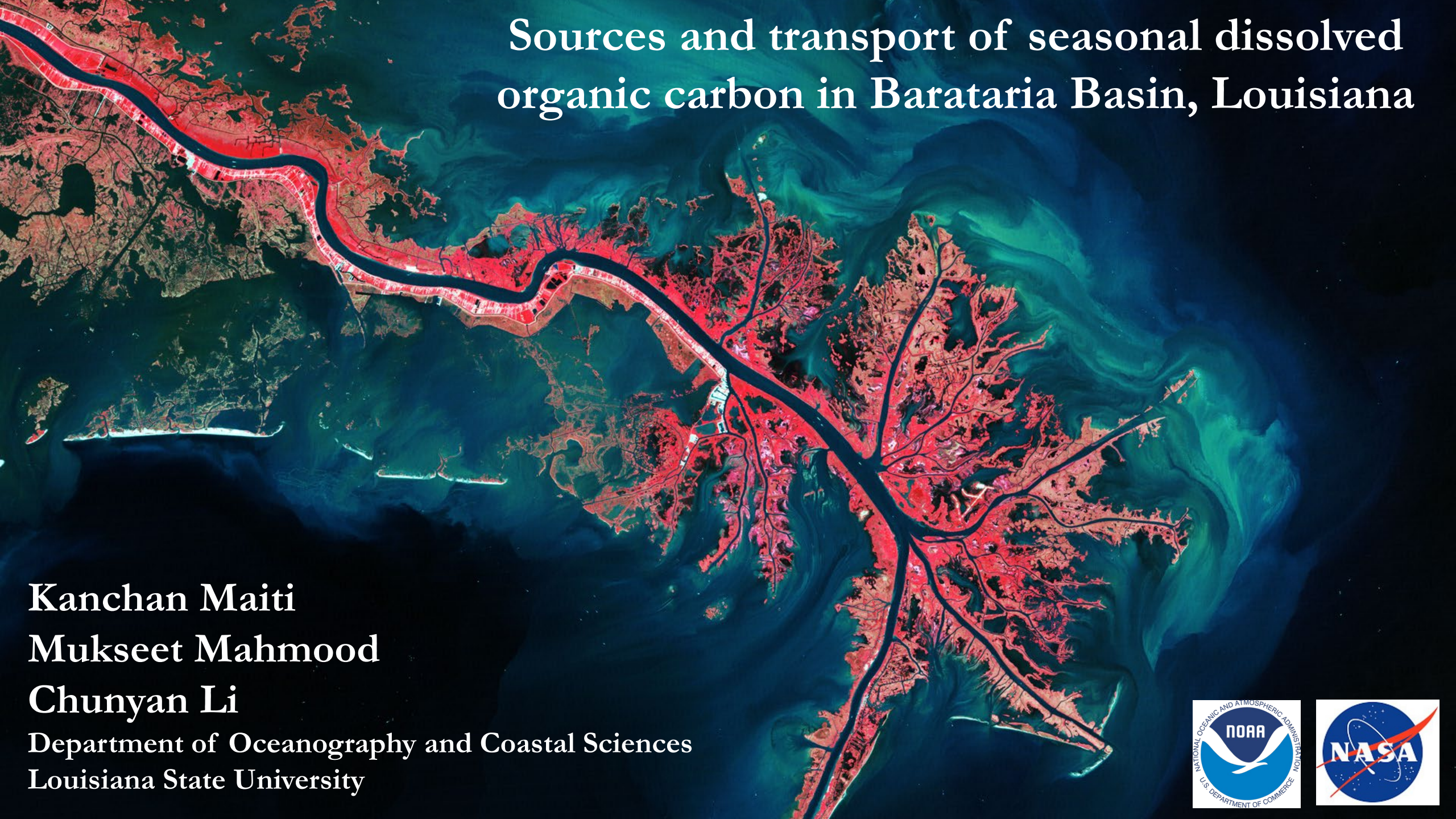
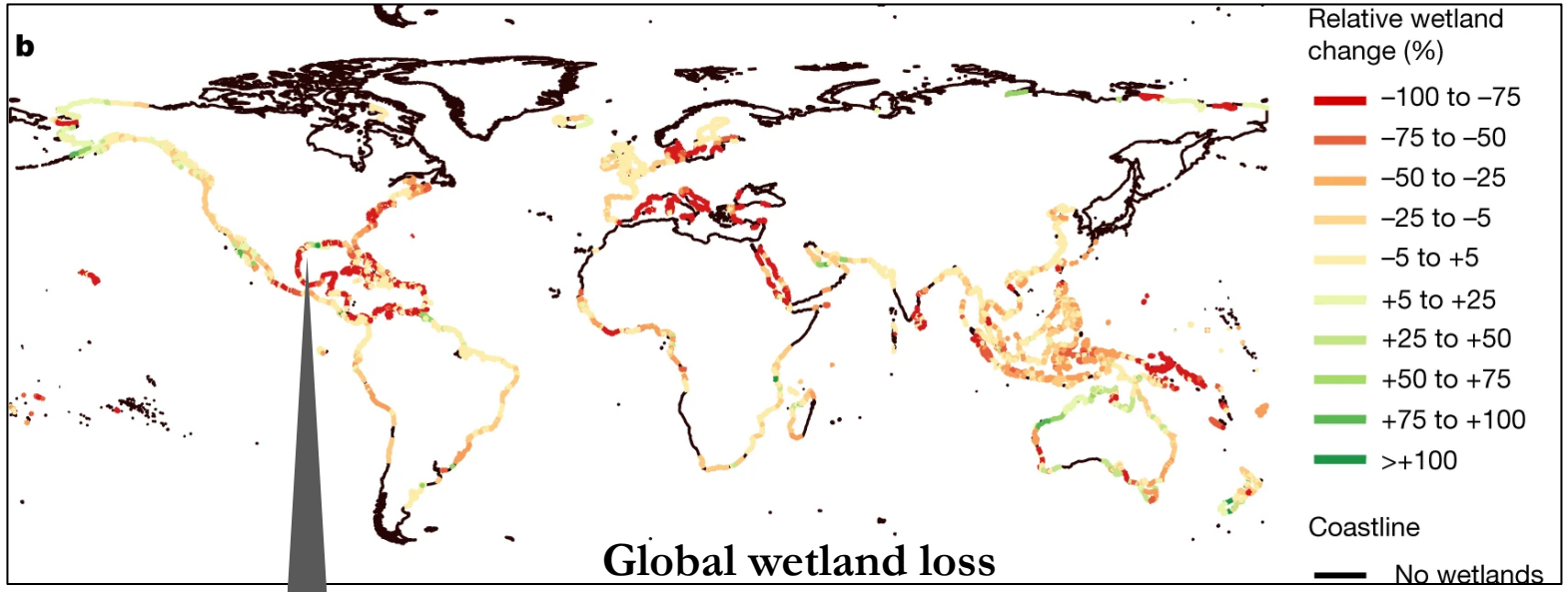
Sources and transport of seasonal dissolved organic carbon in Barataria Basin, Louisiana



