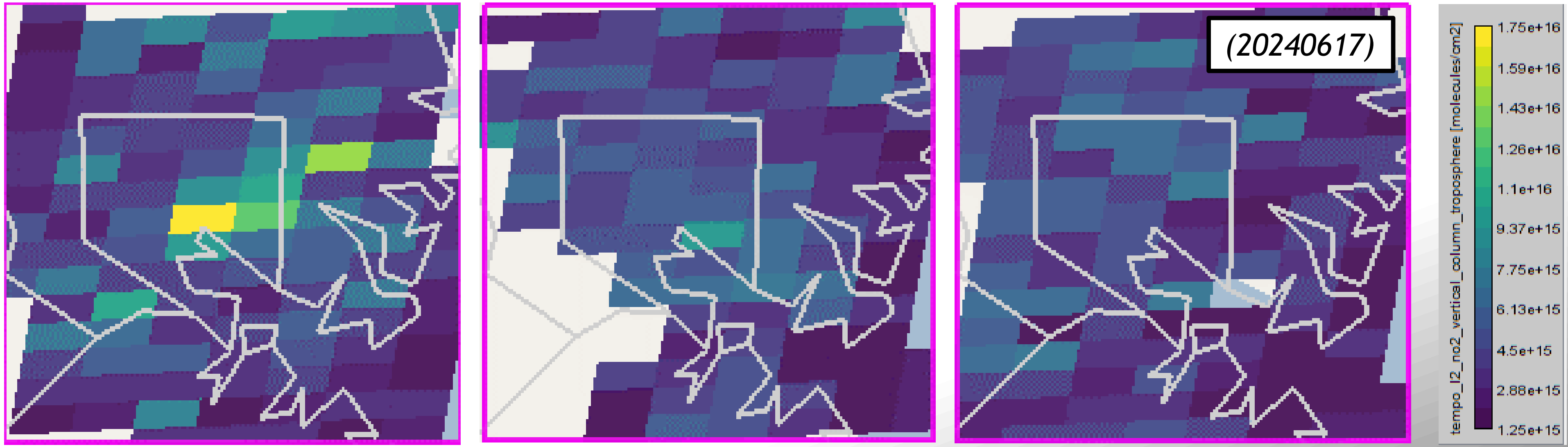
- Martin State Airport was very supportive!
- MD Fleet Week occurred right before ALEGROS (6/12 – 6/17). This made ATC grumpy. Talking to them face-to-face helped.
- BWI traffic on some days led to diversions and pilot fatigue. Shifting flight lines helped. A third pilot would help too.
- Baltimore heat was manageable in June without a hangar or AC cart (we did have a floor fan while on the ground).
- Reliefbands actually work!

