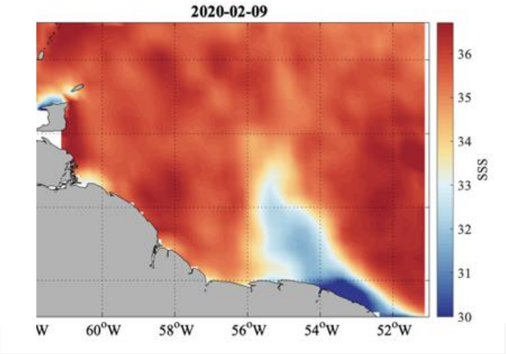


Fresh water plumes of Amazon water in boreal winter: impact on stratification/CO2fluxes

(EUREC4A/ATOMIC)

G. Reverdin, L. Olivier, G. Foltz, S. Speich, J. Karstensen,
J. Horstmann, D. Zhang, R. Laxenaire, X. Carton, H. Branger,
R. Carrasco, J. Boutin, R. Wannikhof

https://doi.org/10.1029/2020JC016981

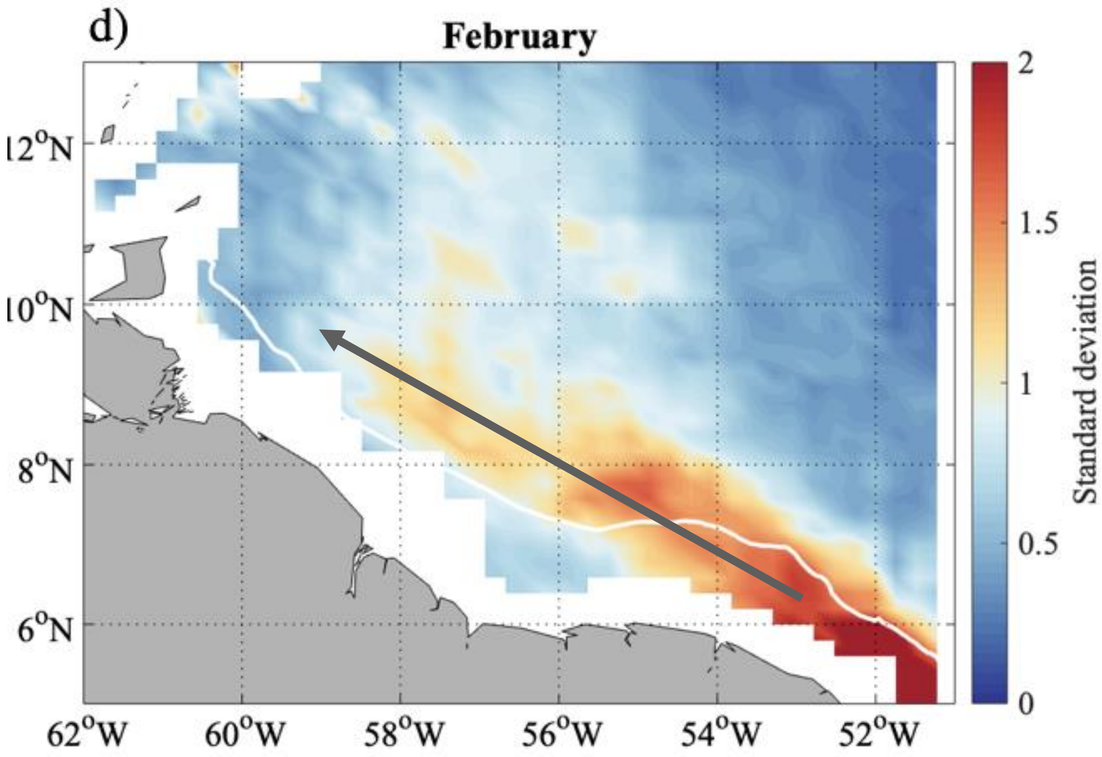
Mean seasonal situation in February (boreal winter)

- January to March -> season of maximum salinity
- Average outflow of the Amazon and most other rivers
- Freshwater transport takes place mainly on shelf/shelf-break

- Occasional freshwater transport from the shelves?

  - How common?
  - Does it affect stratification?
  - Air-sea pCO2 fluxes?

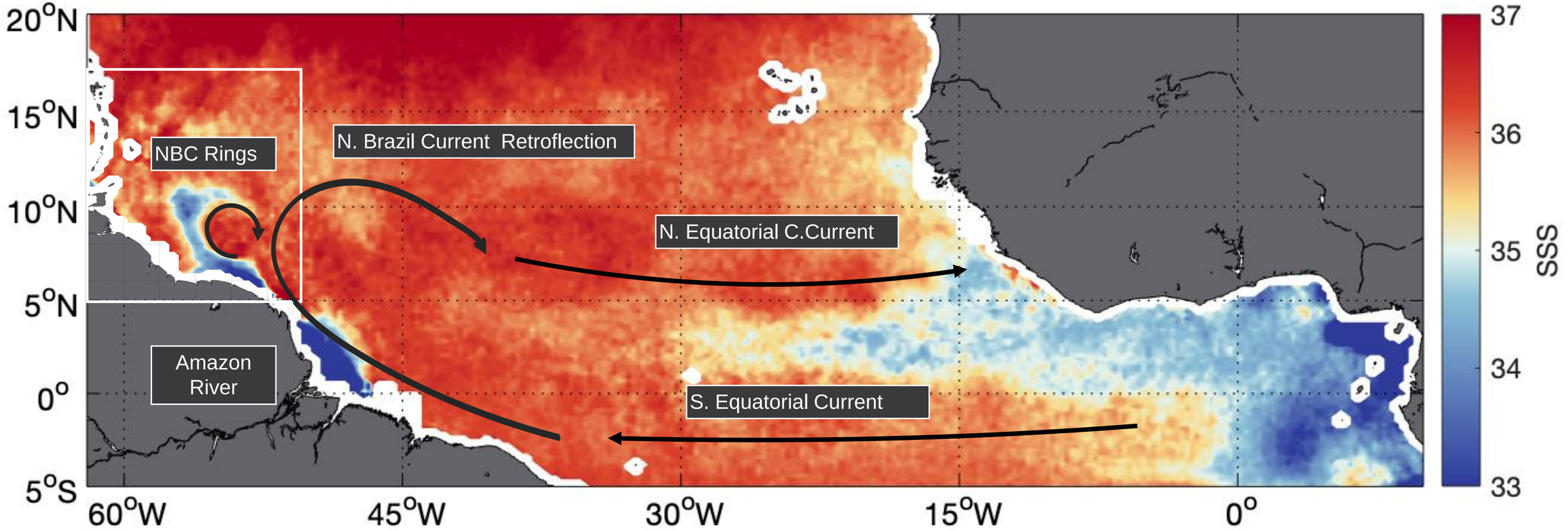
CCI+SSS std from 2010-2019



From Reverdin et al., 2021

From the Equatorial Atlantic circulation to NBC rings formation in the North Western Tropical Atlantic