Kanchan Maiti
Mukseet Mahmood
Chunyan Li

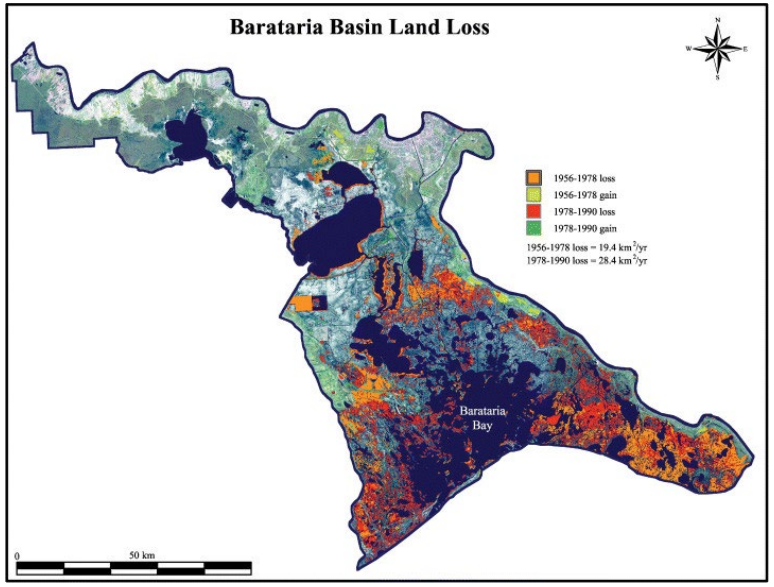
Department of Oceanography and Coastal Sciences
Louisiana State University