TEMPO Spatial and Temporal Variability

ALEGROS
20240618



TEMPO L2
Trop. NO_2



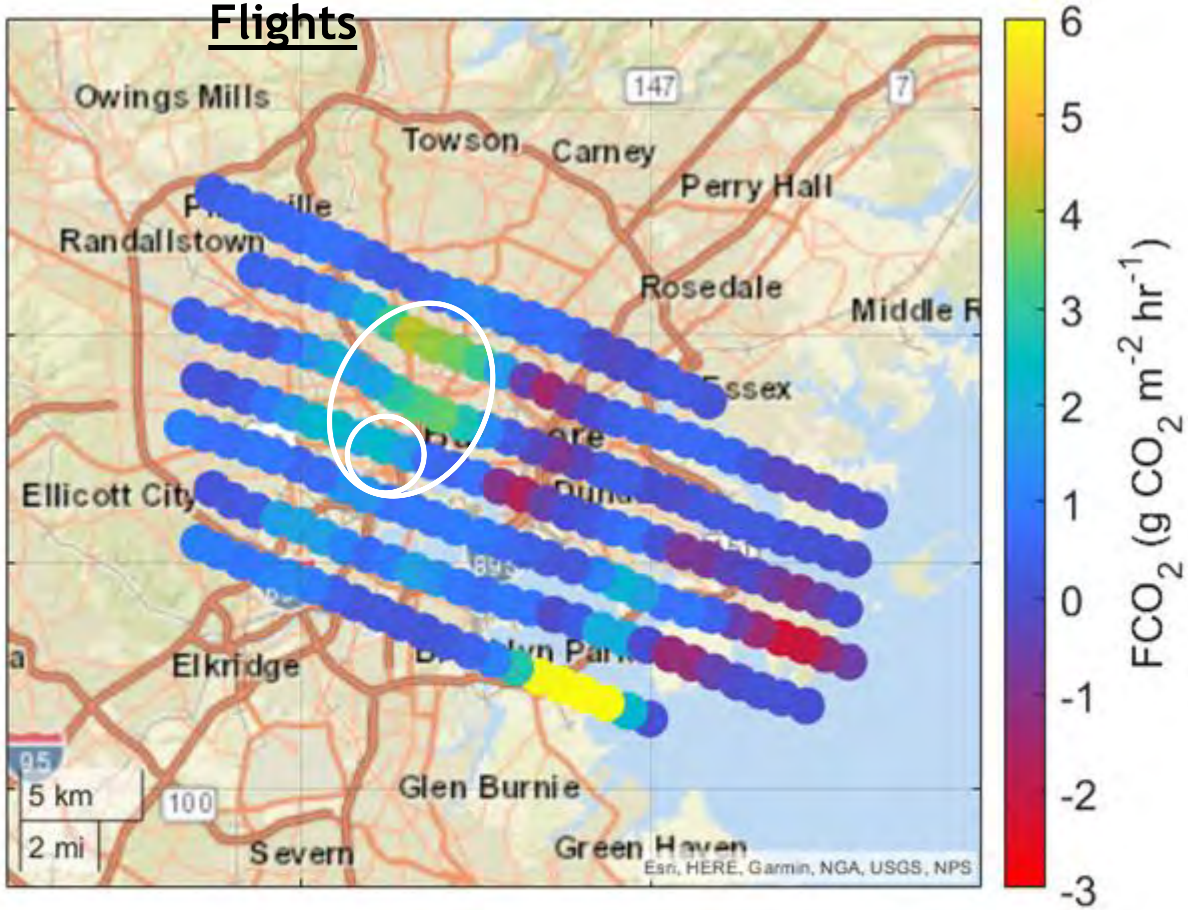
Urban CO_2 Fluxes

Erin Delaria

Reem Hannun

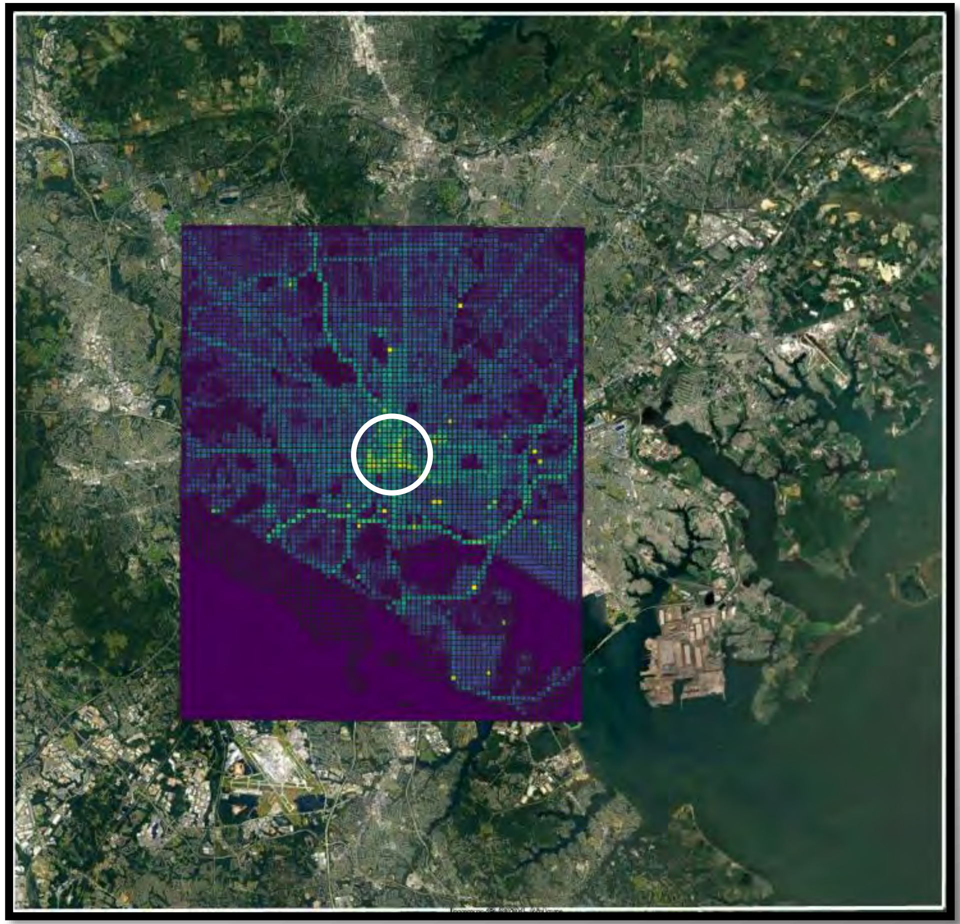