- North Brazil Current Rings (NBC rings) : formed by the NBC retroflection
  travel northwestward toward the Caribbean
  can advect fresh water from the Amazon river plume



CCI+SSS 8 Fev2017

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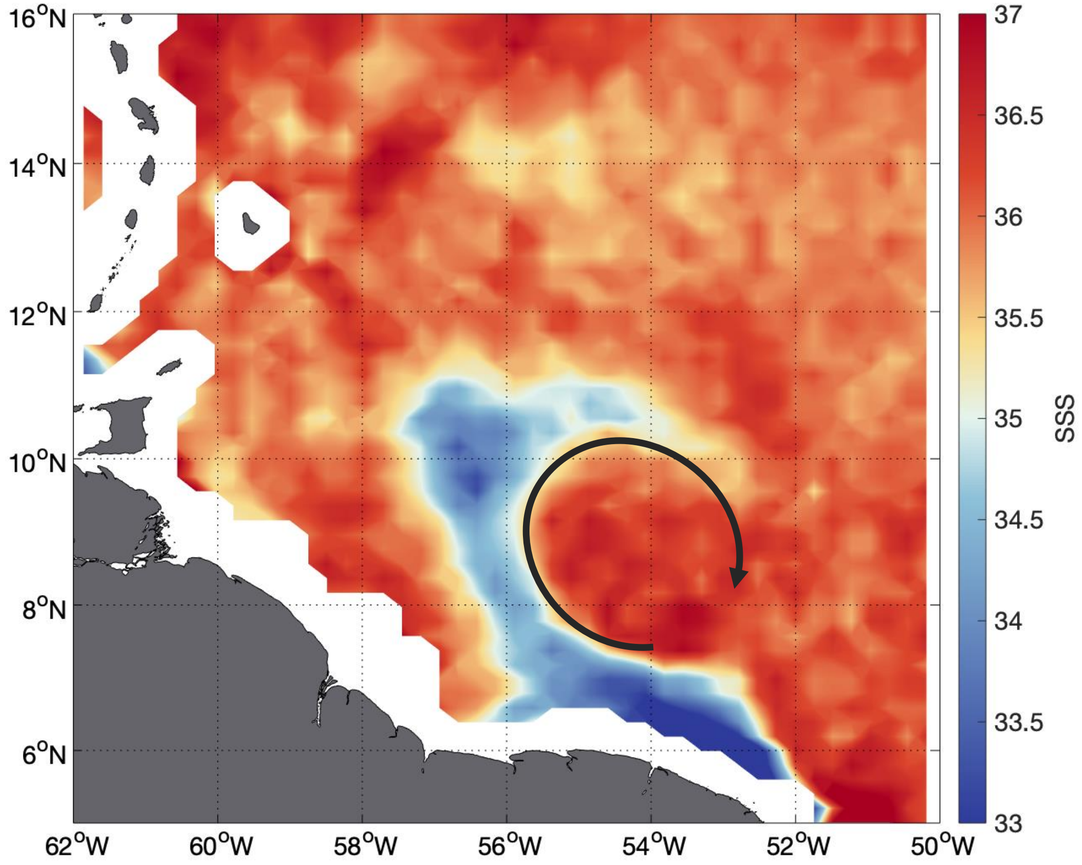

Two scales:

- North Brazil Current Rings (mesoscale)
- Fresh water filament (sub-mesoscale)

EUREC^{4}A/ATOMIC in situ data

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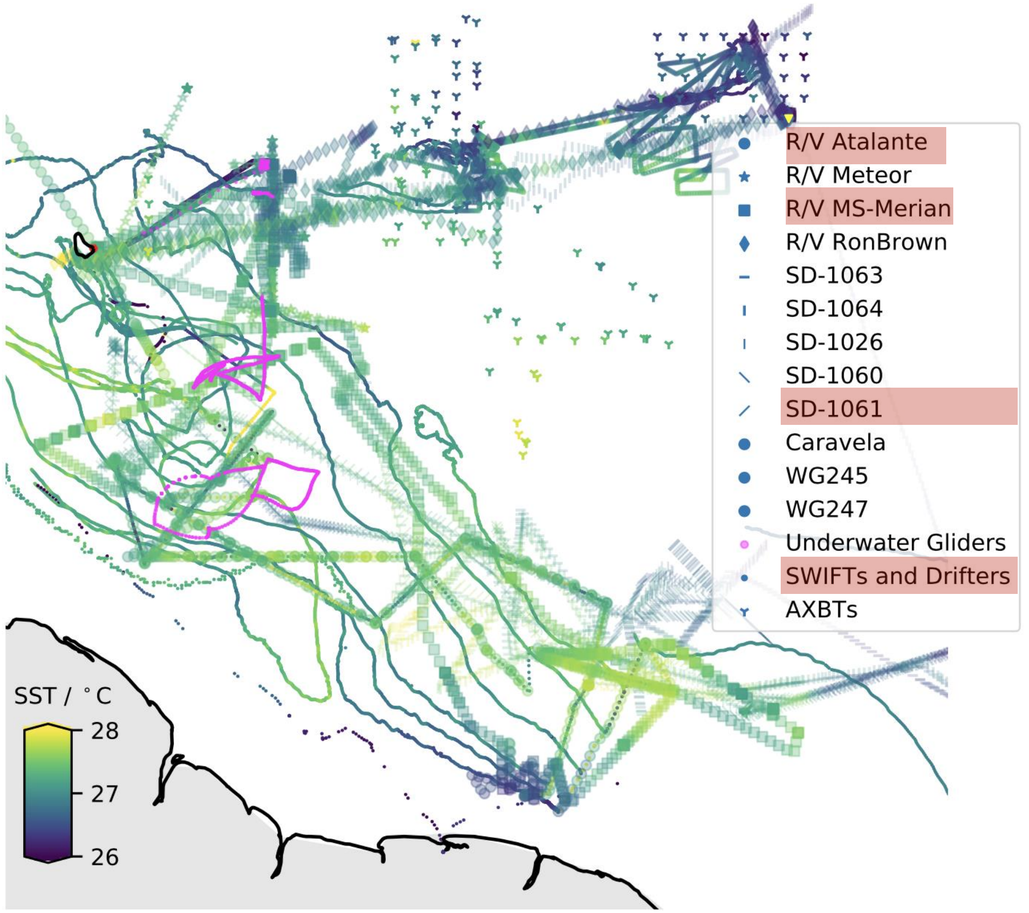
EUREC^{4}A-OA/ATOMIC cruises
01-02/2020