Research Motivation



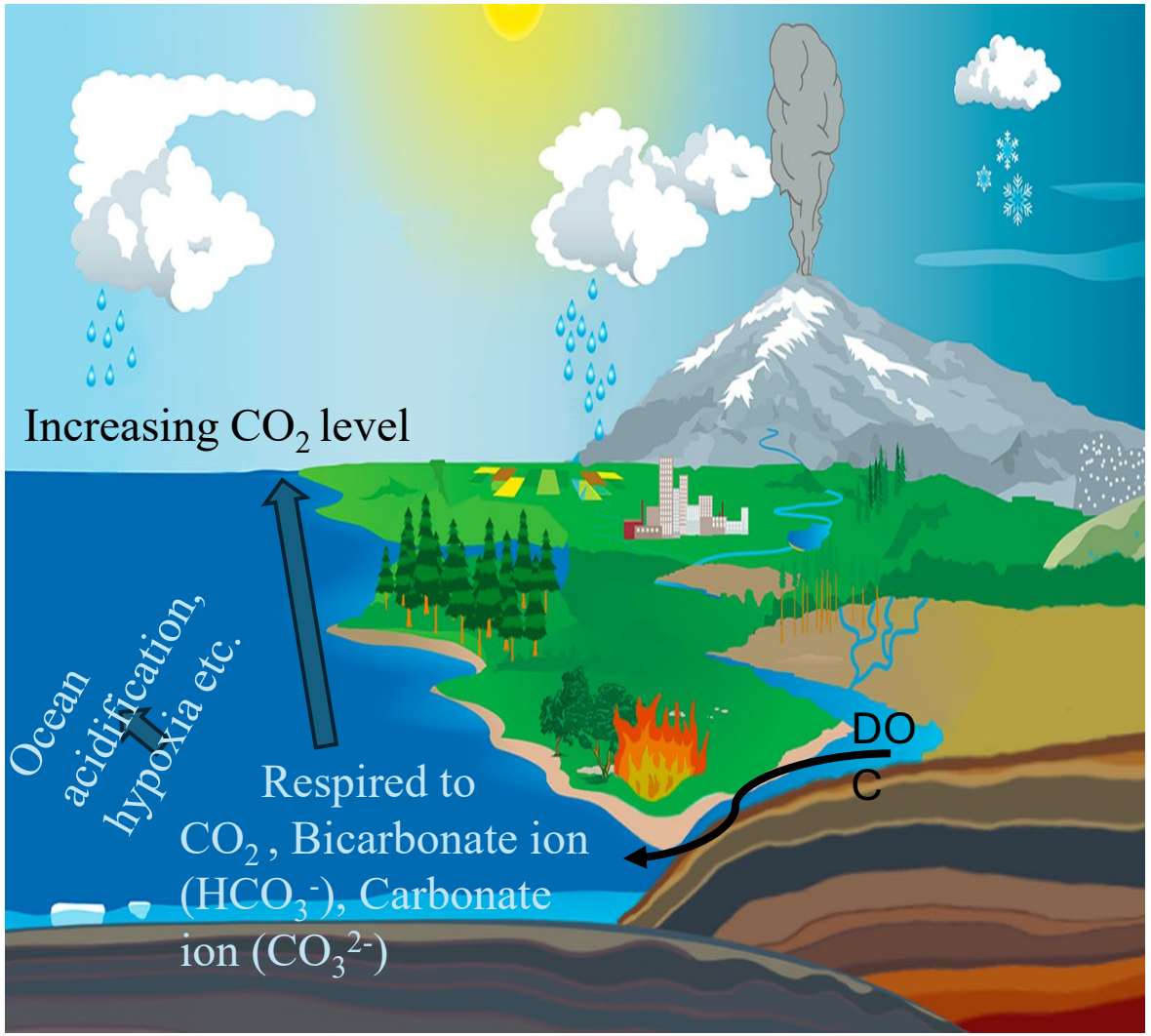
Global wetland loss

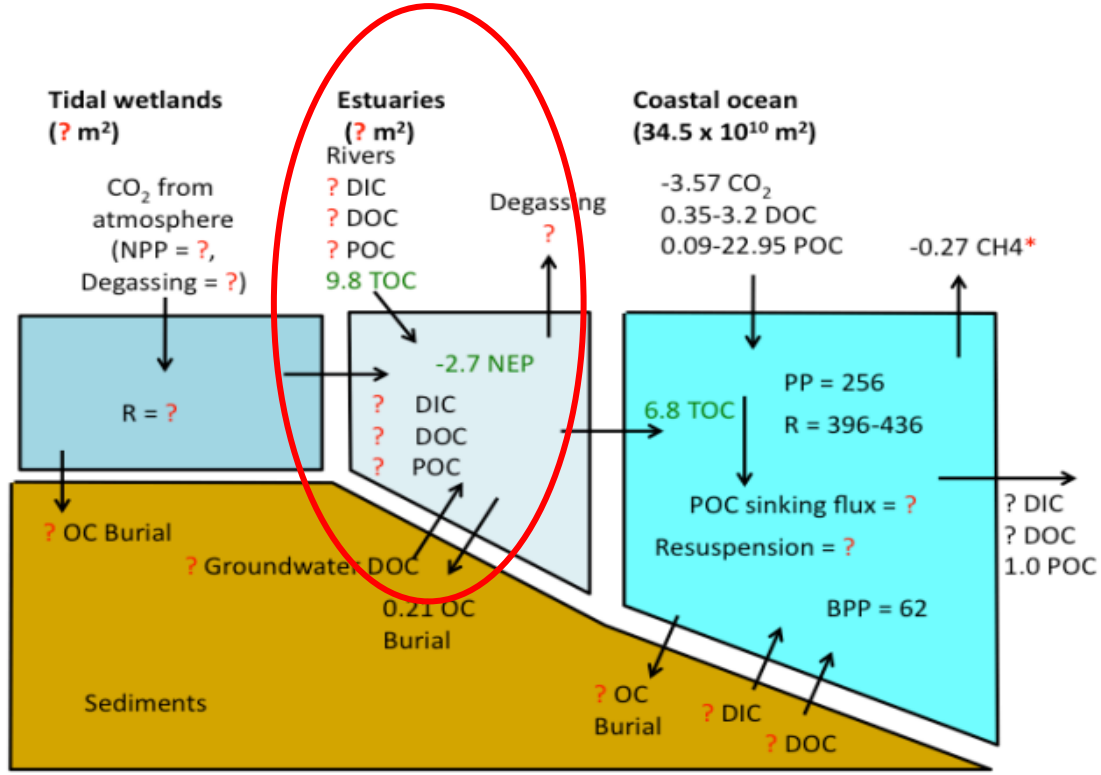
Land loss



- Up to 87 Tg C per year is sequestered in coastal wetlands.
- Barataria basin - a major estuary within the Mississippi River delta has one of the highest wetland loss rates in the United States (~13.3 km^2/yr) (Hayes et al., 2021).
- About 1.0 terra gram (One million tons) of carbon per year is lost from this wetland loss (Baustian et al., 2021)
- The extent and dominant pathway for carbon loss is currently not well documented.

Why focus on DOC transport?





Carbon budget status in Northern Gulf of Mexico

Hypothesis and Objectives

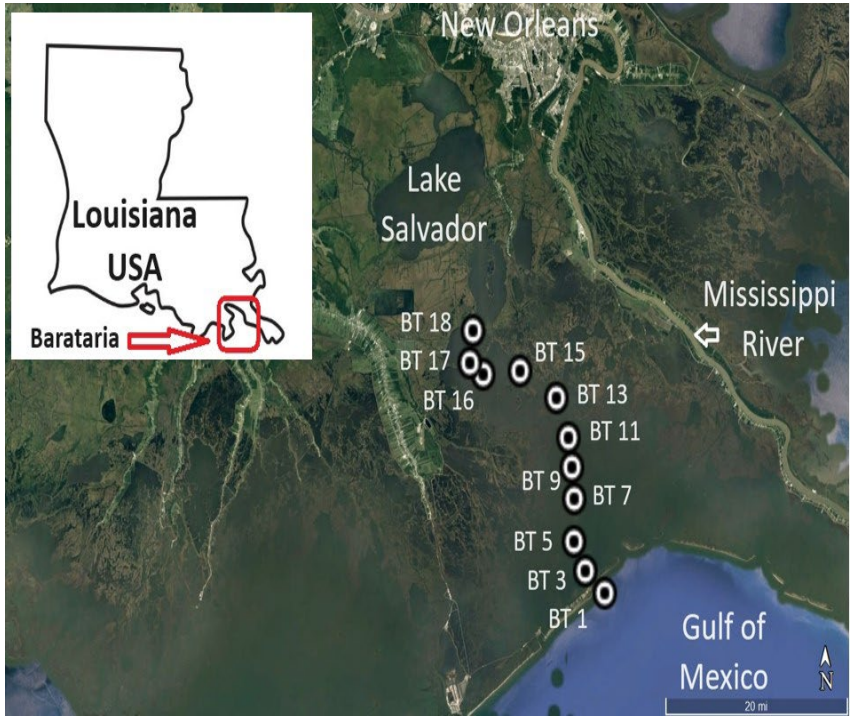
The main objectives of this study are –

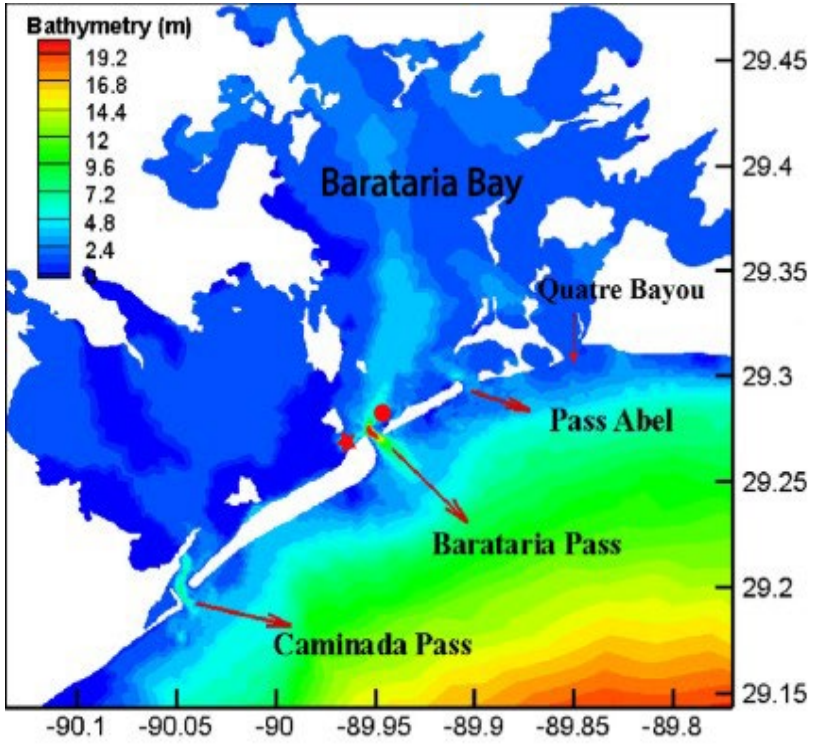
- Measuring the seasonal variability in carbon dynamics in the Barataria Basin, Louisiana.
- Characterizing the changing sources of DOC across the basin on a seasonal scale.
- Combining field observations with hydrodynamic modeling to estimate the seasonal DOC transport from this basin into the NGOM.

Hypothesis –

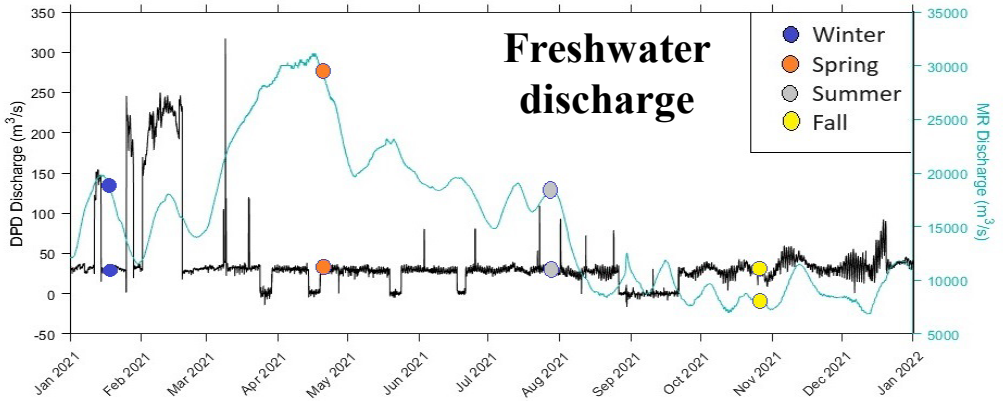
DOC transport from Barataria Basin will be highest during spring coinciding with higher river discharge.