Jay Tomlin

ALEGROS, Average All Flights



Airborne Eddy Covariance
Wolfe et al., AMT (2018)

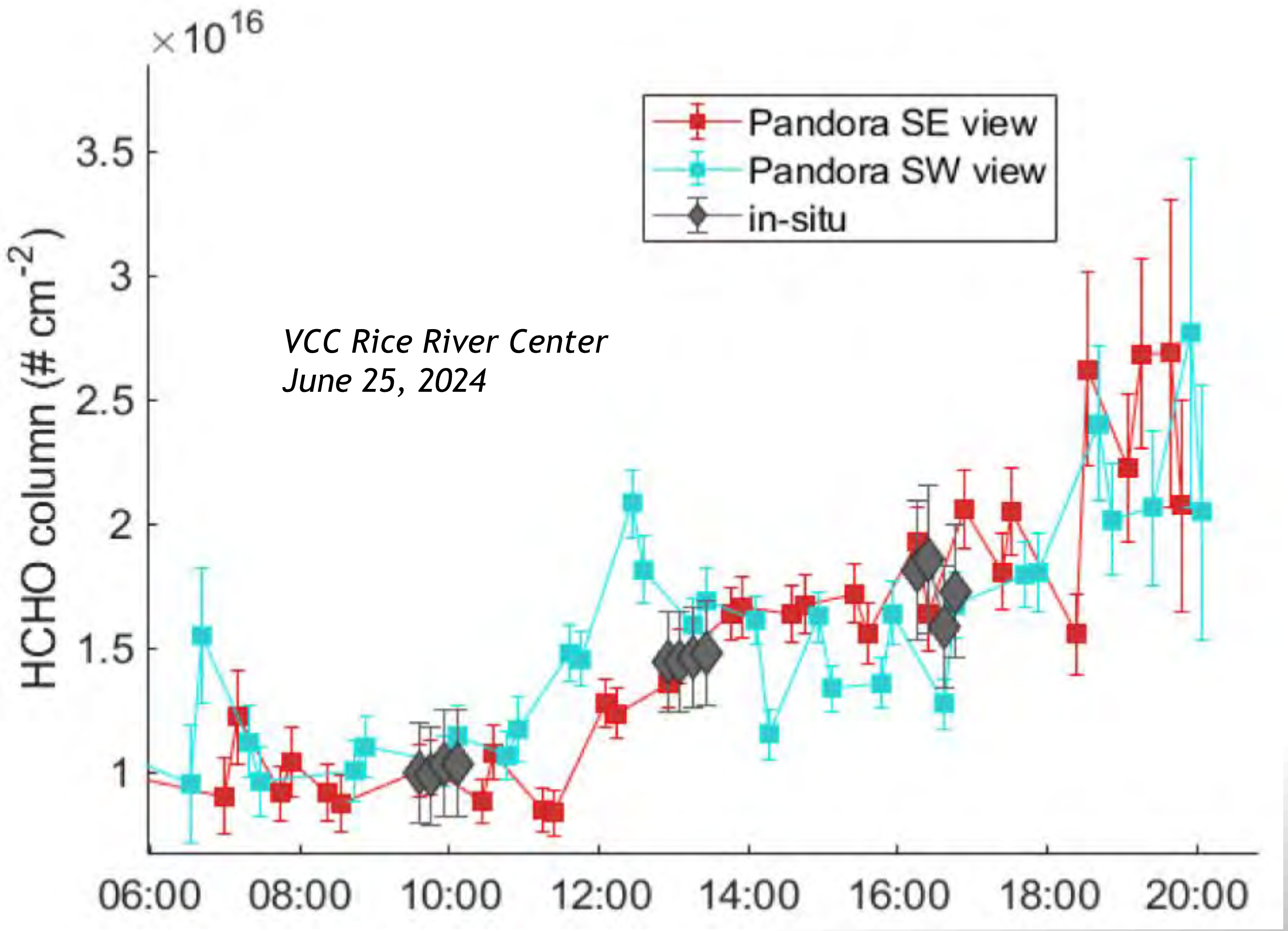
Hestia 200m x 200m CO_2 inventory (2010 – 2015)



