Net ecosystem carbon balance in a tidal mangrove forest

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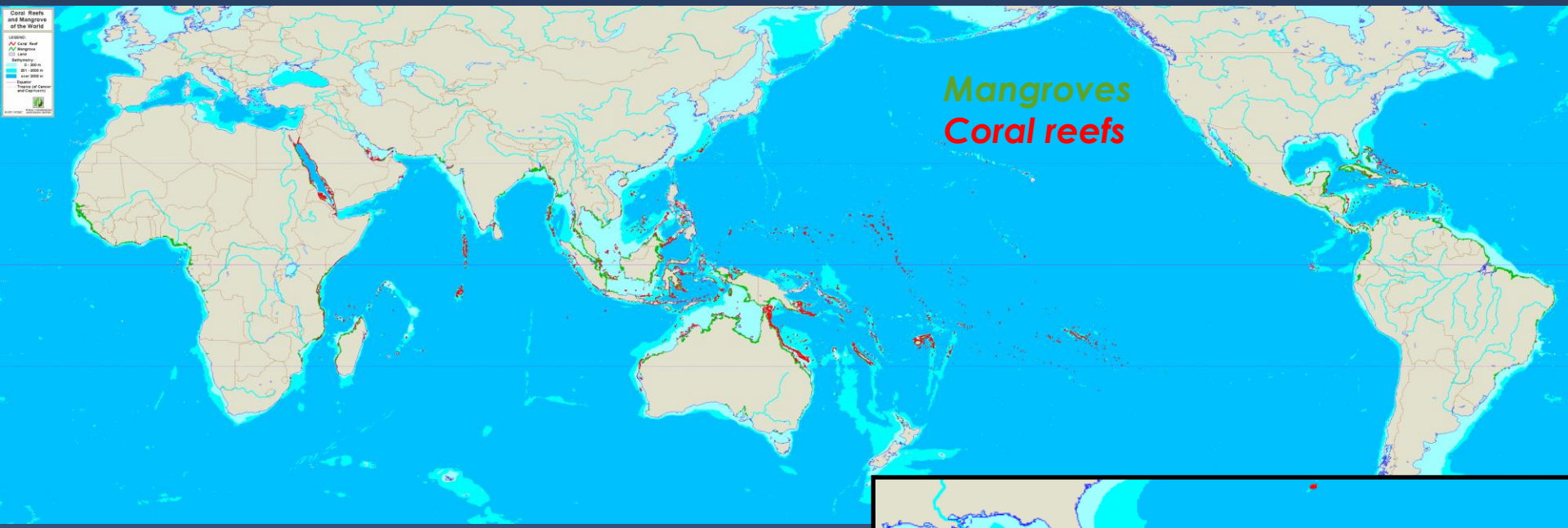
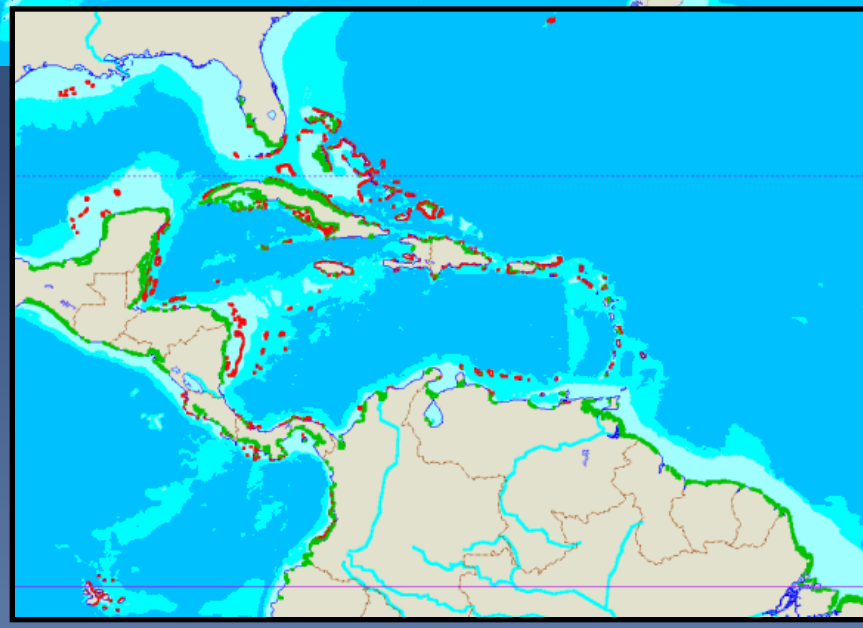
Mangrove forests are pan-tropical and often co-occur with adjacent coral reefs or seagrass communities. TOTAL AREA = 160,000 to 200,000 km^2



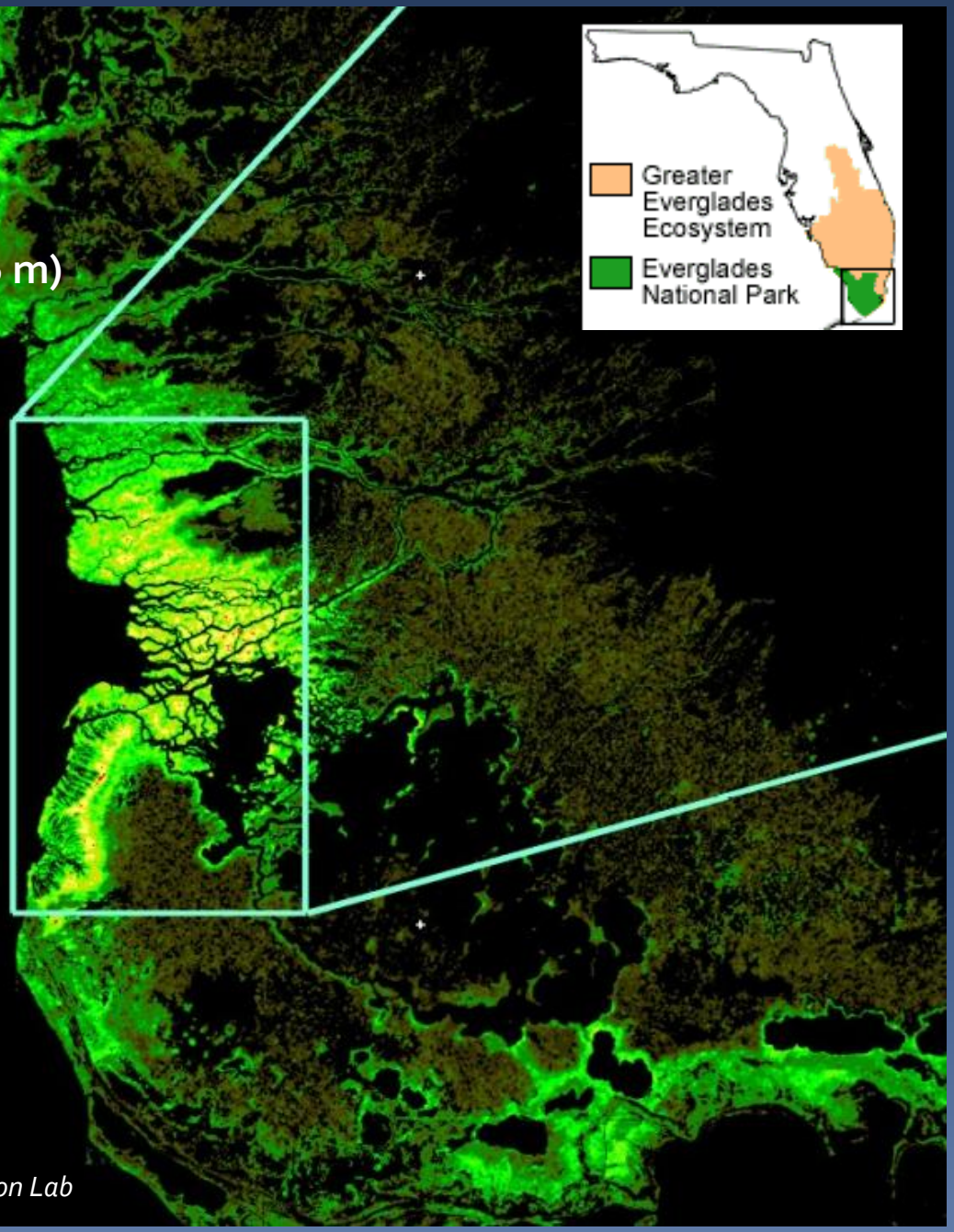
- <1% of the continental surface
- NPP equal to 218±72 Tg C yr^{-1} (Boullion et al. 2008)
- 50% NPP cannot be accounted for in site carbon balance
- Contribute more than 10% of all refractory DOC transport to oceans (Ditmar et al. 2006)



Source: http://www.unep-wcmc.org/marine/data/coral_mangrove/pix/world.jpg

- Mangrove forest structure varies across the salinity mixing zone

- Growth and total biomass reflect [P] gradients and peat depths (up to 6 m)



Mangrove Height (m)

- Not Mangroves
- 0-2
- 2-4
- 4-6
- 6-8
- 8-10
- 10-12
- 12-14
- 14-16
- 16-18
- > 18