R/V Atalante & MS-Merian, Ron Brown, Meteor

- TSG
- Underway pCO2
- ADCP
- uCTD/MVP

SVP Drifters (T & S at 20 cm, 5 m, 10m)

Saildrone (T, S, wind, currents)



From Stevens et al., 2021

Satellite data/products

Daily Chlorophyll-a (CLS, 0.02°)

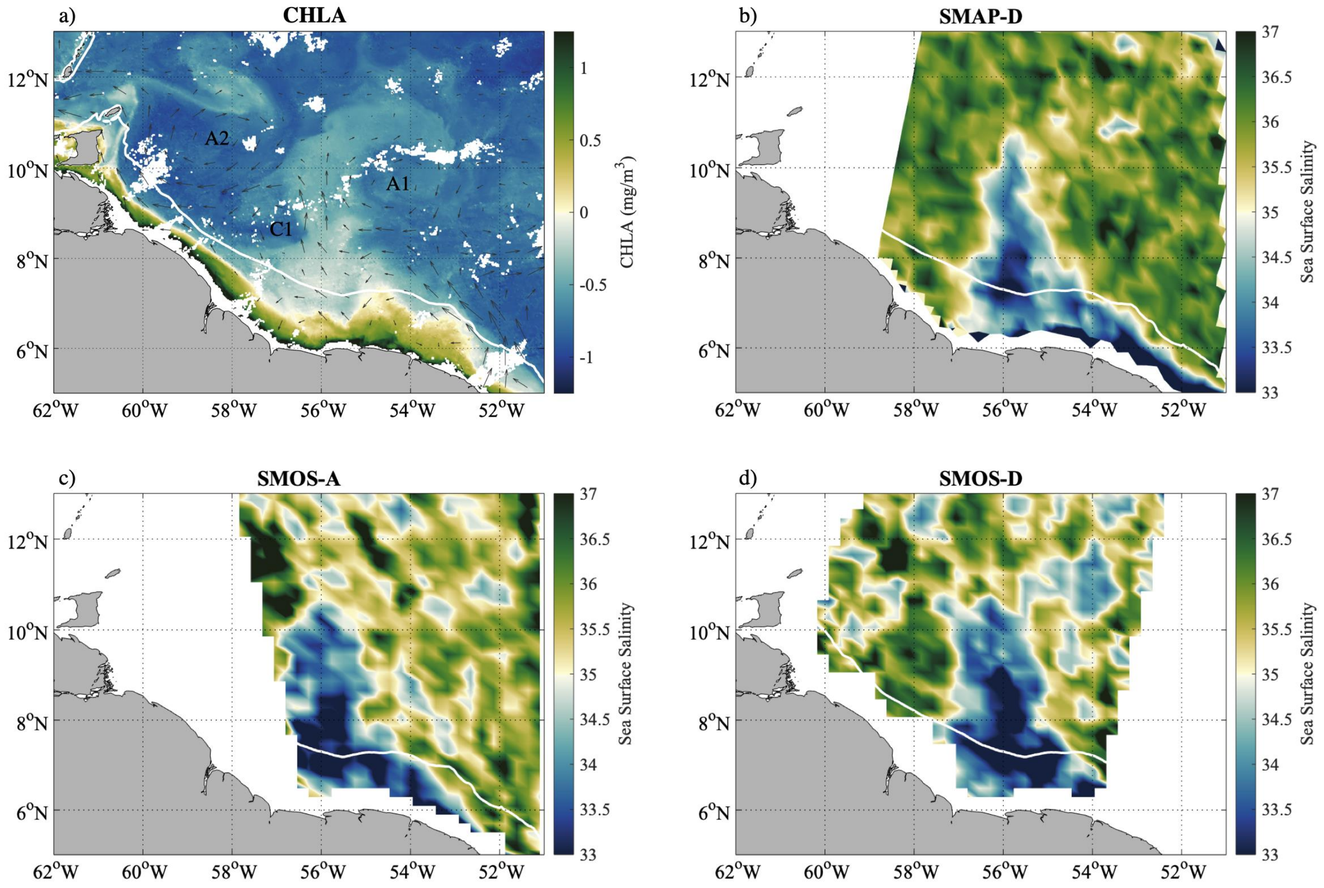
Daily SMAP and SMOS combined SSS (70km)

Daily SST (CLS, 0.02°)

Daily Winds (CERSAT)

ADT-currents from altimetry (CLS, 0.25°)

CCI+SSS (50km)