https://hestia.rc.nau.edu

Pandora Validation

Apoorva Pandey



Local Hour of Day

Onward

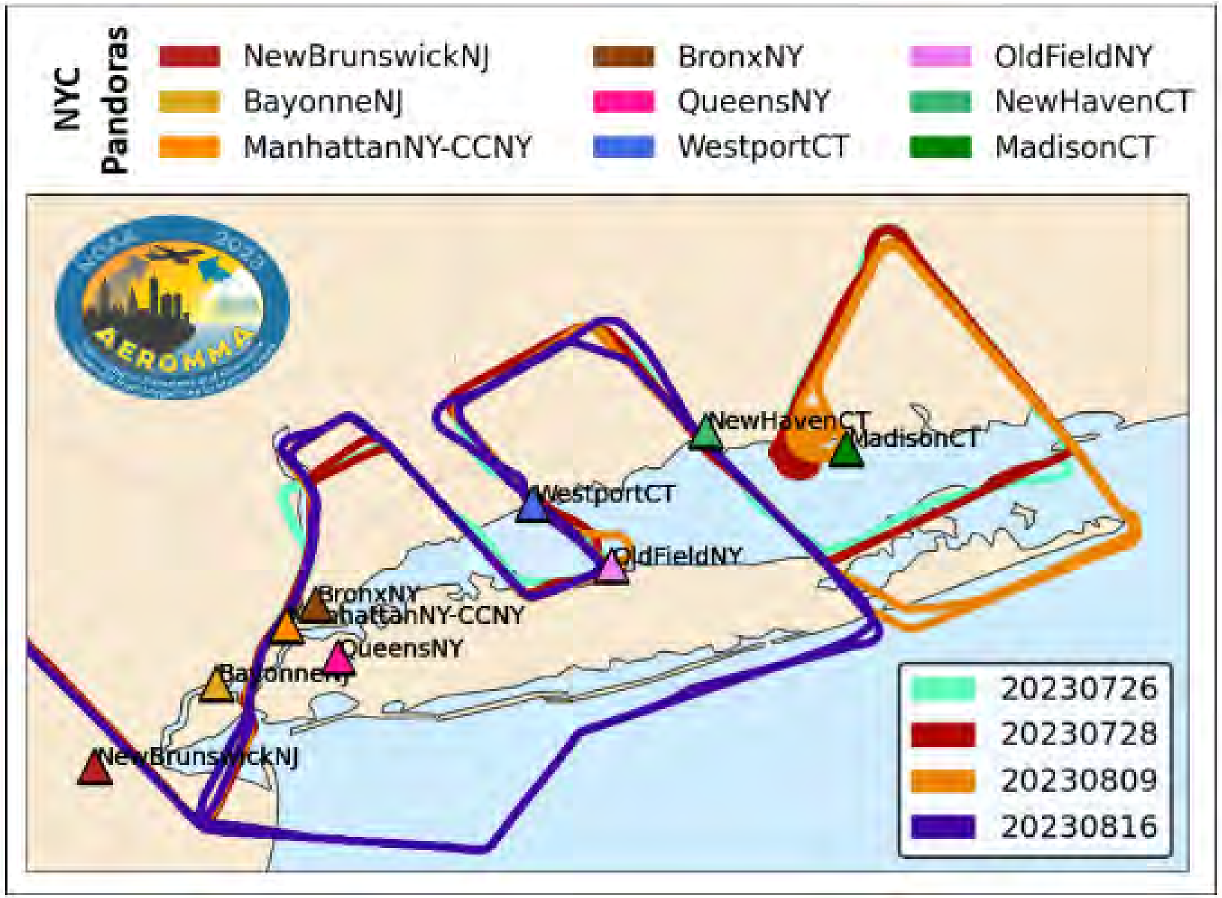
Final data will be publicly available within a month (google “SARP”).
If you want it sooner, just ask.