Marc Simard
CalTech Jet Propulsion Lab

Everglades Gulf Coast mangrove forest

Mixed species stand

R. mangle, L. racemosa, A. germains

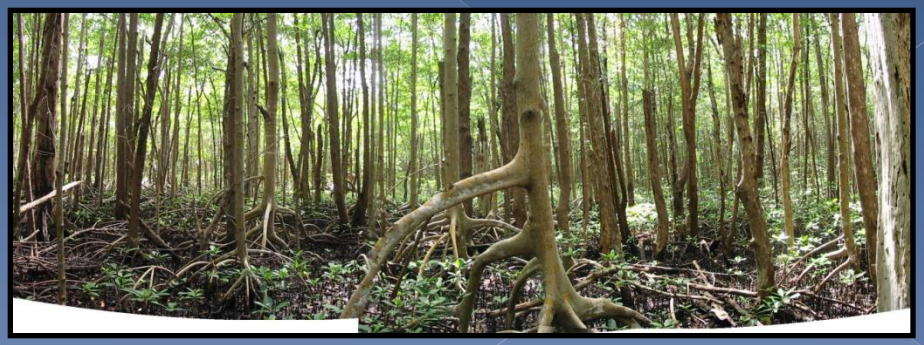
Peat depth > 5 m

Semi-diurnal tides

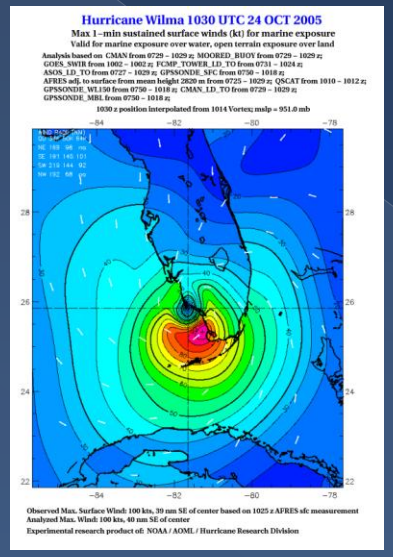
Flooded 52% of the time

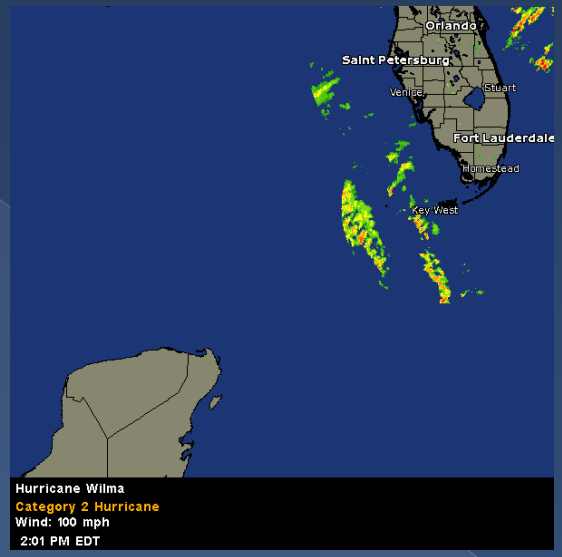
Precipitation:1600 mm yr^{-1}

Average air temperature: 24 C



Hurricane disturbance Wilma 2005 Everglades National Park





Wilma (October 2005) makes landfall as a Category 3 storm.

Near 100% defoliation

Delayed mortality as high as 20% of mature trees

Near 100% mortality closer to Gulf Coast

METHODS

NEE (2004 - present)

Ameriflux site SRK

Barr et al. (2009)

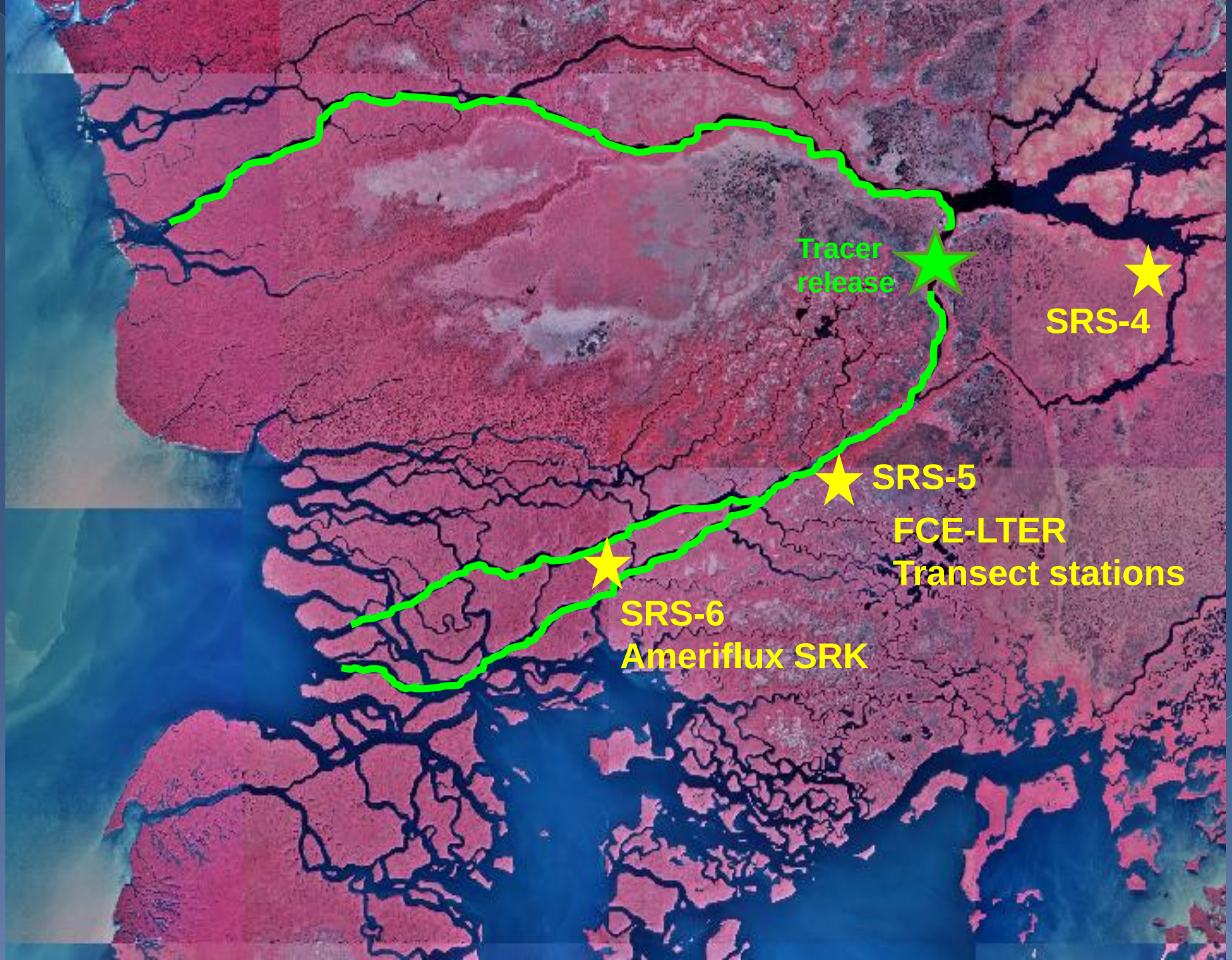
Barr et al. (2010)

Carbon balance

- Stand surveys (1995-present)
- Root growth and decomposition (biannual)
- Sediment elevations (quarterly)
- Soil accretion

Complementary Data

- Continuous surface and groundwater levels
- Routine water chemistry
- Flow velocity


Tracer
release
SRS-4
SRS-5
FCE-LTER
Transect stations
SRS-6
Ameriflux SRK

Net ecosystem carbon balance

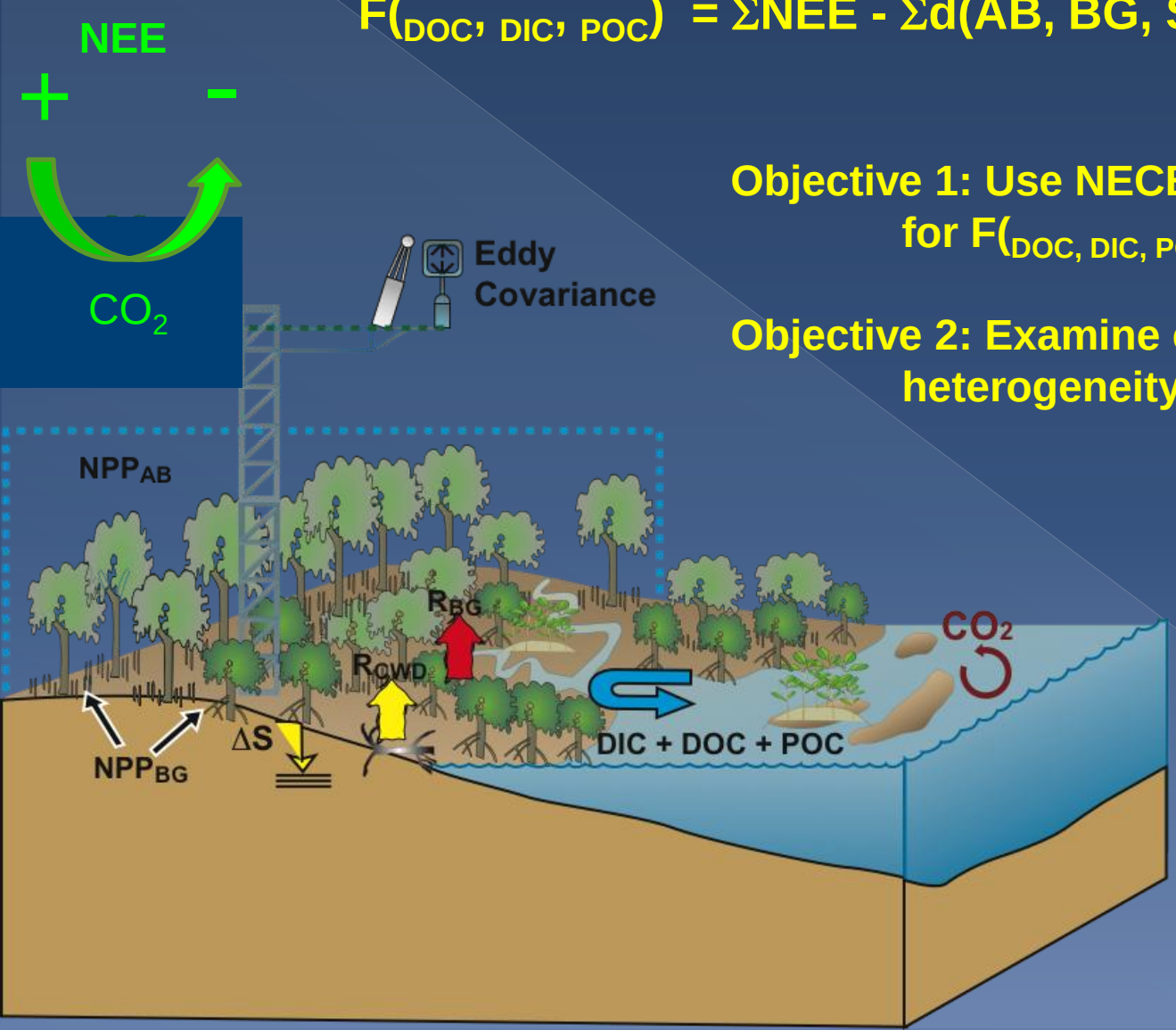
$$NECB = \Sigma NEE + F(_{DOC,\ DIC,\ POC})$$