02/12 From Reverdin et al., 2021

Mesoscale structures in Feb. 2020

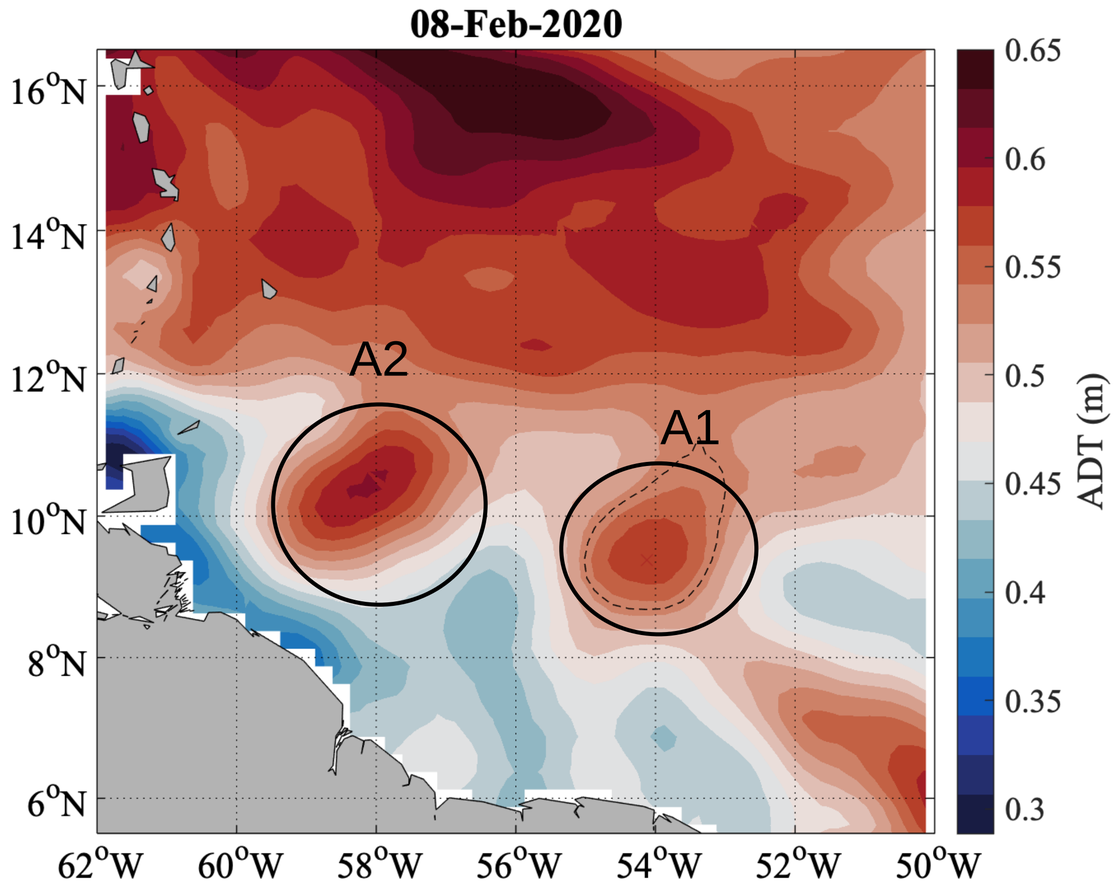
Anticyclone A2

Centered around
58°W-11°N

Anticyclone A1

Centered around
54°W-9°N

Separates from the retroflection around the 1st of Feb



Submesoscale structures in Feb. 2020

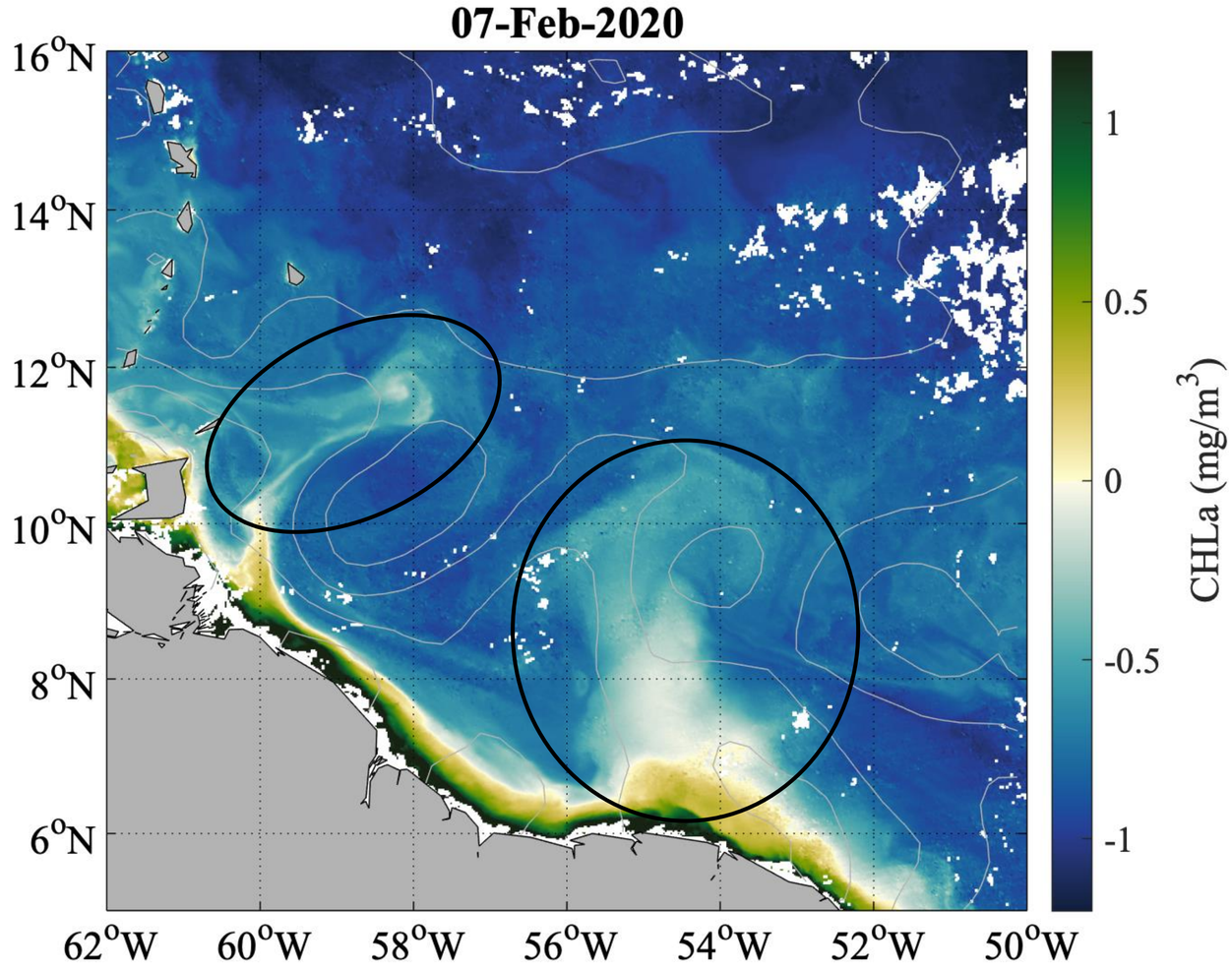
Submesoscale filament steered by A2

A2 centered around
58°W-11°N

Mesoscale plume steered by A1

A1 centered around
54°W-9°N

Penetrates offshore from the shelfbreak in early February, and associated with ‘freshwater plume’