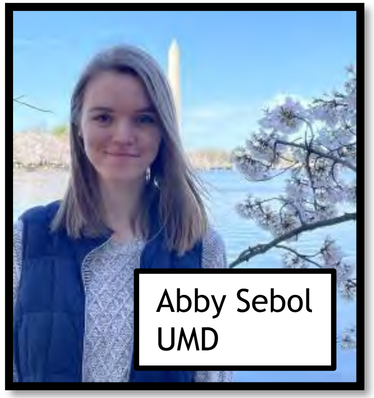
Data is like a box of chocolates.
It’s meant to be shared.

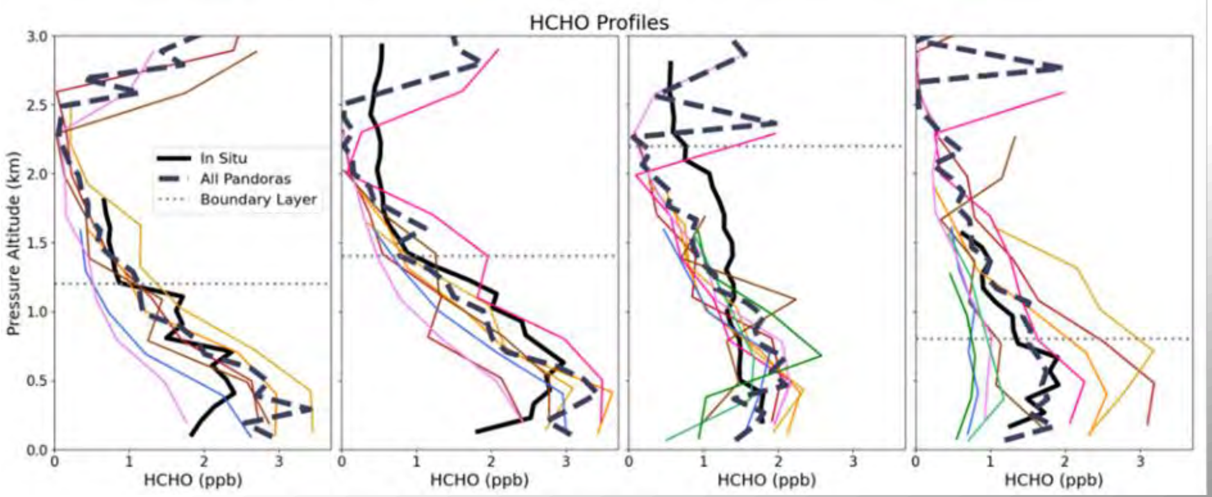
glenn.m.wolfe@nasa.gov

EXTRA

AEROMMA Pandora Validation







Mo	Tu	We	Th	Fr	Sa	Su
10 Integration, KVBW				ATP	Test flight (2h)	Tr2 KMTN (1 h)
17 ALEGROS (30h)			DOWN		Tr2 KWAL (1 h)	DOWN
24 SARP-East (21h)			Tr2 KONT (14 h)		SARP-W	DOWN
1 SARP-W (21h)		Tr2 KVBW (12 h)	DOWN			
8 De-integrate						