$$NECB = \Sigma d(AB, BG, SOILS, LITTER)/dt$$

$$F(_{DOC,\ DIC,\ POC}) = \Sigma NEE - \Sigma d(AB, BG, SOILS, LITTER)/dt$$

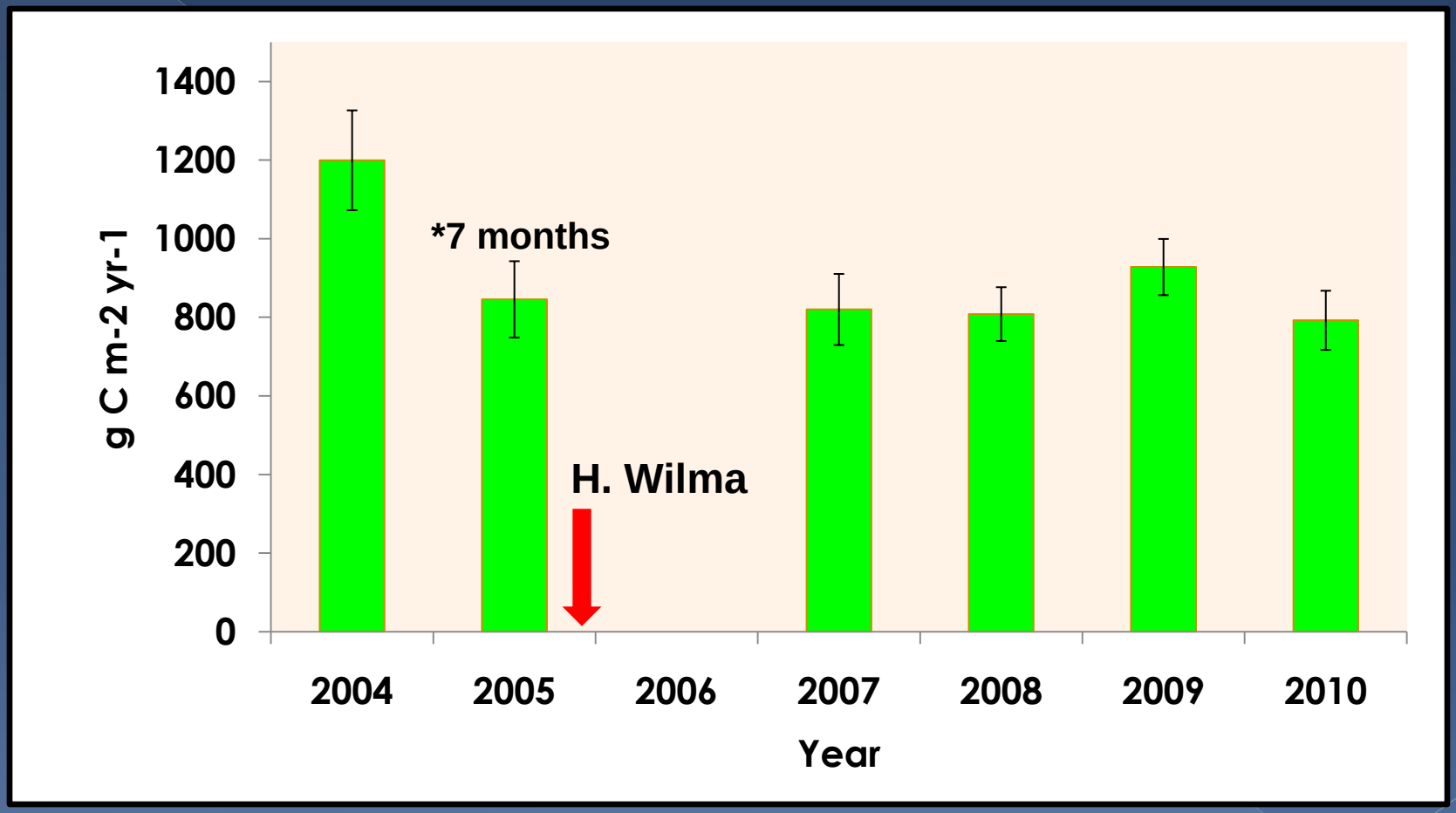
Objective 1: Use NECB and NEE data to solve for $F(_{DOC,\ DIC,\ POC})$

Objective 2: Examine controls on and spatial heterogeneity in river C fluxes



Net ecosystem carbon balance

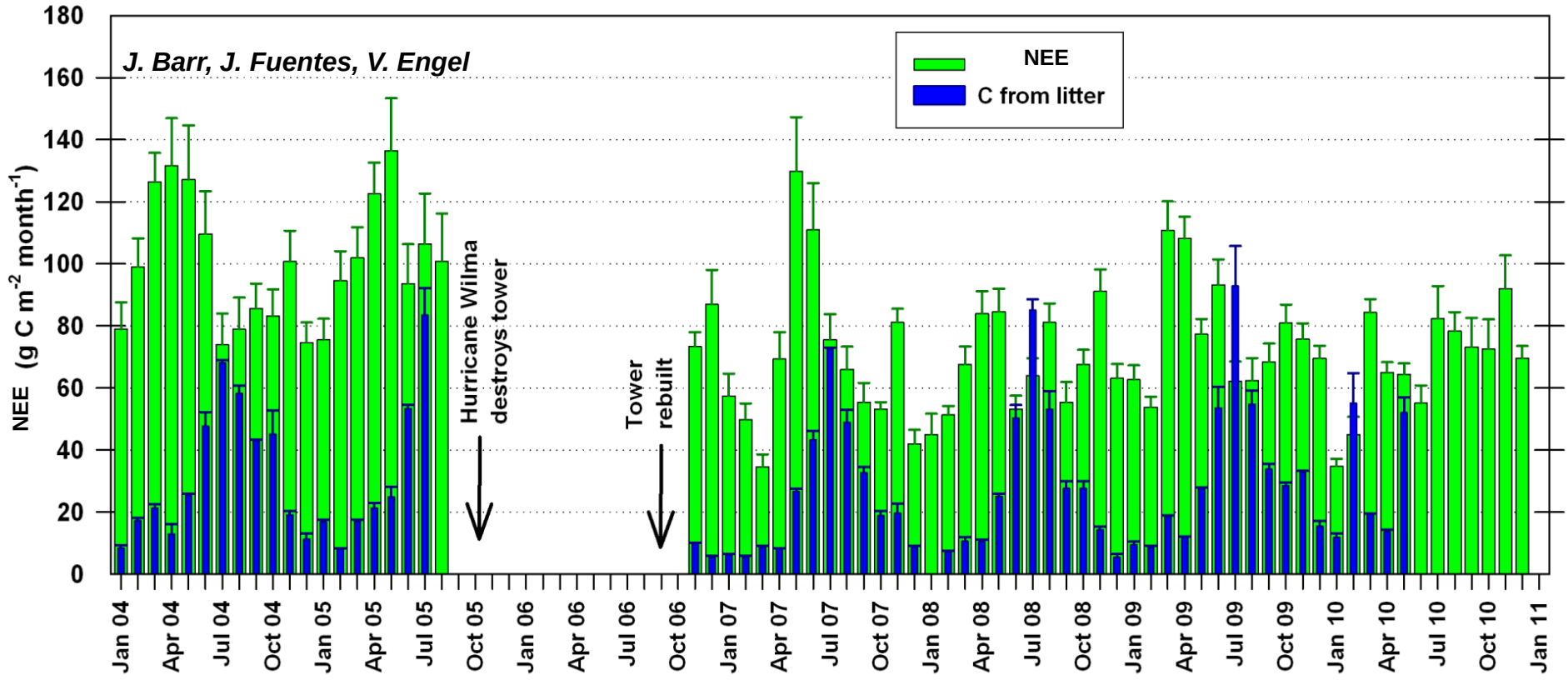
$-\Sigma NEE = 850$ to 1100 g C m^{-2} yr^{-1}