The life of the freshwater plume

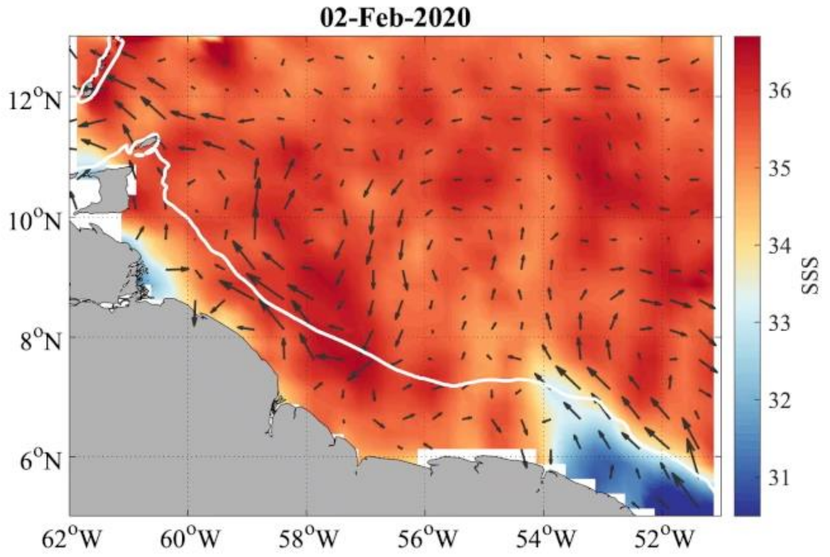
Forms on February 2d

Stirred by Anticyclone A1

Channeled on the west by Cyclone C1
then Anticyclone A2

Separation from the shelf around February 14

Salinity minimum eroded in time, but still visible until the 19



Freshwater plume

Atalante/MSM sections across the plume

Plume width ~120km

- But on 02/02 with front of more than 1.2 pss, probably less than 100m wide

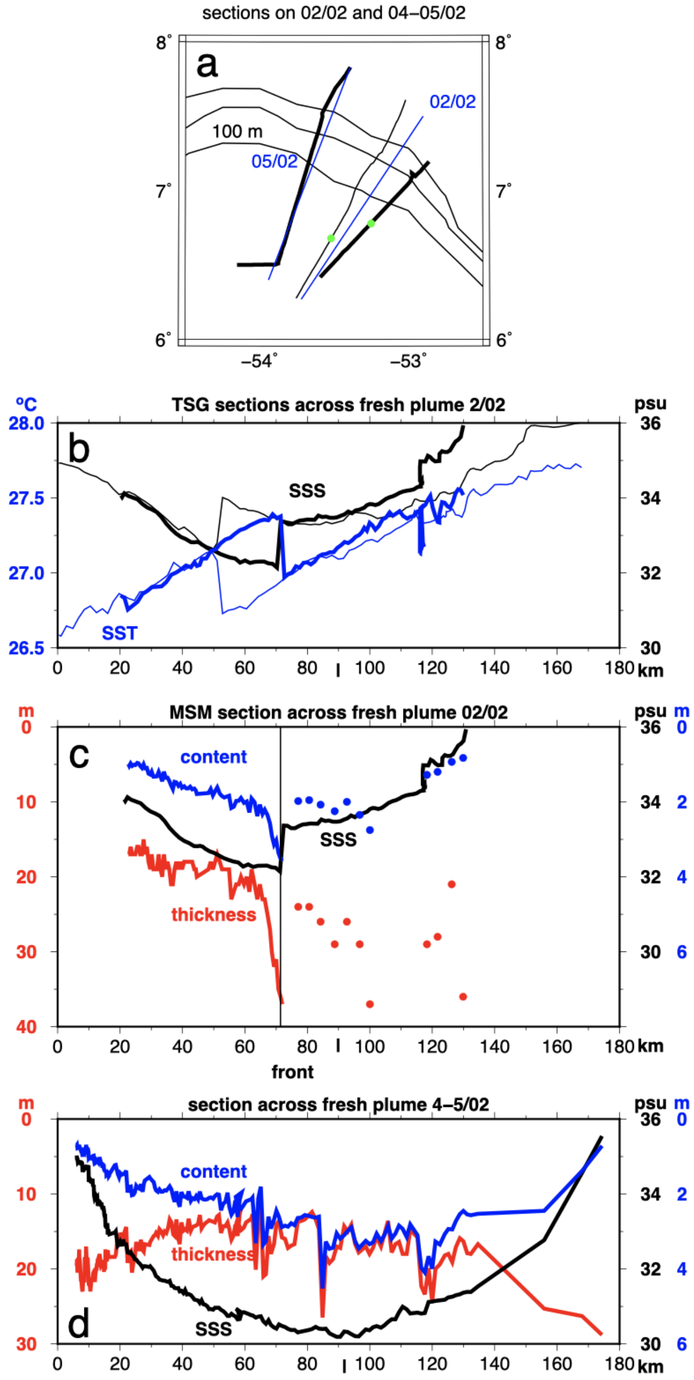
Thickness of Fresh layer (red) : depth of the isohaline 0.5*(36.4 + SSS) (fractions of surface and subsurface waters are equally mixed, 36.4 pss was a typical subsurface salinity near 50 m)
Freshwater content (blue) : vertically integrating the salinity profiles assuming mixing of fresh water with salty water at 36.4 pss.

Freshwater content mainly distributed in the top 20m; MLD ~10m

On 17/02, MLD in plume (33.5) still ~20m

Indirect estimate from shear (saildrone)

whereas background MLD= 45m



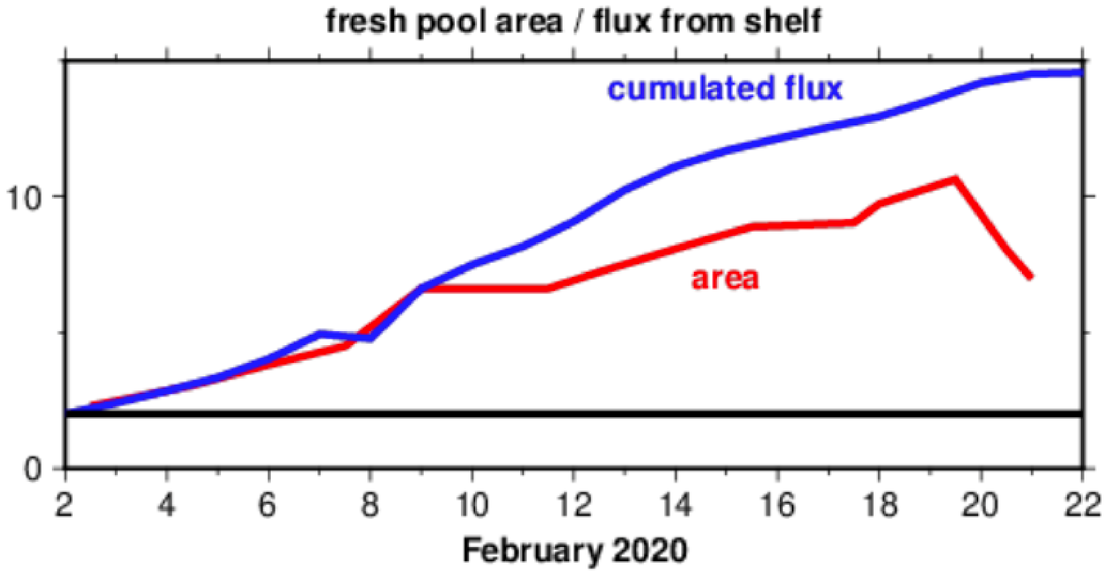
From Reverdin et al., 2021

Advective budget

Maximum area (s<35 pss, offshore of 100m isobath) : 100 000 km2

Total area transport driven almost equally by Ekman and geostrophic advection until the 11th (Ekman afterwards)