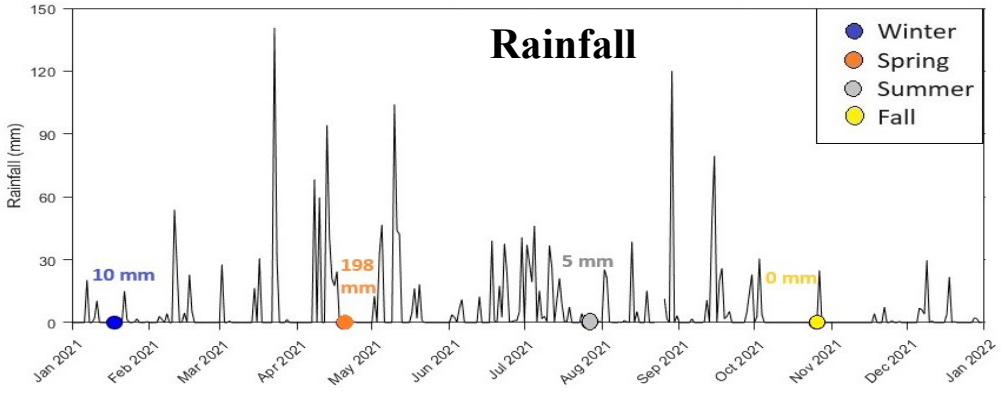
Sampling site





- Sampling was carried out during winter (January), spring (April), summer (July) and fall (October) of 2021
- Water samples were collected ~0.5m below the surface seasonally to address the





Measurements

- Laboratory analysis
  - Dissolved Organic Carbon (DOC)
  - Dissolved Inorganic Carbon (DIC)
  - Nitrate + Nitrite concentration analysis
- Absorption spectroscopy analysis
  - aCDOM
  - Humification index

Shimadzu TOC 5000A (with ASI-5000A autosampler)

Apollo SciTech AS-c5 Dissolved inorganic carbon (DIC) analyzer

OI Analytical Flow Solutions IV auto analyzer

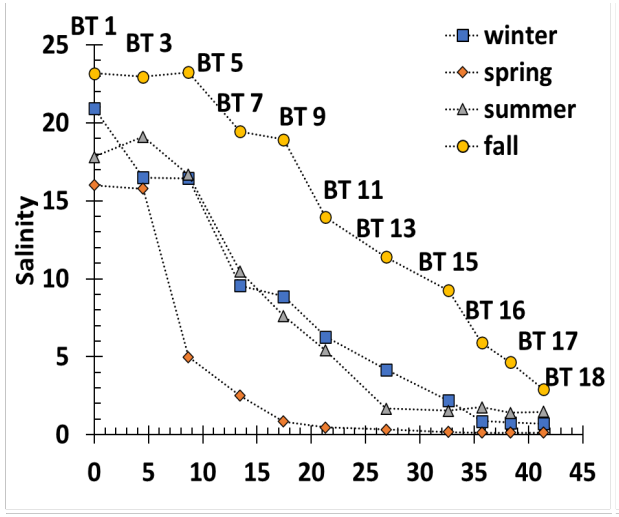
$$CDOM\ absorption\ coefficient$$

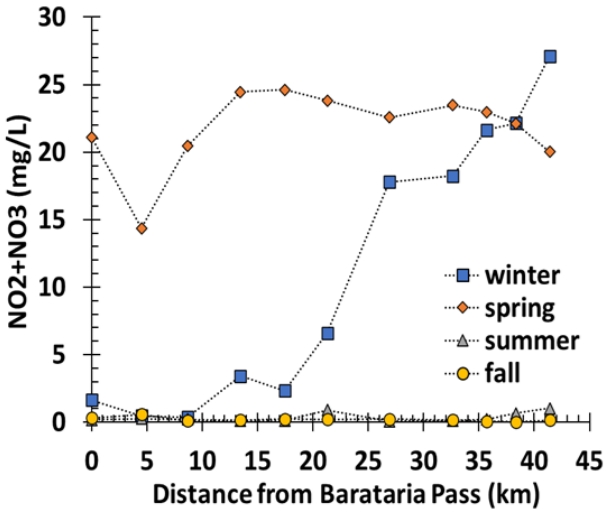
$$a\mathrm{CDOM}(350) = \frac{2.303 * \mathrm{A}(350)}{L}$$

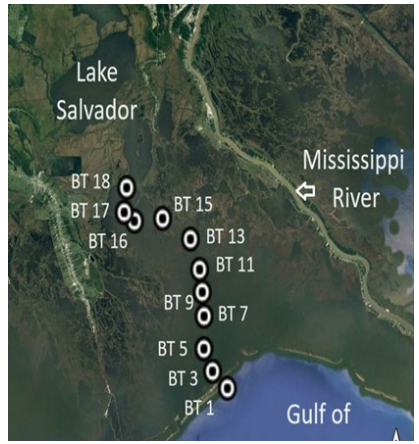
$$Humification\ Index$$

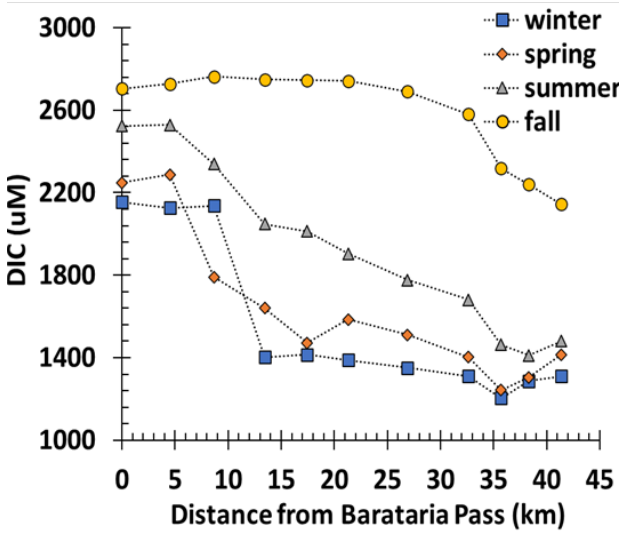
$$\frac{absorption\ at\ 472\ nm\ \text{wavelength}}{absorption\ at\ 664\ nm\ \text{wavelength}}$$