Net ecosystem carbon balance

$-\Sigma NEE$ = 850 to 1100 g C m^{-2} yr^{-1}

Litter = 312 ± 64 g C m^{-2} yr^{-1}

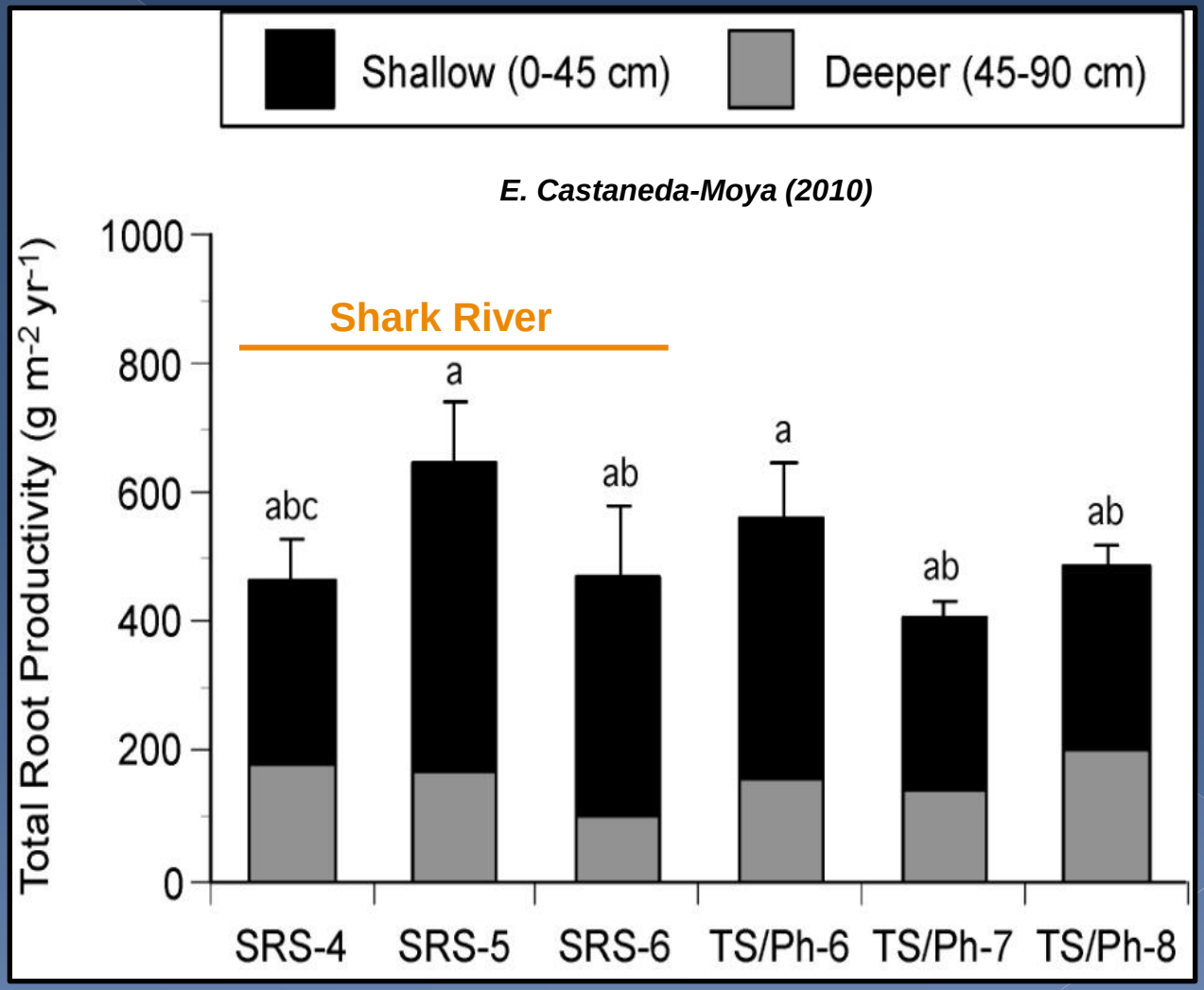


Net ecosystem carbon balance

$-\Sigma NEE$ = 850 to 1100 g C m^{-2} yr^{-1}

Litter = 312 ± 64 g C m^{-2} yr^{-1}

Roots = 215 ± 36 g C m^{-2} yr^{-1}



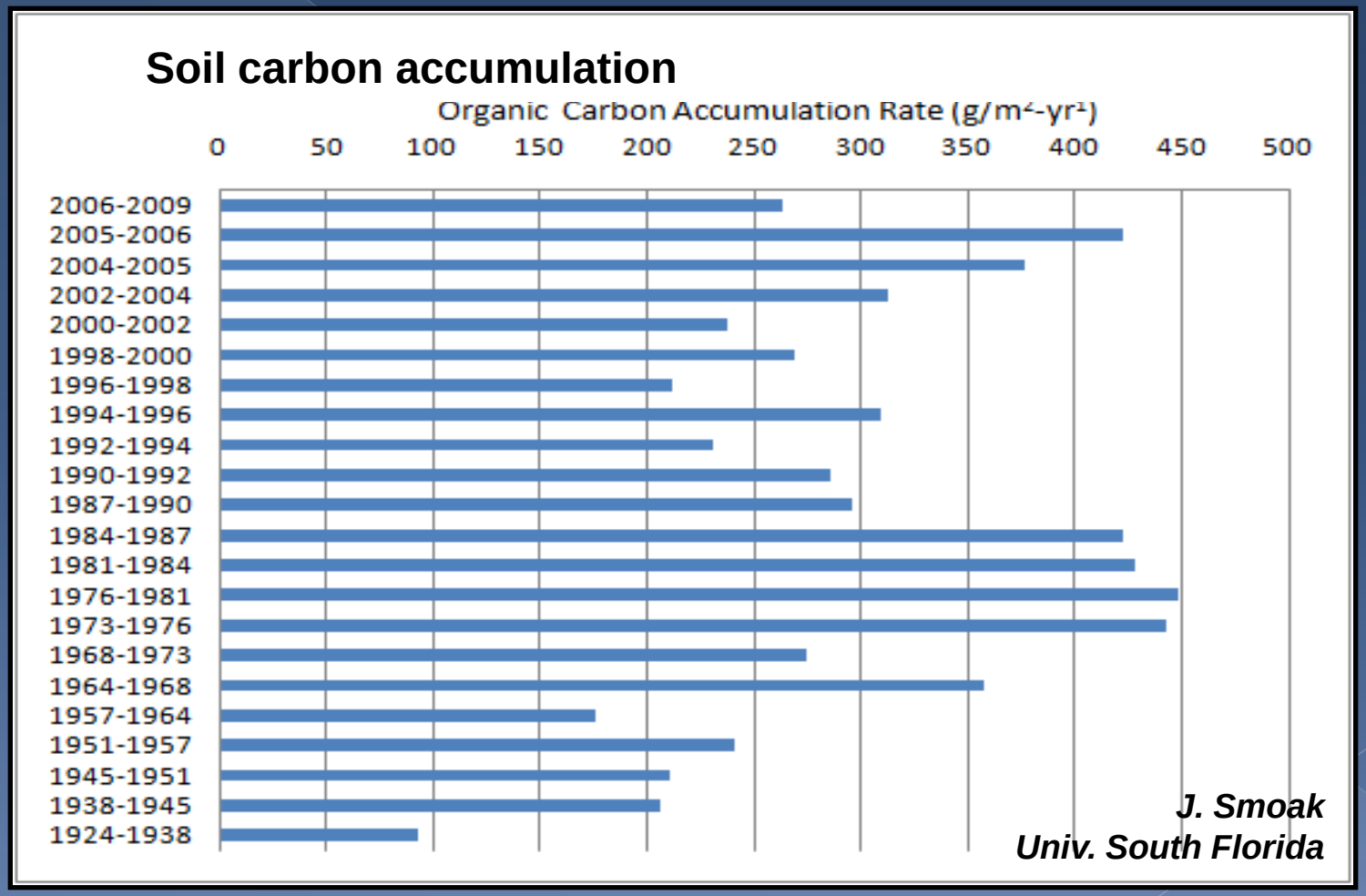
Net ecosystem carbon balance

Burial (max) = 450 g C m^{-2} yr^{-1}

$-\Sigma$NEE = 850 to 1100 g C m^{-2} yr^{-1}

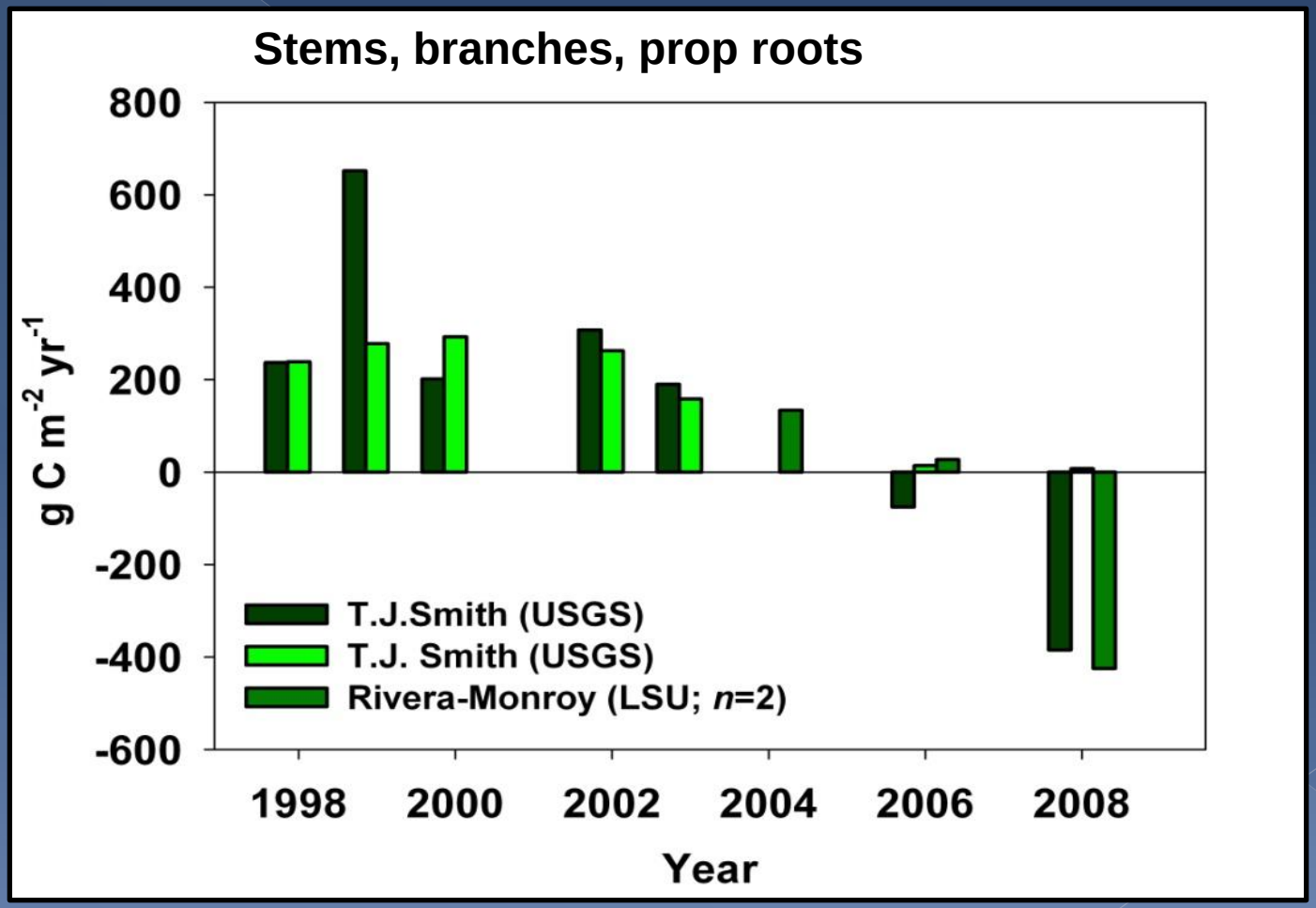
Litter = 312 ± 64 g C m^{-2} yr^{-1}

Roots = 215 ± 36 g C m^{-2} yr^{-1}



Net ecosystem carbon balance

		$-\Sigma$NEE	= 850 to 1100 g C m^{-2} yr^{-1}
Burial (max)	= 450 g C m^{-2} yr^{-1}	Litter	= 312 ± 64 g C m^{-2} yr^{-1}
Wood	= 260 ± 60 g C m^{-2} yr^{-1}	Roots	= 215 ± 36 g C m^{-2} yr^{-1}