Flow of freshwater : 0.15 Sv from the 2/02 to 11/02



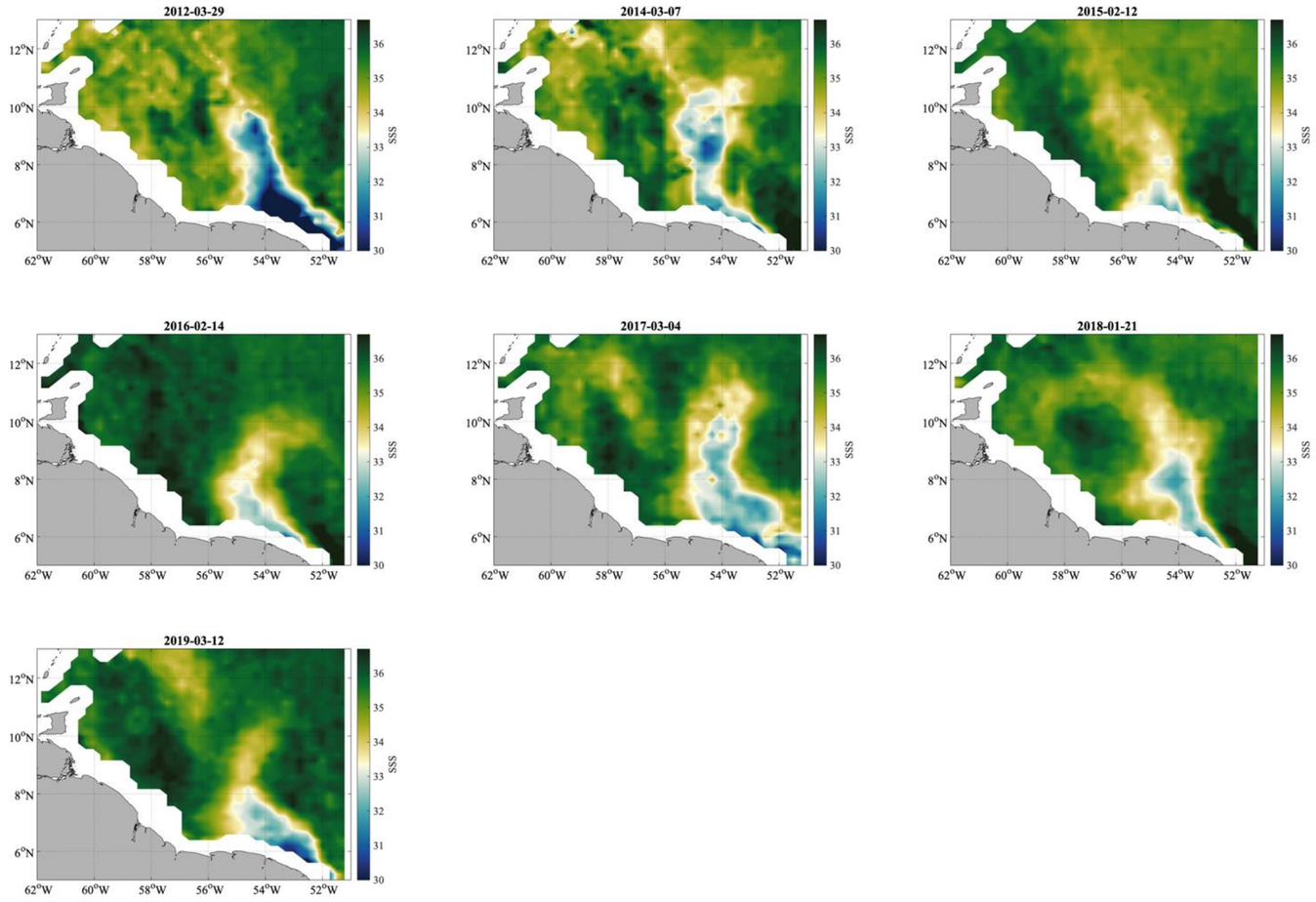
From Reverdin et al., 2021

Freshwater plume

Frequency of such February plumes

- 7 out of 10 years

- 6 years out of 7 plume years, the freshwater event is preceded by an event of along-shore winds (close to equator-5°N)