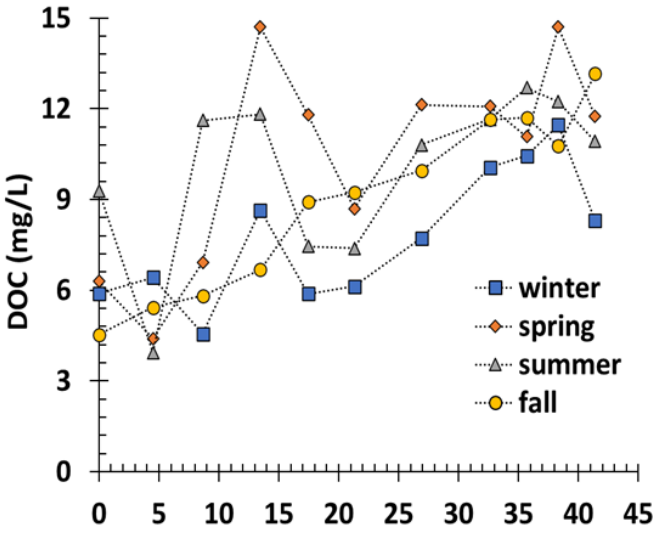
Seasonal variability





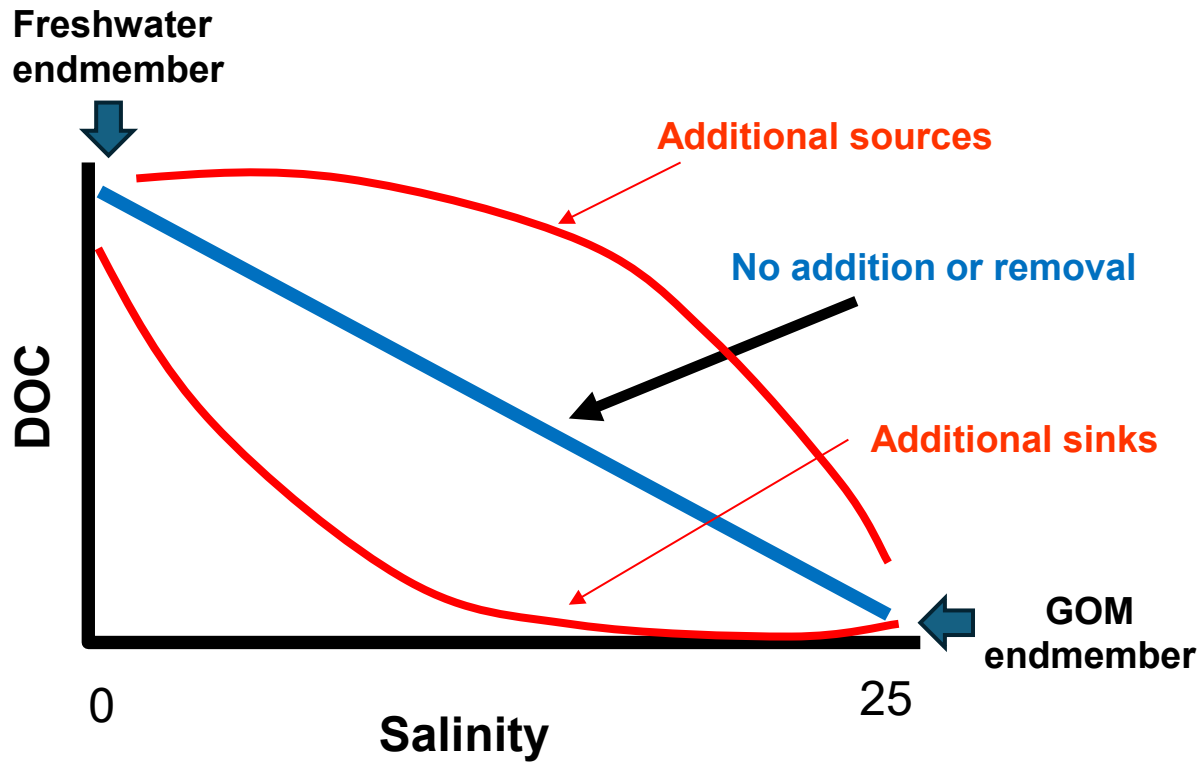






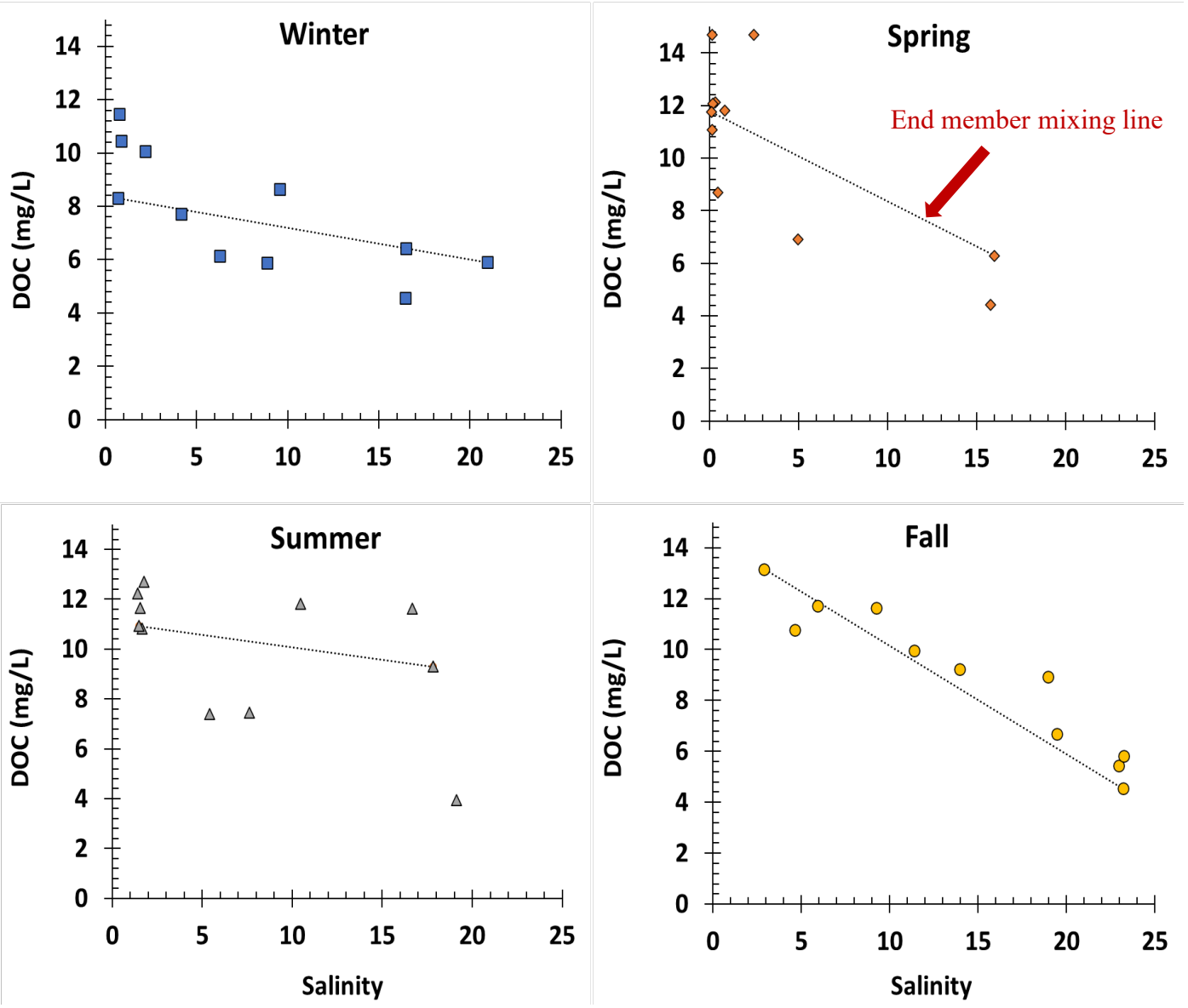
- ❑ Fall had significant saltwater in the basin.
- ❑ Spring had significant freshwater in the basin.
- ❑ Summer and fall had lowest NO_2+NO_3.
- ❑ Average DOC highest in spring (10.41 mg/L) and lowest in winter (7.78 mg/L).
- ❑ Average DIC highest in fall (2582.47 uM) and lowest in winter (1553.26 uM).