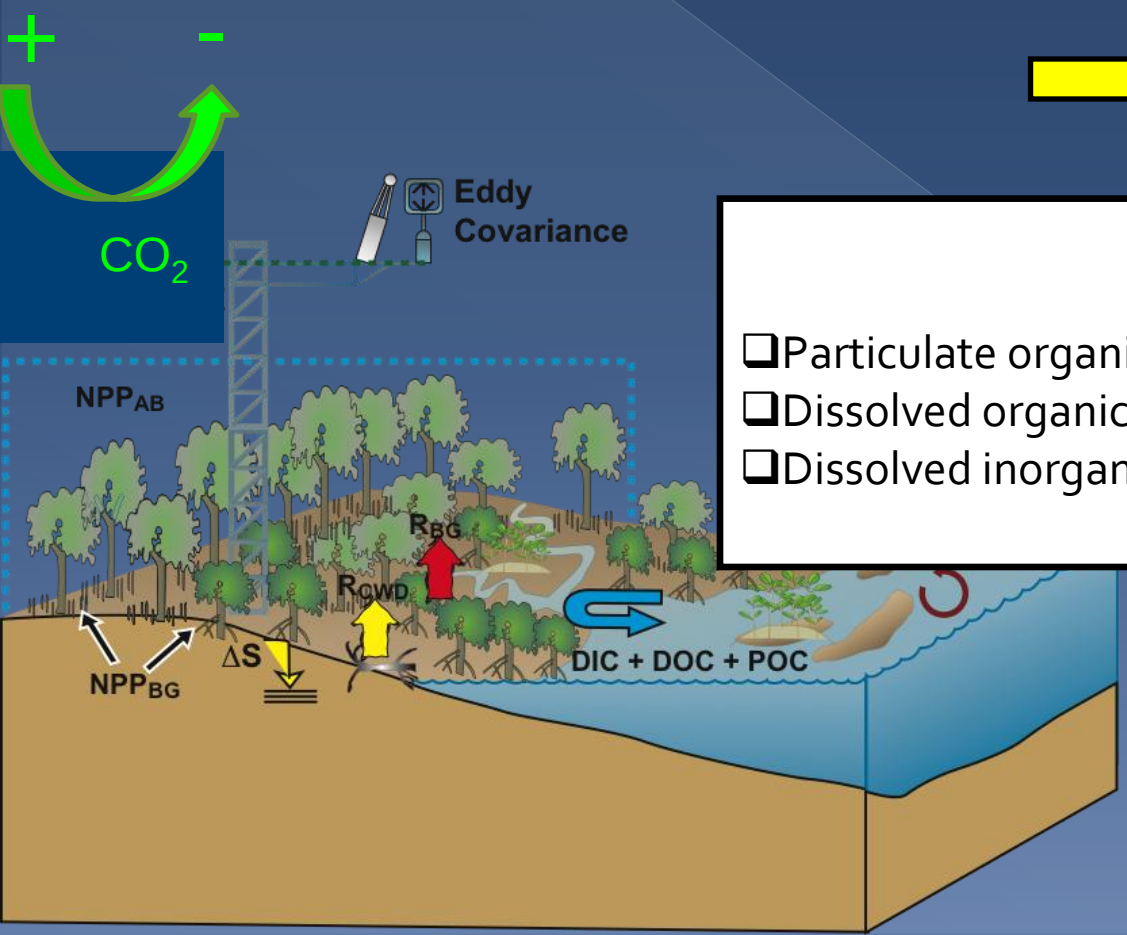
Net ecosystem carbon balance

		$-\Sigma NEE$	$= 850$ to 1100 g C m^{-2} yr^{-1}
Burial (max)	$= 450$ g C m^{-2} yr^{-1}	Litter	$= 312 \pm 64$ g C m^{-2} yr^{-1}
Wood	$= 260 \pm 60$ g C m^{-2} yr^{-1}	Roots	$= 215 \pm 36$ g C m^{-2} yr^{-1}

$F_{(DOC,\ DIC,\ POC)} = \Sigma NEE - d\Sigma(AB, BG, SOILS, LITTER)/dt$

2004 → $F_{(DOC,\ DIC,\ POC)}$ 370 ± 227 g C m^{-2} yr^{-1}

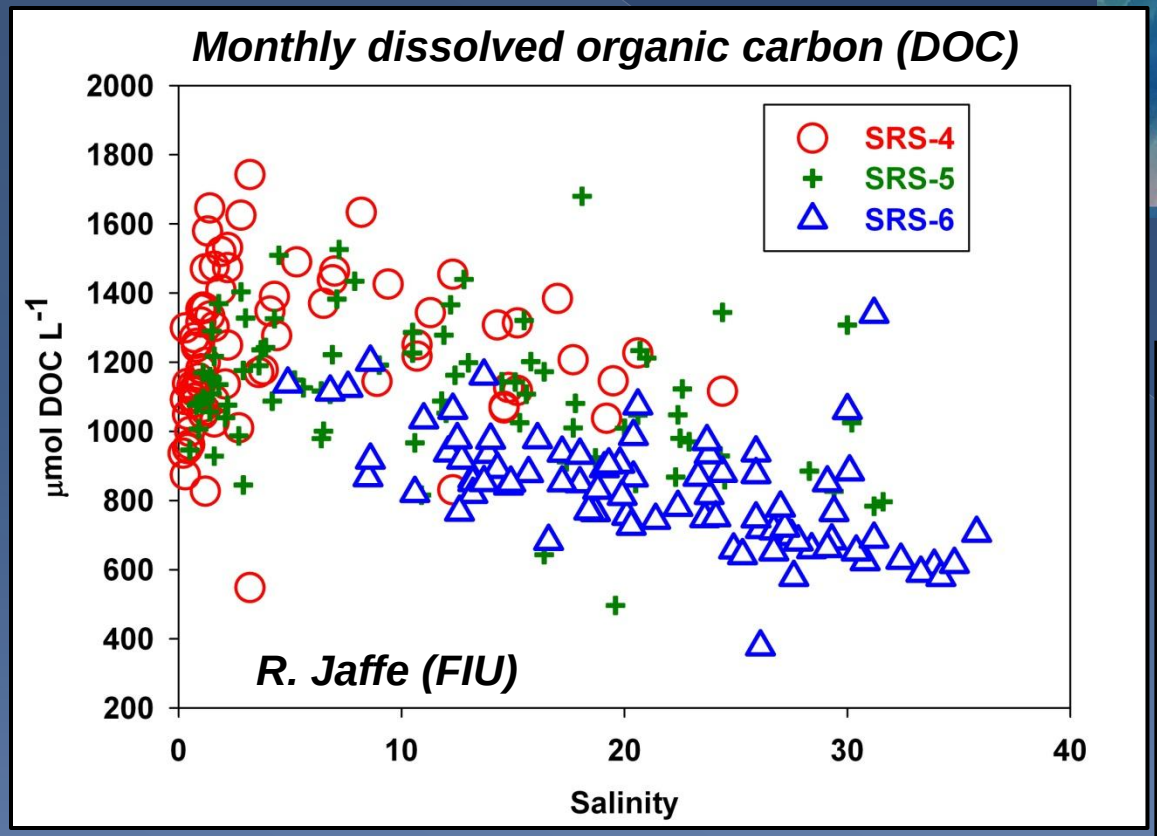
2008 → Up to 800 g C m^{-2} yr^{-1}



	Global Average ($g\ C\ m^{-2}\ yr^{-1}$)
❑Particulate organic carbon (POC)	137 ± 172^{a}
❑Dissolved organic carbon (DOC)	150 ± 134^{a}
❑Dissolved inorganic carbon (DIC)	450 ± 1500^{a}

Objective 2: Examine controls on and spatial heterogeneity in river C fluxes

- Non-conservative mixing which varies spatially along the SRS transect



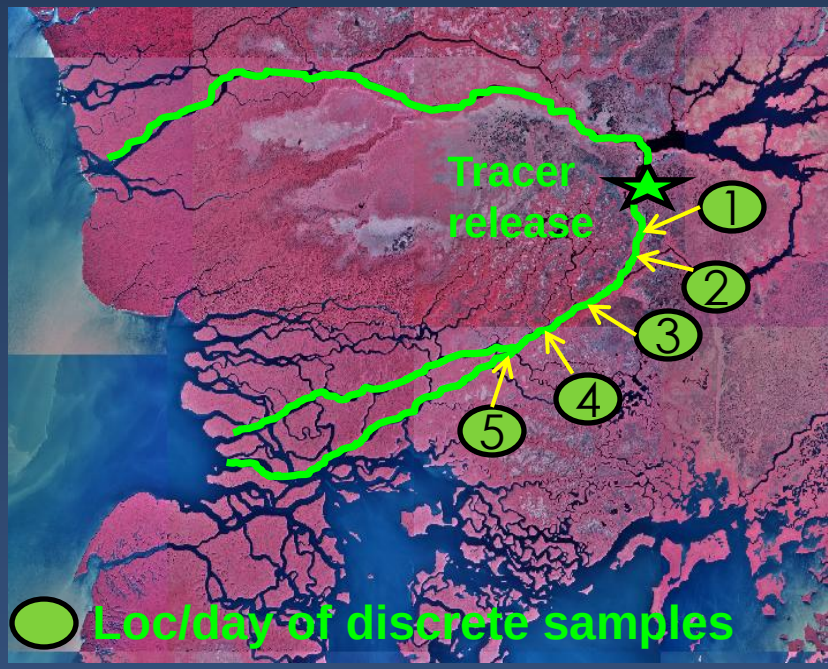
Shark River TRacer Experiment a.k.a. "SharkTREx"

- Line release of SF_6 across channel
- Continuous [SF_6], pCO2, salinity, DO, temperature, radon msmts

RSV NPS Houseboat

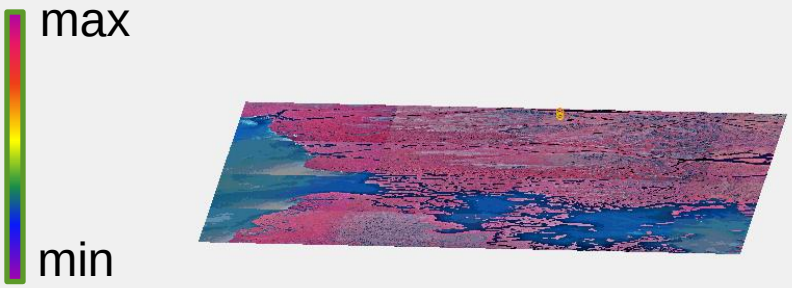
Shark River TRacer Experiment a.k.a. "SharkTREx"

- Line release of SF_6 across channel
- Continuous [SF_6], pCO2, salinity, DO, temperature, radon msmts
- 3 to 5 discrete DIC, DIC^{13}, DOC, TOC, Alk, and DOM (PARAFAC) msmts in the tracer plume on each day