Signature in pCO2 of mesoscale structures

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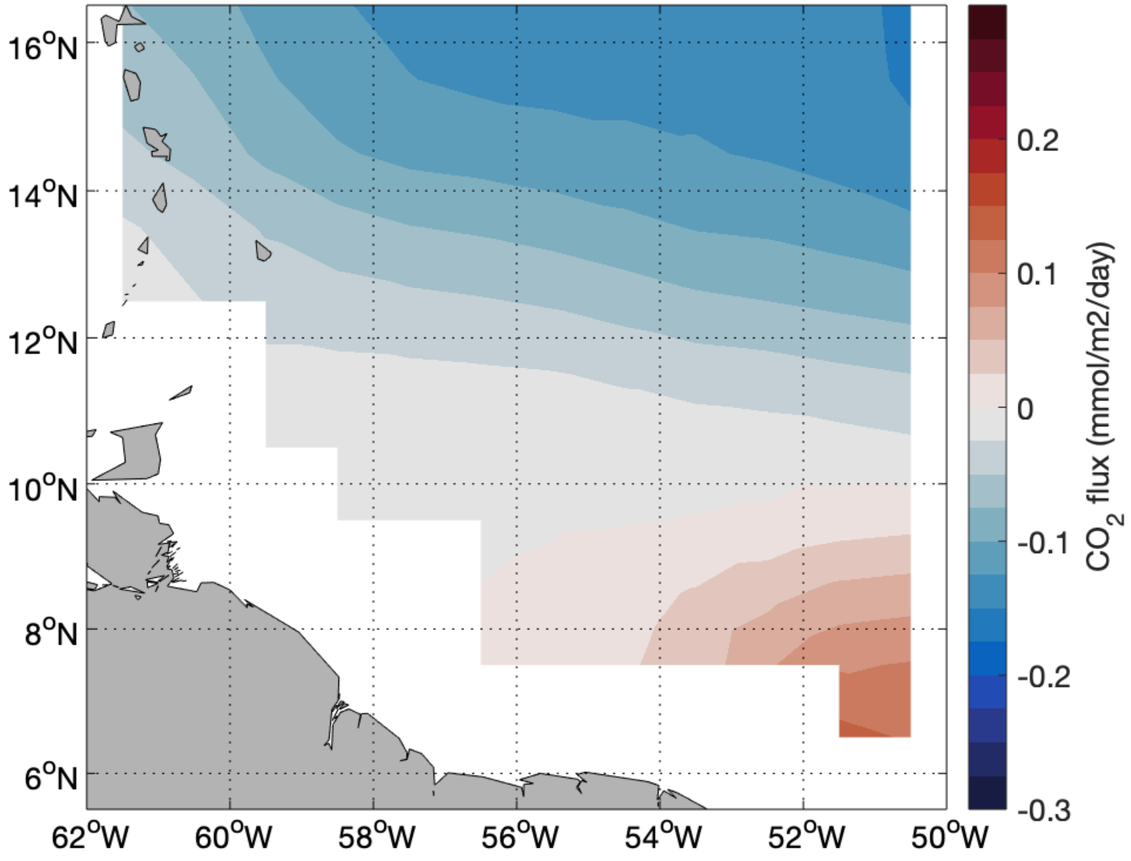
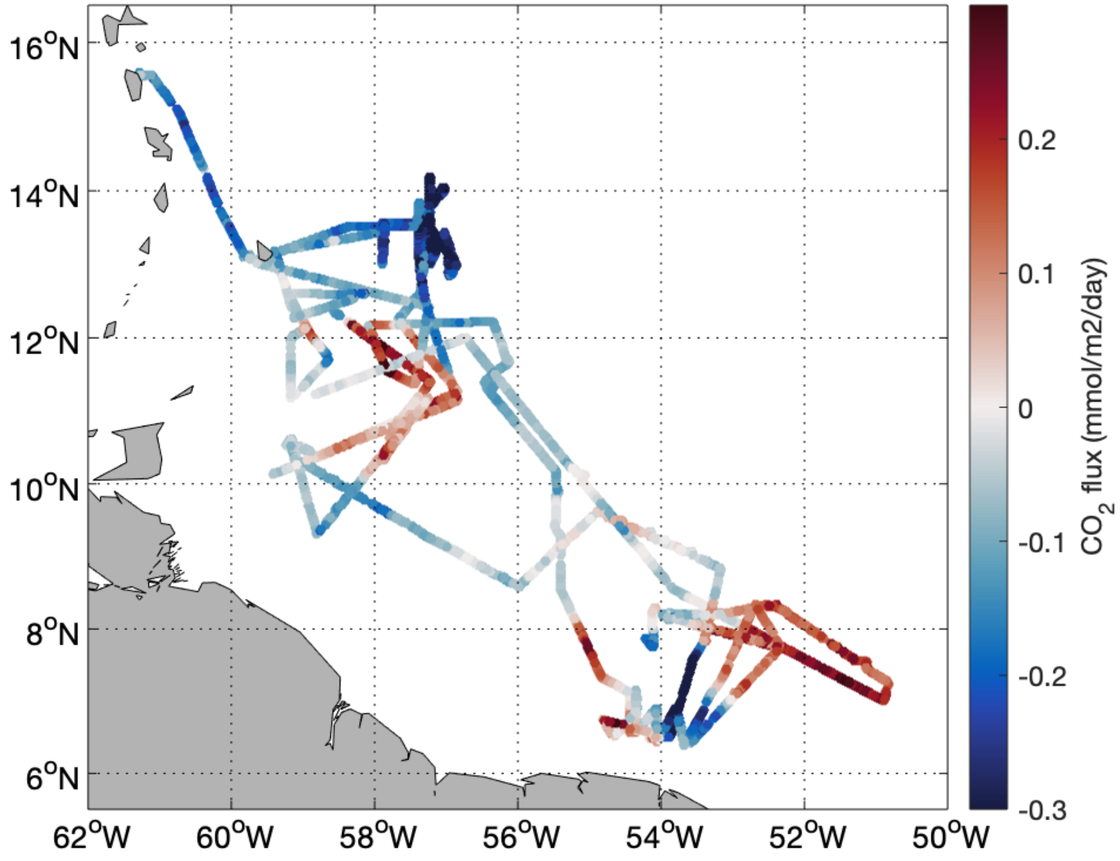
February air-sea CO2 flux climatology



Landschützer et al., 2017

R/V Atalante and Merian data



Freshwater plume

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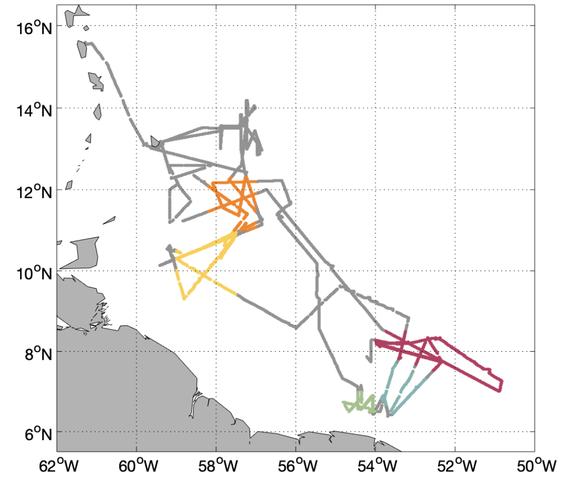
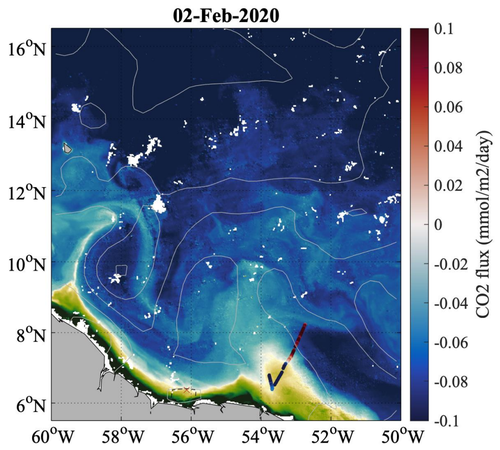
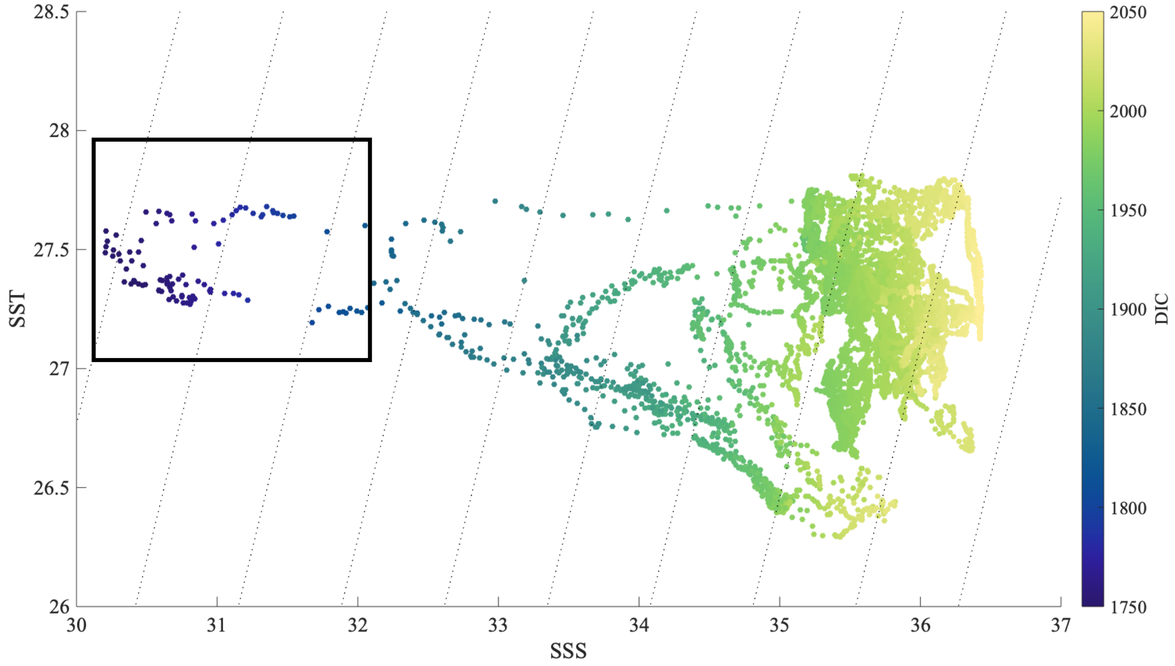