Eddy Covariance 101

$c = CH_4$, w = vertical wind speed

Distance or Time

TURBULENCE

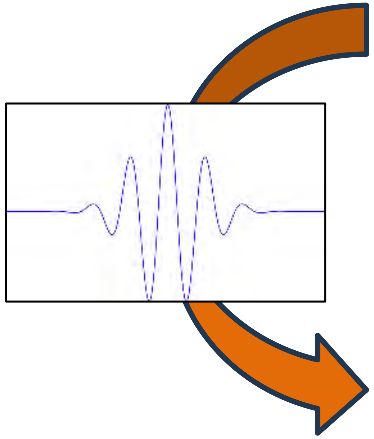
1) Acquire fast (10 Hz) measurements of vertical wind speed (w) and a scalar (c)
2) Remove large-scale trend or mean (c’ = c - <c>)
3) Calculate flux as the covariance of w’ and c’

Wavelets Resolve Spatial Variability

c = CH_4, w = vertical wind speed

Distance or Time

Morlet wavelet transform

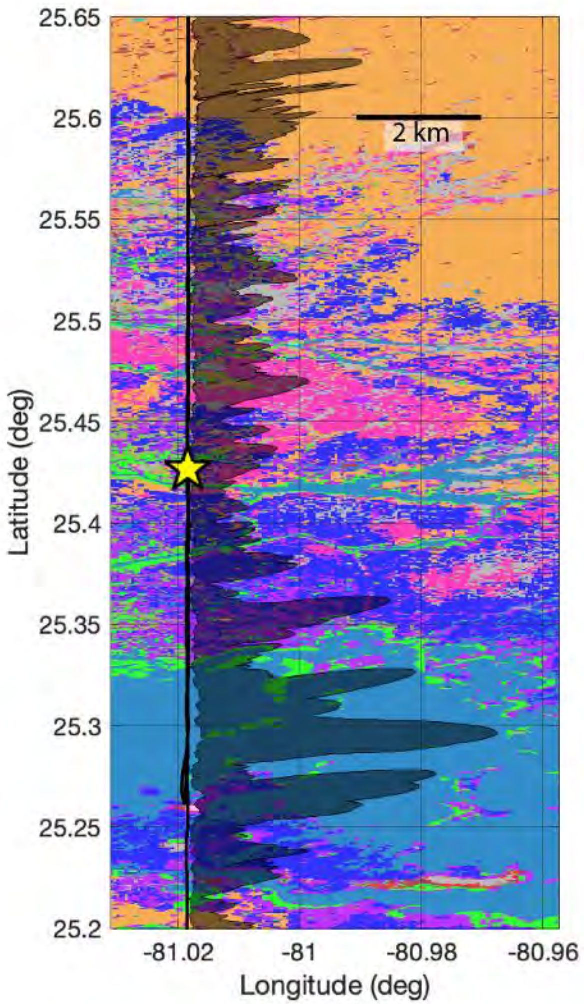


wavelet flux (1Hz)

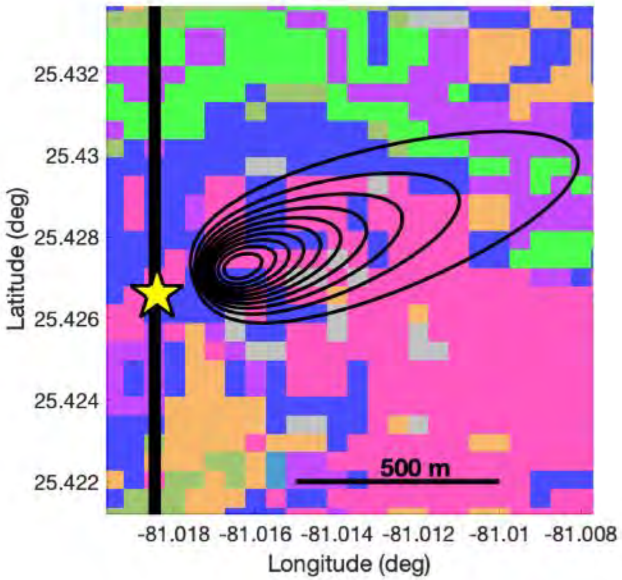
EC average flux

Distance or Time

Footprints Connect Fluxes to Surface Properties



Kljun et al., GMD (2015)