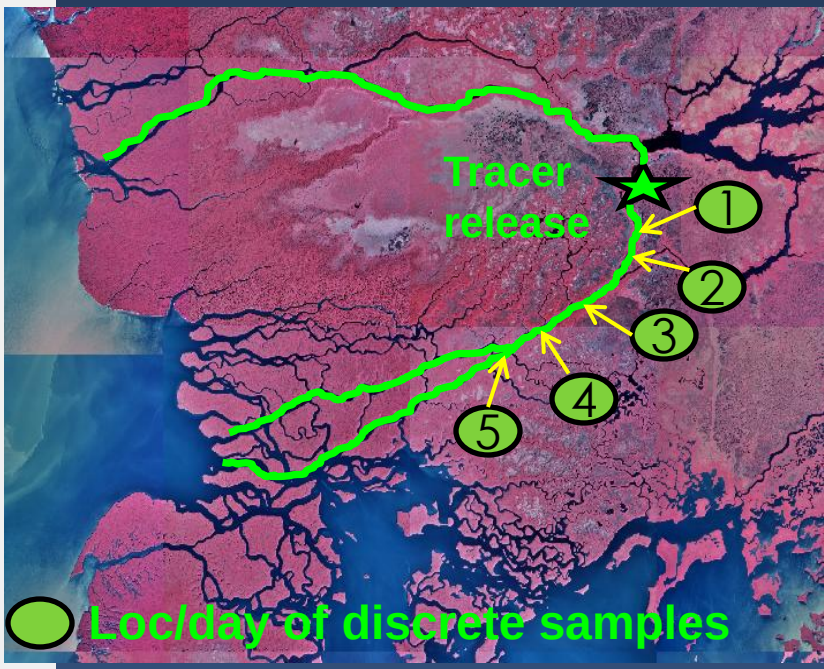


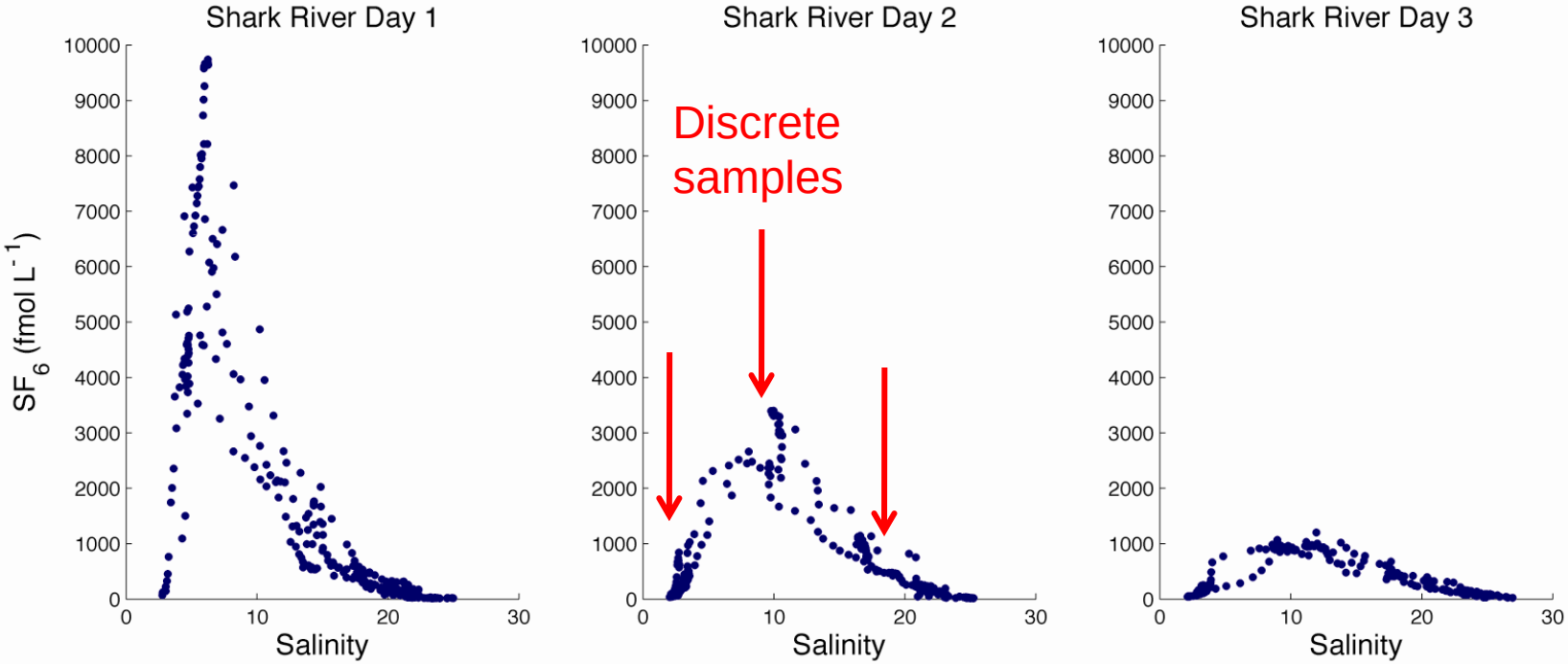
RSV NPS Houseboat

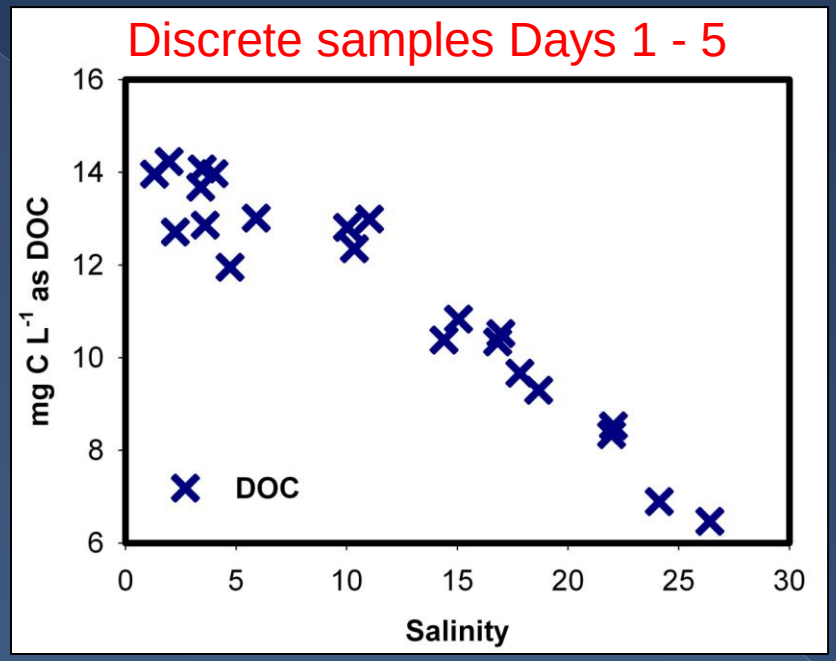
SharkTRex animations

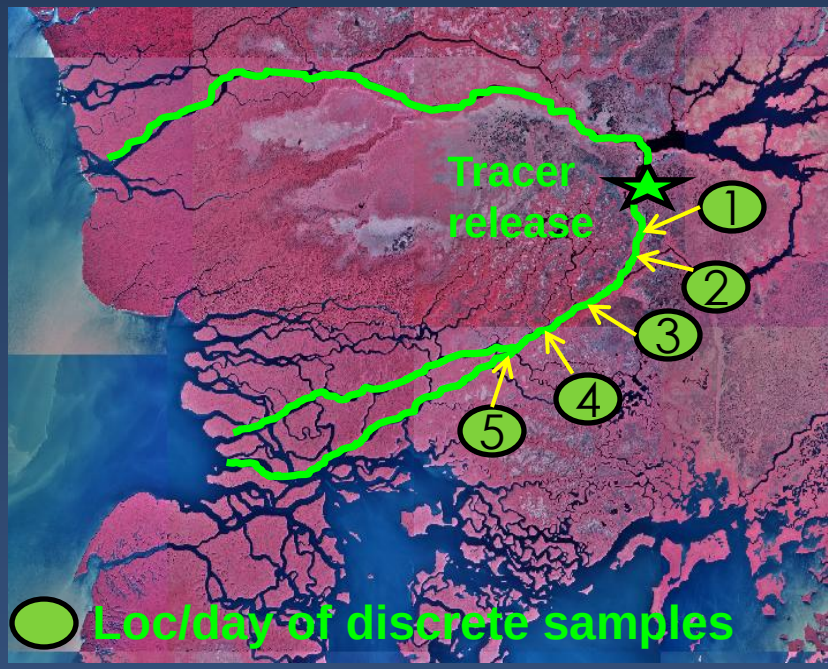


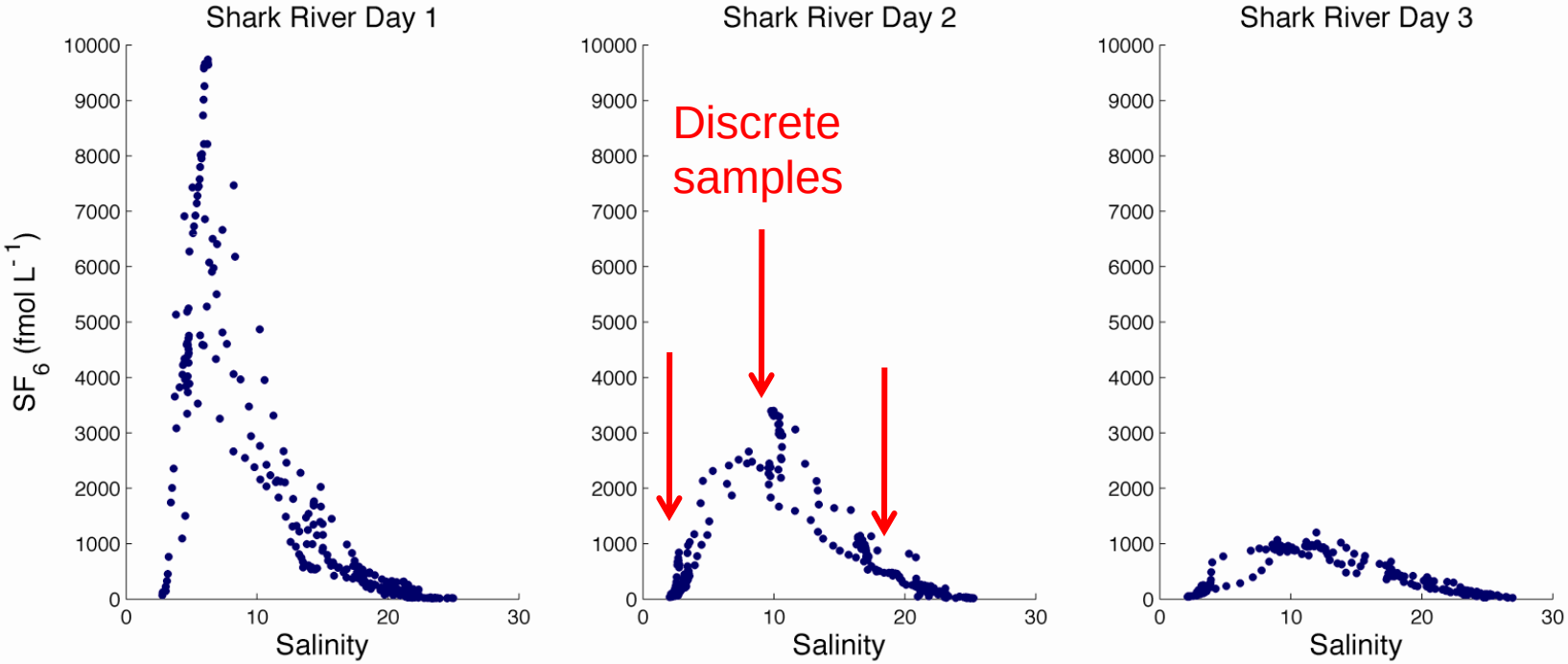
SF_6 (fmol L^{-1})