DOC Endmember Mixing Model



Simple two end-member mixing model to understand processes controlling seasonal DOC distribution in the basin.

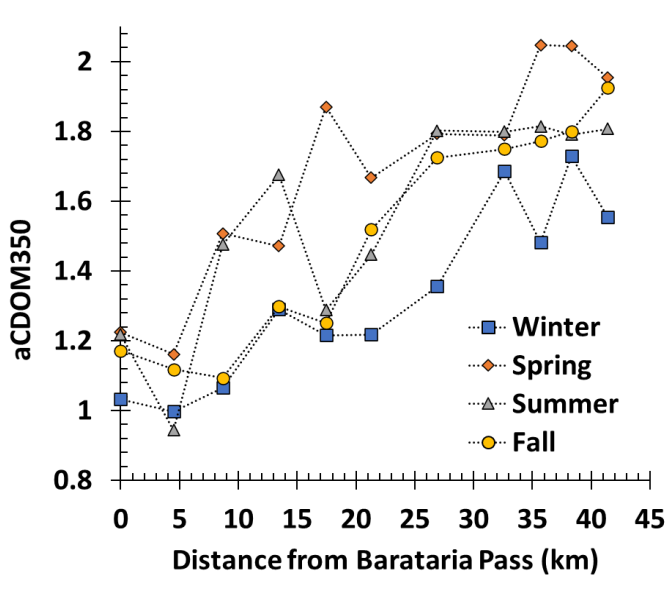
Processes impacting seasonal DOC distribution

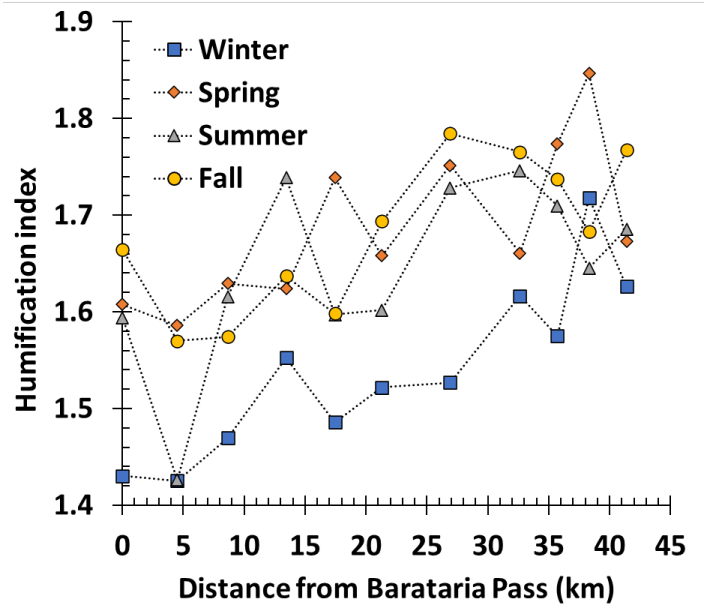


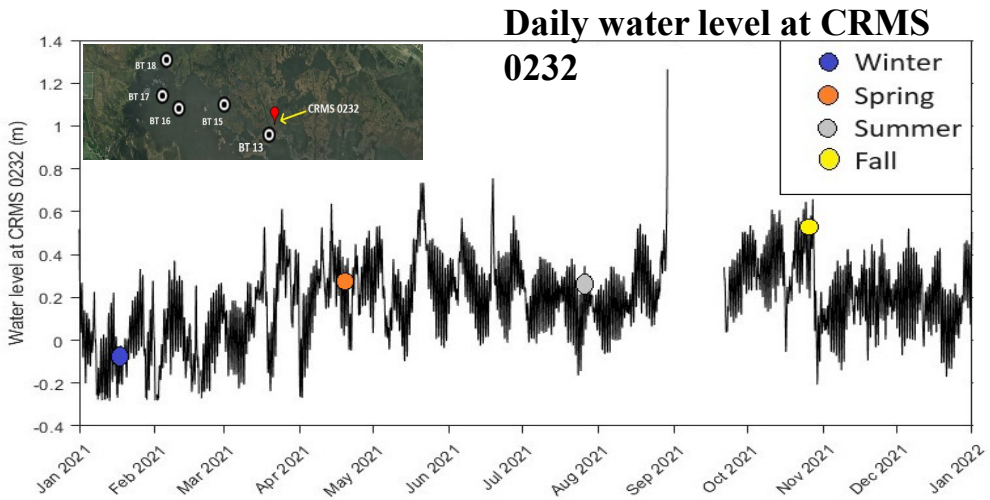
Deviation from the end-member physical mixing line reflects additional source or sink of DOC in the basin

- ❑ Winter - Lower temperature and lower primary production resulted in the lowest DOC concentration across the bay.
- ❑ Spring –Freshwater flow and the flooding in marshes increased. Higher temperature enhanced respiration in the lower bay.
- ❑ Summer – Increased tidal flushing rate. Higher temperature enhanced respiration in the lower bay.
- ❑ Fall – Export from the marshes increased. Dilution in DOC was observed in the lower bay due to the high-water level in the gulf.

Terrestrial DOC signal into the NGOM



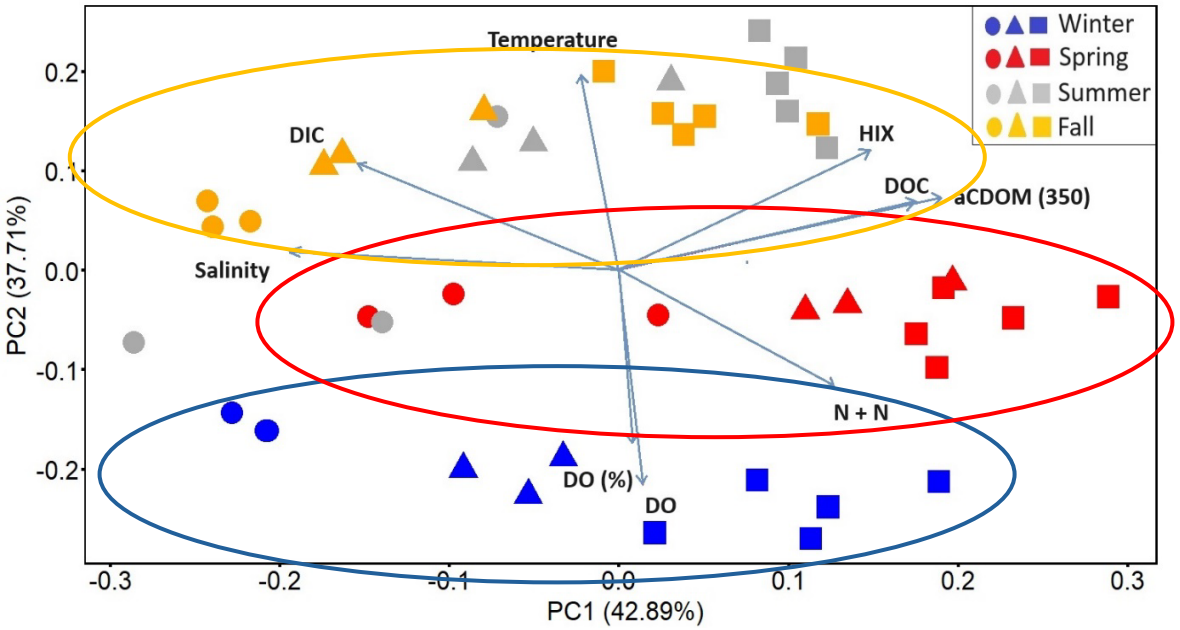




- The highest terrestrial OM input was in spring and summer due to the highest terrestrial OM supply from the marshes.
- The lowest terrestrial OM input was in winter due to the lowest terrestrial OM supply from the marshes.