contours are 10th percentiles of footprint influence

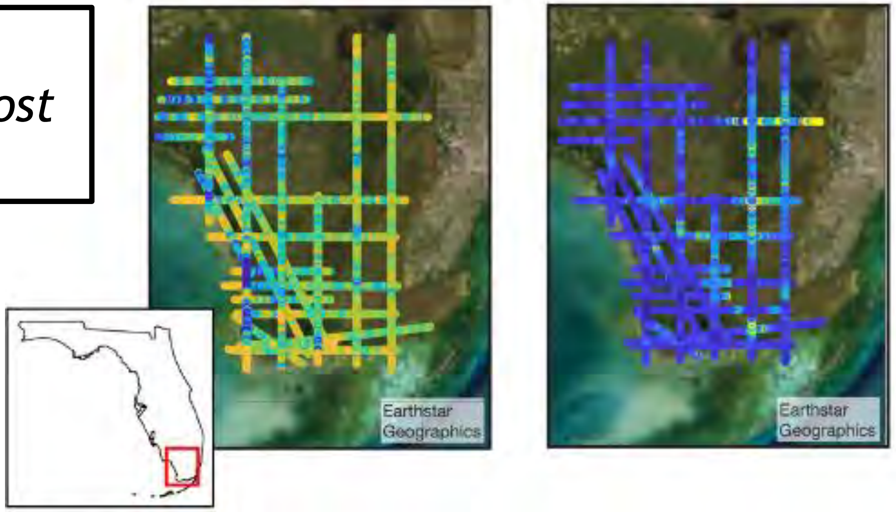
- At each point in time, the observed flux originates from some surface upwind of the aircraft
- The <u>footprint</u> defines the fractional contribution of surface area
- We combine footprints with maps of land surface information to disaggregate fluxes by land cover, water depth, etc.

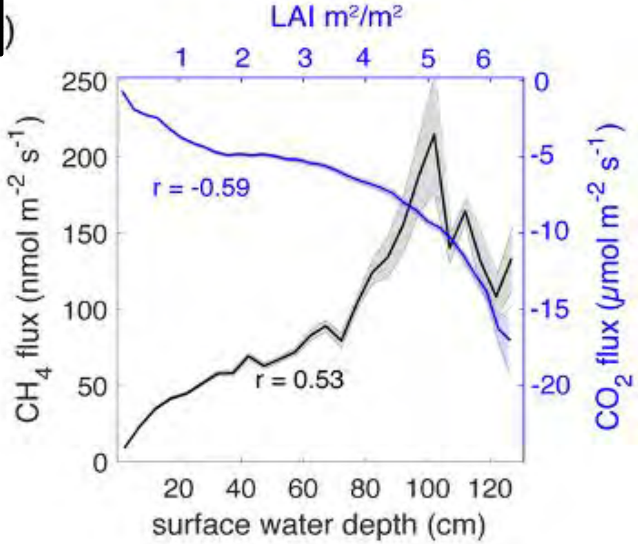
Airborne Fluxes Quantify Regional Surface Exchange

BlueFlux
Delaria et al., almost submitted (2024)

High NEE over Mangroves

CH_4 emissions over freshwater marsh





Footprint-based evaluation of Surface Drivers

- Wavelet transform eddy covariance provides vertical fluxes with nominal spatial resolution of 100 – 1000 m
- Flux footprints connect to surface activity (land cover properties, emission inventories, etc.)
- All in situ instruments on the B200 are sufficient for eddy covariance (except WAS)