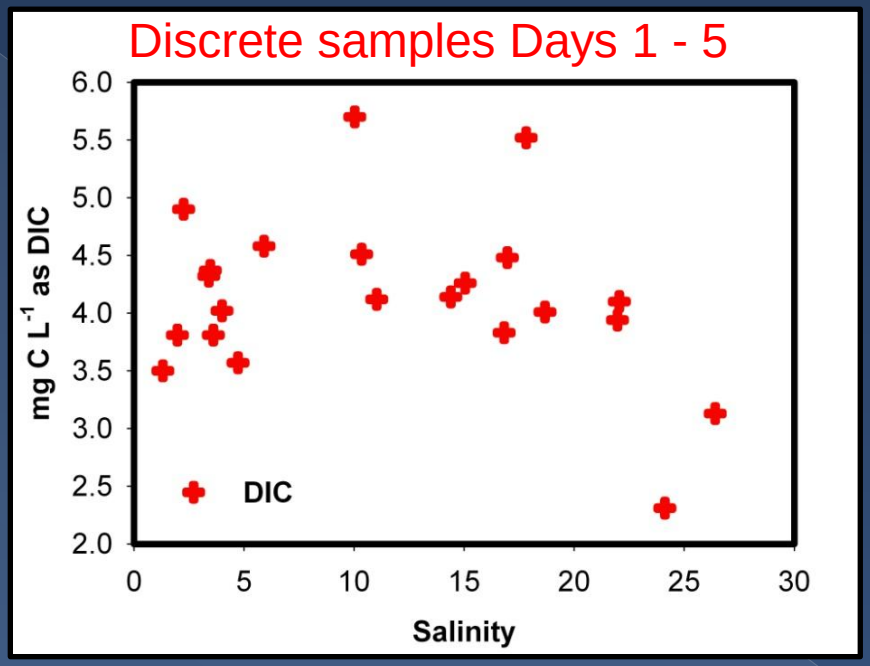


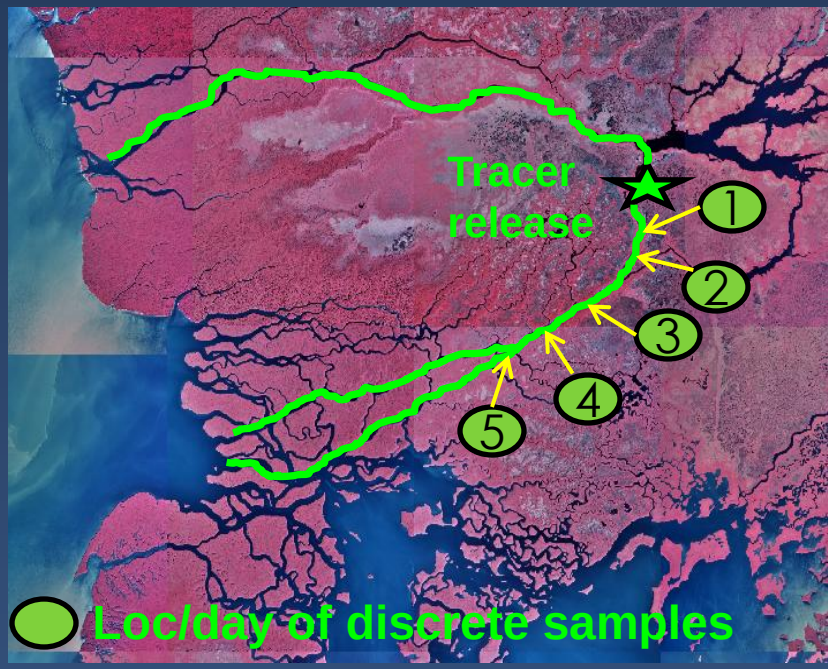


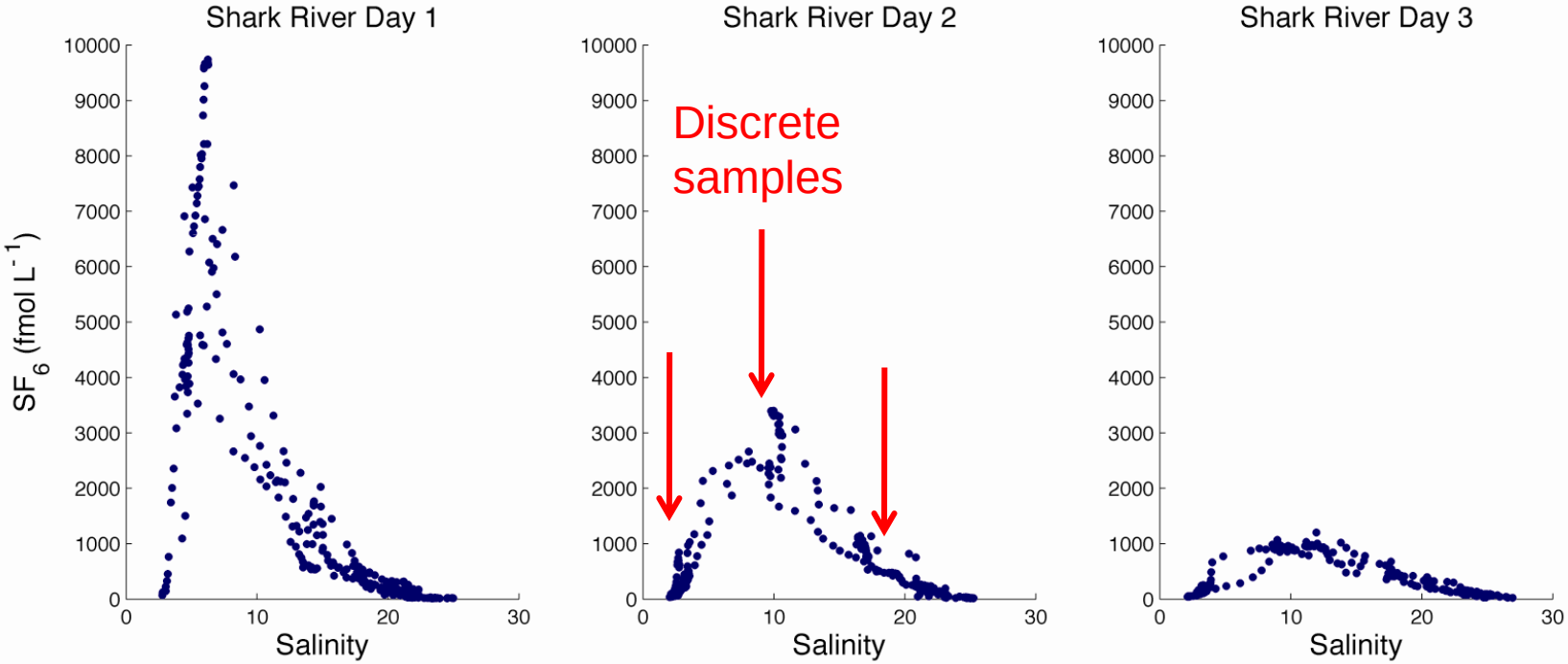

Discrete samples Days 1 - 5
mg C L-1 as DOC
DOC
Salinity

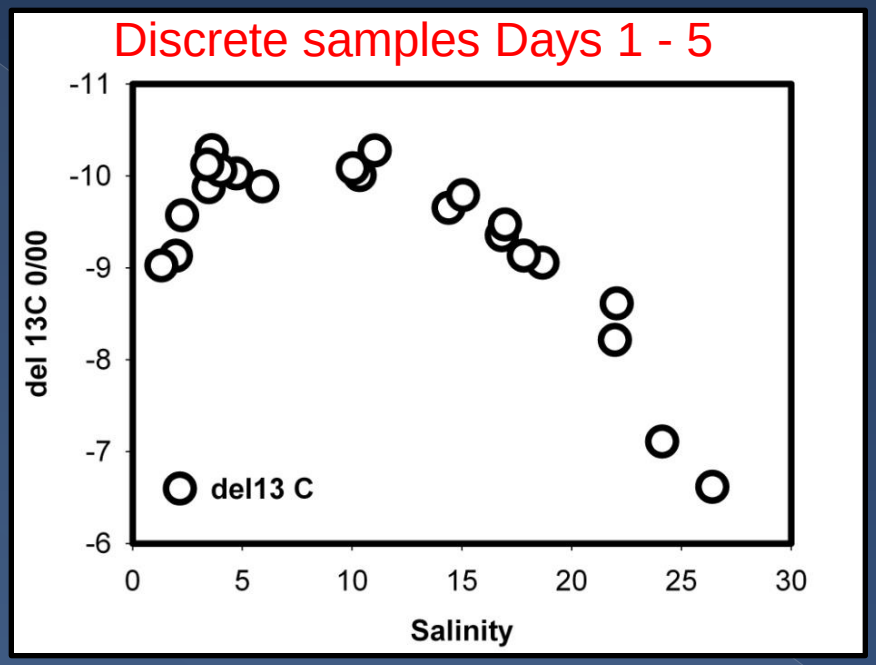

Tracer release
1
2
3
4
5
Loc/day of discrete samples

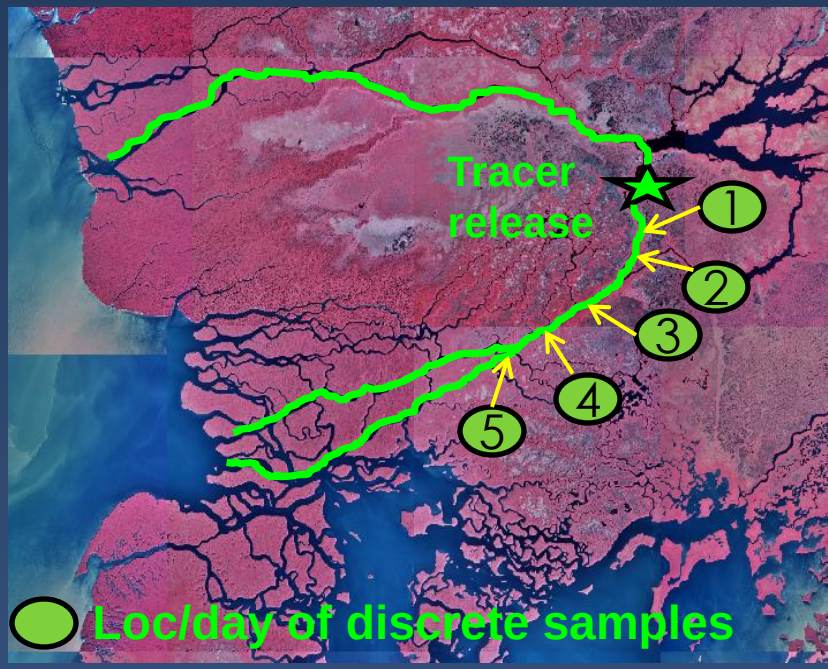

Shark River Day 1
Shark River Day 2
Shark River Day 3
Discrete samples
SF6 (fmol L-1)
Salinity