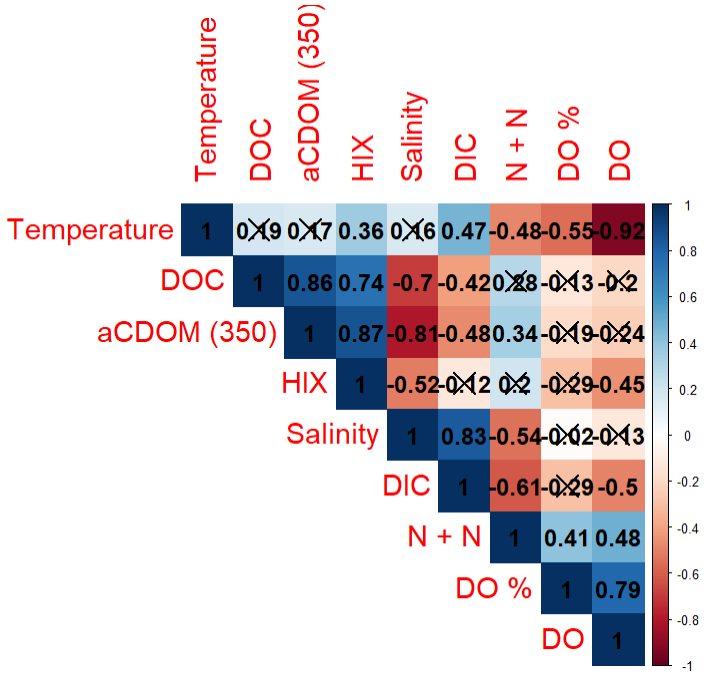
Correlating DOC and environmental parameters

Principal component analysis



Circle =BT 1 to BT 3 (**saline region**)
Triangle =BT 5 to BT 9 (**transition region**)
Square = BT 11 to BT 18 (**freshwater region**).

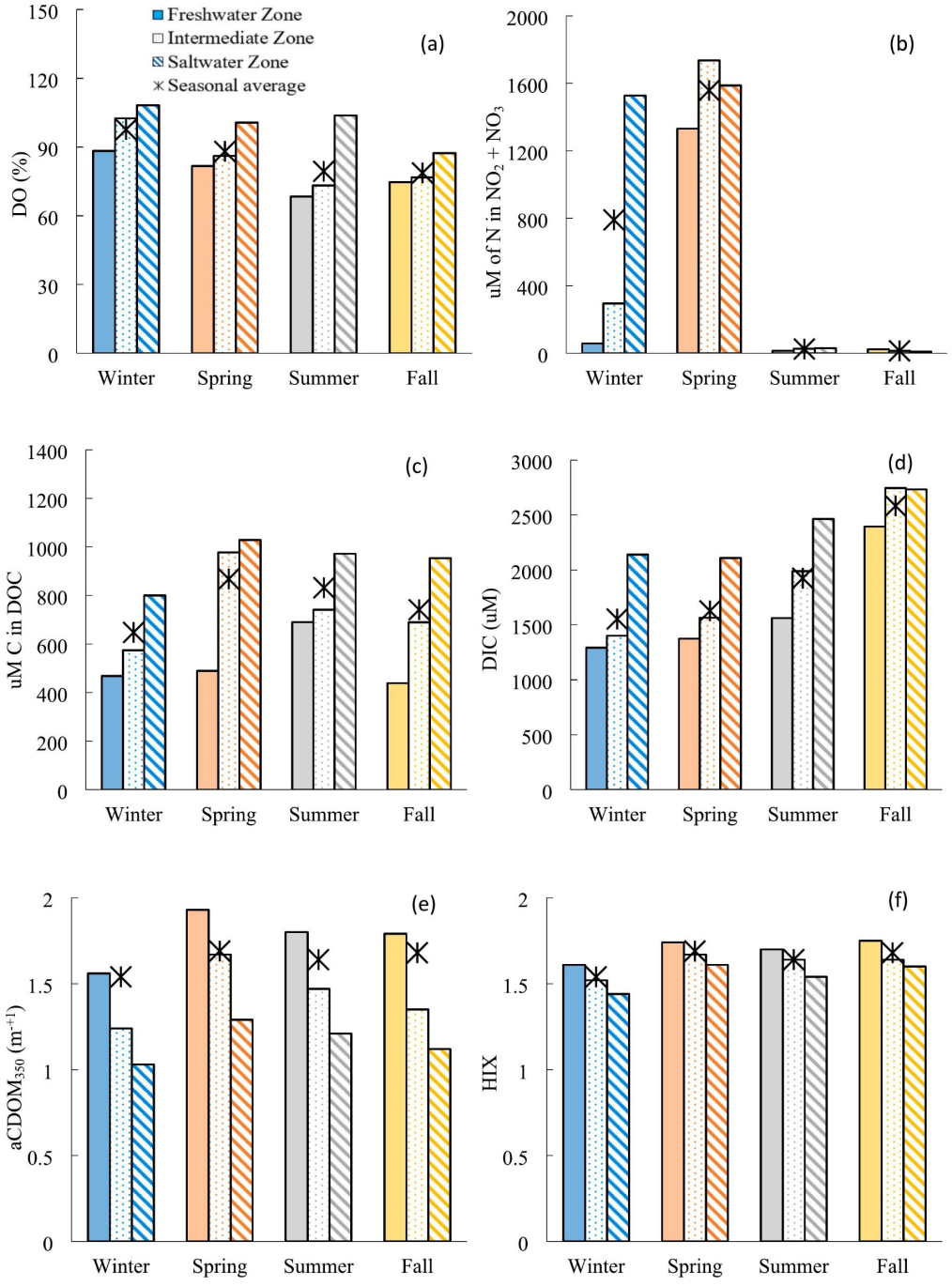
Correlation analysis



X = statistically significant at 0.05 level.

- ❑ Samples from different salinity regions can be distinguished by PC1.
- ❑ PC2 mainly separated the seasonal observations.
- ❑ Highest positive correlation among DOC, aCDOM (350).
- ❑ HIX which are negatively correlated with salinity.
- ❑ Significant positive correlation between salinity and DIC and these are negatively correlated with N+N.