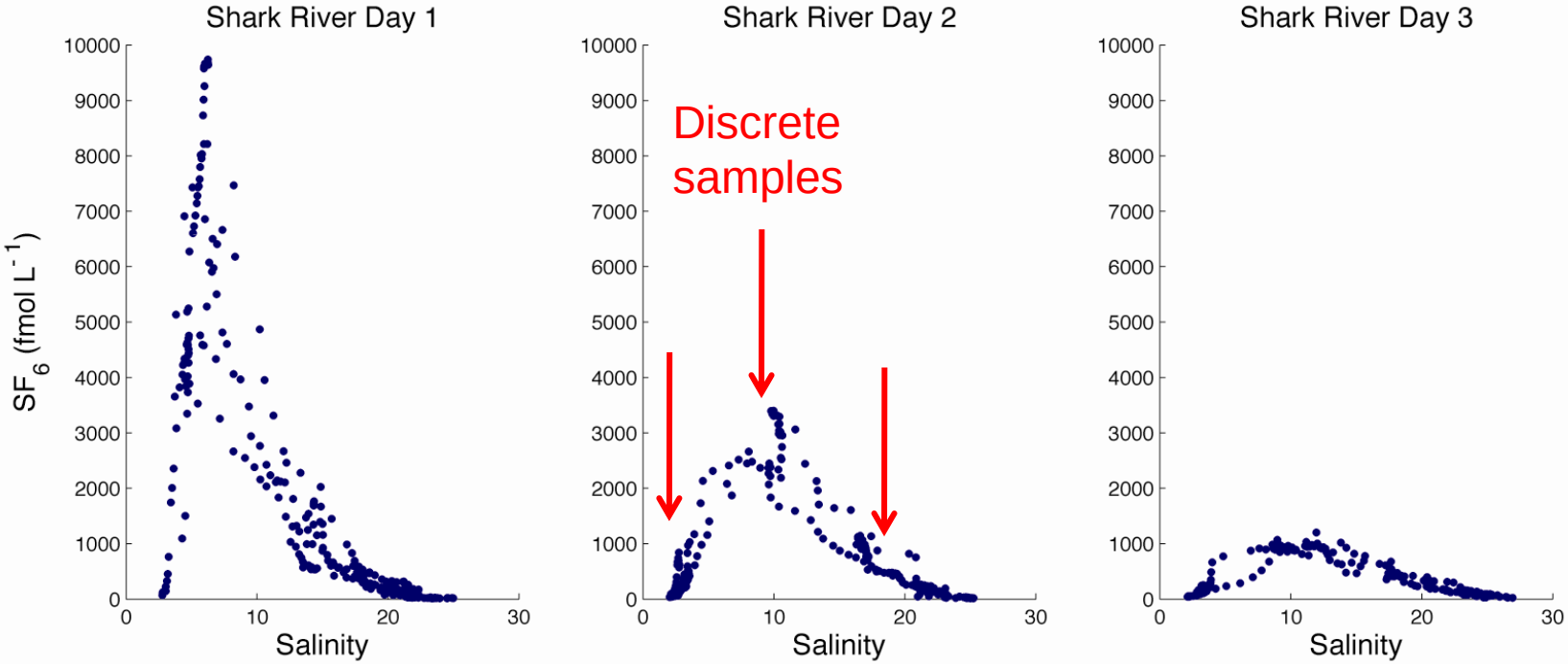

Discrete samples Days 1 - 5
mg C L-1 as DIC
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
DIC
0
5
10
15
20
25
30
Salinity


Tracer release
1
2
3
4
5
Loc/day of discrete samples


Shark River Day 1
Shark River Day 2
Shark River Day 3
SF6 (fmol L-1)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Discrete samples
0
10
20
30
Salinity


Discrete samples Days 1 - 5
del 13C 0/00
Salinity
del13 C
-11
-10
-9
-8
-7
-6
0
5
10
15
20
25
30


Tracer release
1
2
3
4
5
Loc/day of discrete samples

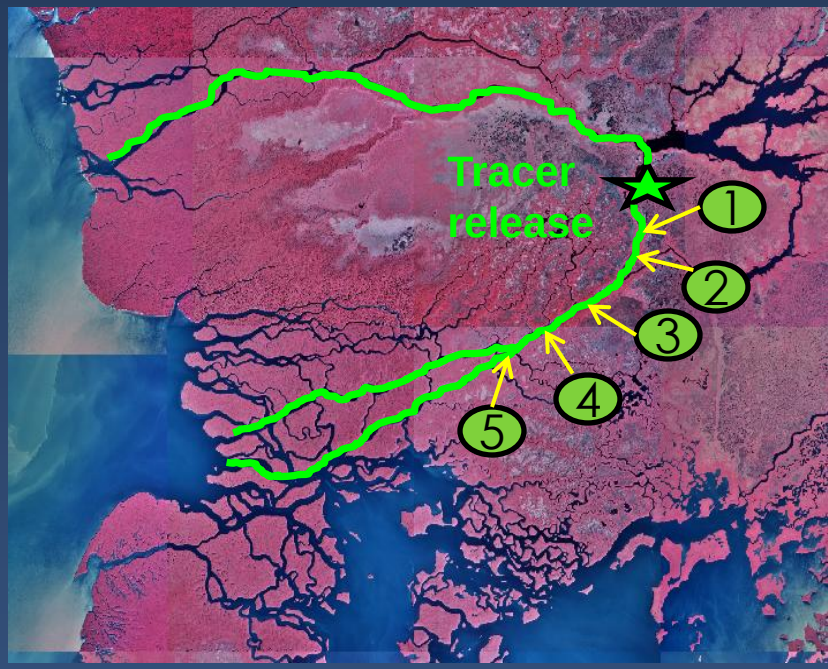

Shark River Day 1
Shark River Day 2
Shark River Day 3
Discrete samples
SF6 (fmol L-1)
Salinity
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
0
10
20
30

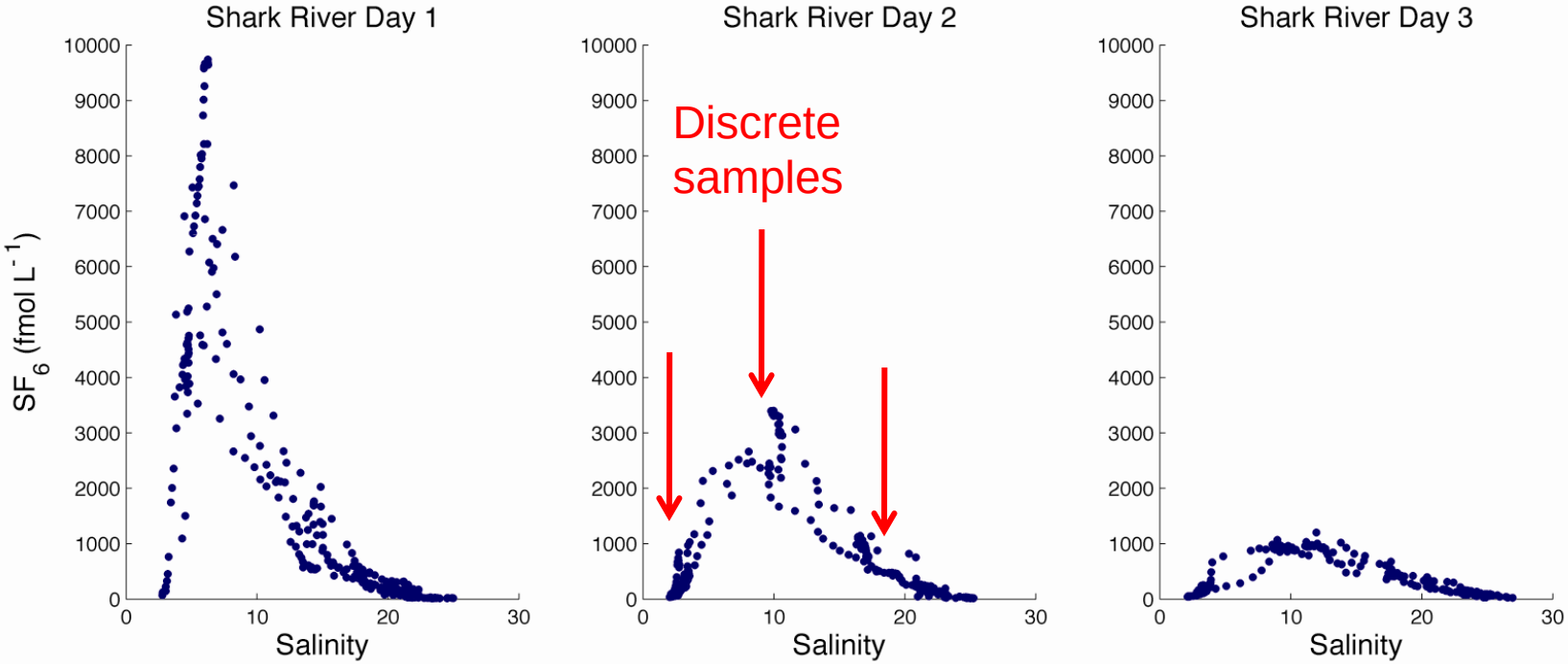
Future Directions

- Calculation of net advection and dispersion from SF_6 movement

- Apply end member mixing analysis in a Lagrangian framework to model (e.g. DIC, DOC, 13C) over time in the plume

- Develop hydrodynamic simulation models which include solute transport





Key Findings

•Eddy covariance measurements must be coupled with measurements of dissolved and particulate carbon fluxes to improve understanding of mangrove ecosystem carbon budgets

•DIC, DOC, and POC fluxes from mangrove forests are heterogeneous in time and space

•Tracer based measurements hold promise for improving understanding of river carbon fluxes in complex tidal regions and for calibrating hydrodynamics models with solute transport