Teasing out the seasonal distribution pattern across the basin



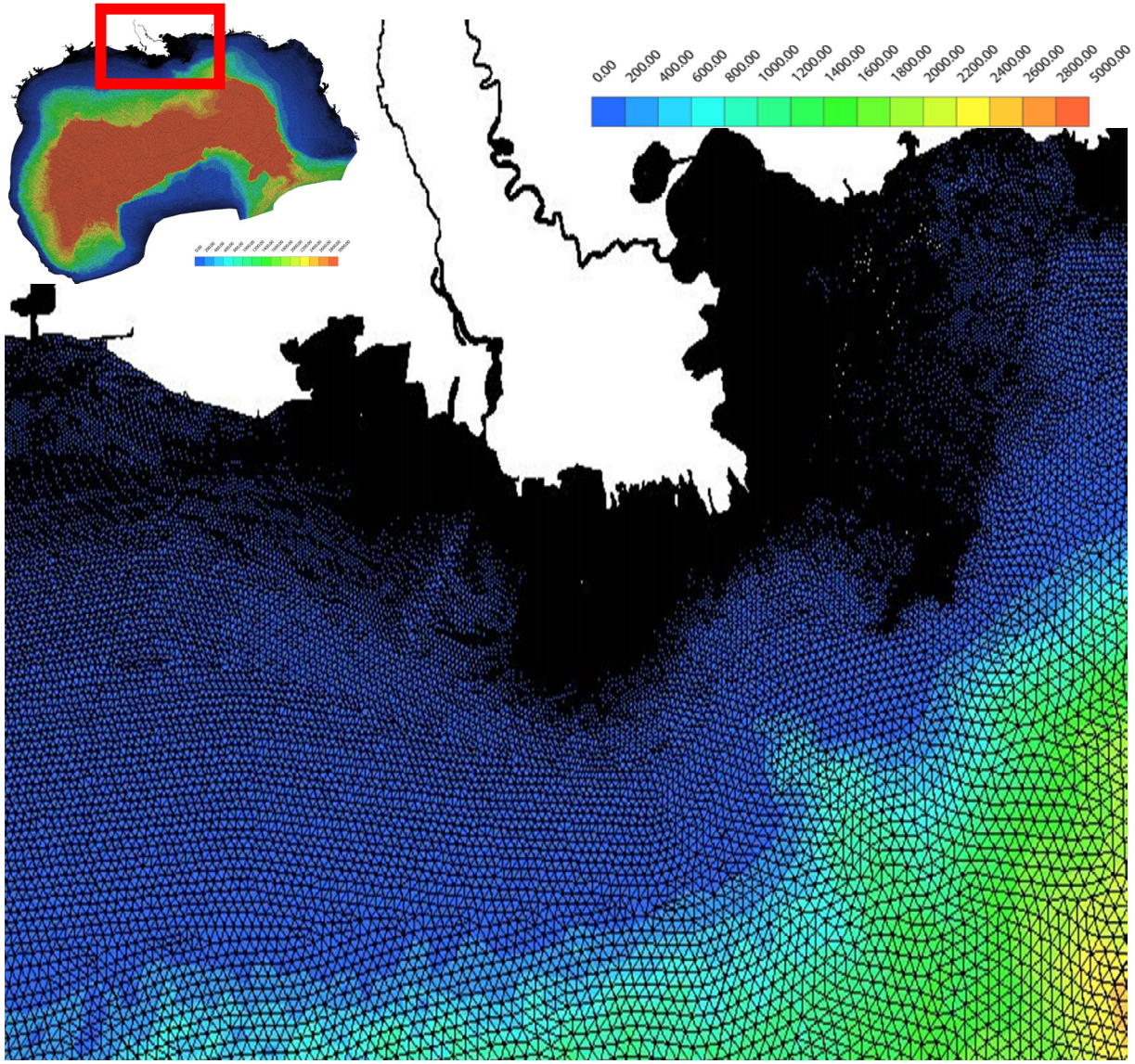
Based on PCA analysis the basin can be divided into three salinity zones –

(i) *freshwater zone* (BT 18 to BT 13) = solid bar

(ii) *transition zone* (BT 11 to BT 7) = dotted bar

(iii) *saline water zone* (BT 5 to BT 1) = hashed bar

Transport model



The model domain covered the entire Gulf of Mexico and was run for the period of Dec. 1, 2020, to Dec. 30, 2021, with 150 seconds time step.

Hydrodynamic modeling (SCHISM 3D computer simulation model) → Computation of water transport at BT 1

Seasonal DOC export to NGOM from the Barataria pass = Multiplying with the DOC concentration at BT 1

Mean velocity, residence time, and discharge rate in the Barataria Basin were computed by a seamless creek-to-ocean SCHISM 3D(Semi-implicit Cross-scale Hydroscience Integrated System Model) to assess the seasonal DOC transport.

How much DOC are we talking about?

Date	Winter	Spring	Summer	Fall
Water discharge to NGOM (m^3/s)	166	371	20	418
DOC at BT 1 (mg/L)	5.9	6.29	9.29	4.54
DOC export to NGOM (tons/day)	84.62	201.62	16.05	163.96
Annual DOC export from Barataria pass ~ 43,000 tons/year				

Only 66% of water discharge occurs through the Barataria pass (Li et al., 2011)

Comparison with other major estuaries

- ❑ Chesapeake Bay ~ 10 to 15 times more water discharge than Barataria pass.
- ❑ The annual DOC export from Chesapeake Bay ~ 4 to 6 times higher compared to Barataria Bay (Signorini et al., 2019)
- ❑ The annual DOC export from Delaware Bay ~ 2 times higher compared to Barataria Bay (Signorini et al., 2019)

Comparison with the Mississippi River

- ➢ Annual DOC exports from the Mississippi River ~ 1.88 to 4.5 million tons/year (Cai et al., 2015, Reiman and Xu 2019, Potter and Xu 2022).

Conclusions

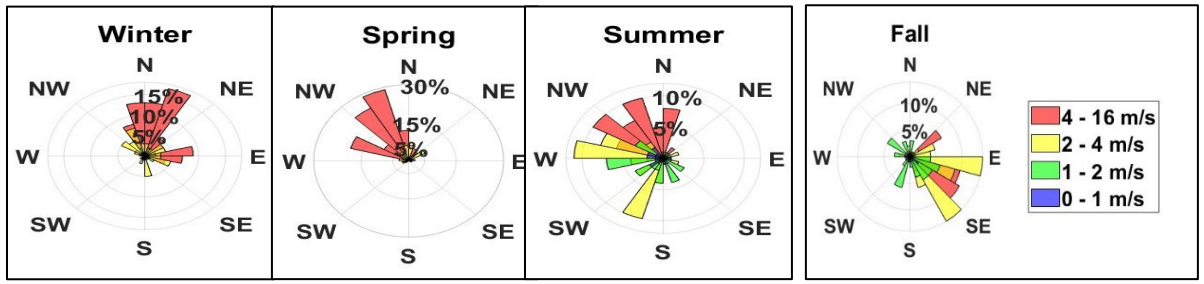
- Seasonal DOC and DIC concentrations across the Barataria Basin are influenced by freshwater input from Davis pond diversion and terrestrial carbon input from adjacent marshes.
- Terrestrial organic matter (OM) input and residence time impact the seasonal DOC transport into the northern Gulf of Mexico (NGOM).
- The annual DOC export from Barataria Pass ~ **43,000 tons** which is equivalent to CO_2 emission from around 40 thousand cars per year.
- Better understanding is required on the fate of this large amount of estuarine DOC export to the ocean globally.

Special thanks to –

Sean Gordon
Songjie He
Matthew Parker
Eddie Weeks

This research was funded through NOAA Ocean acidification program and NASA carbon cycle program.

Wind



Environmental condition on the sampling days in the Barataria Basin, Louisiana in 2021