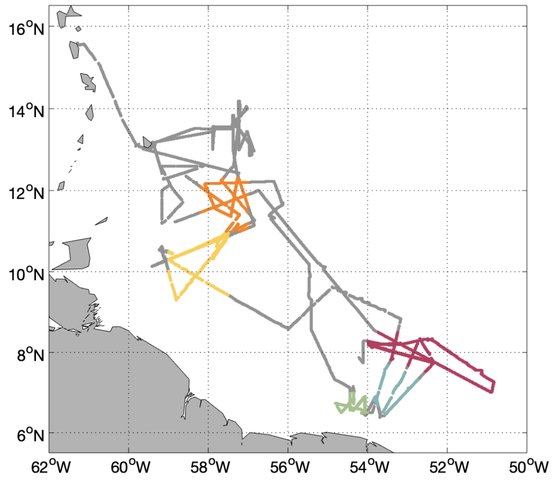
Freshwater plume

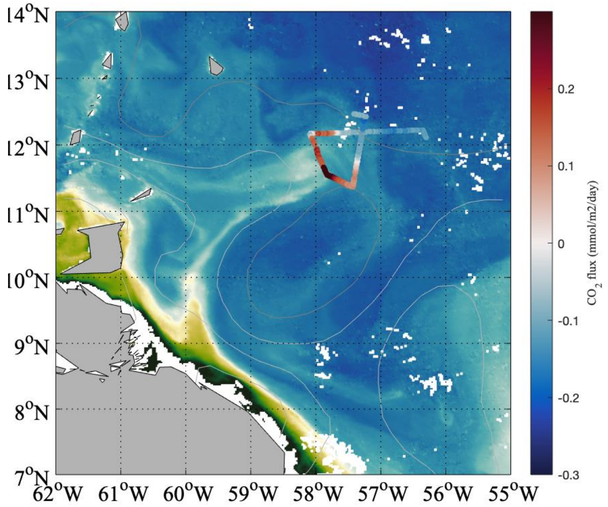
Low salinity and low DIC

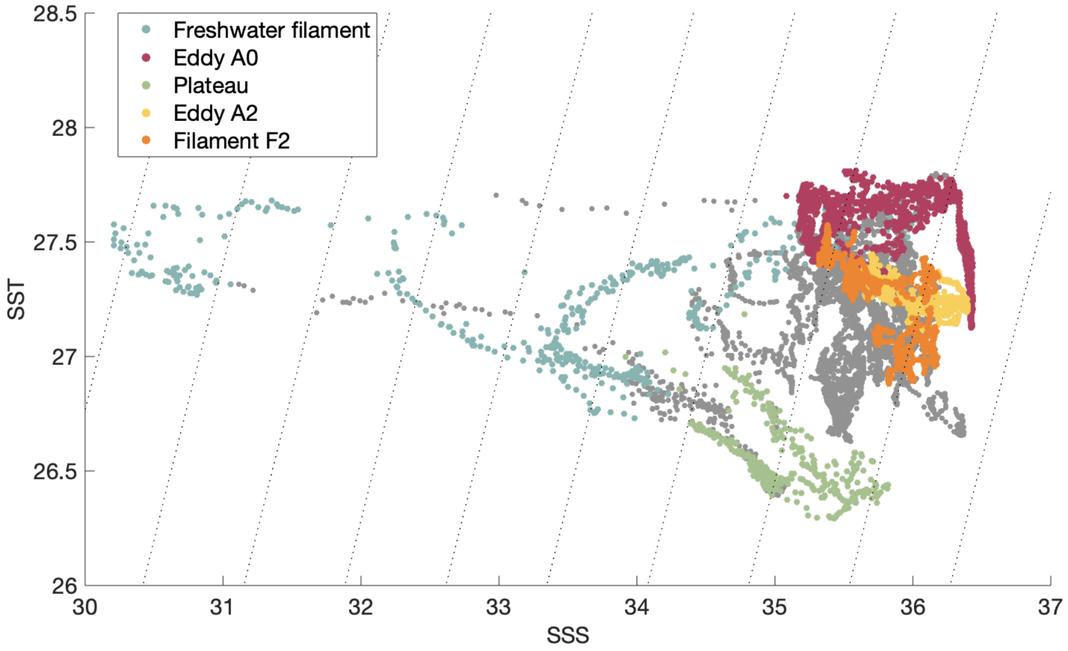
Waters from the Amazon river, rich in chlorophyll /colored matter
High TA/DIC

Strong oceanic sink of CO2

Filament - F2







Filament F2 north of A2

High chlorophyll, high DIC, relatively colder and saltier

Strong source of CO2

Shelf water rich in organic matter and DIC steered by anticyclone A2

Conclusions

Fresh water plumes in February :

- isolated, but not uncommon events (~1/ year in Feb/March)
  2020 EUREC4A/ATOMIC event:
  - Lasts ~20 days
  - Minimum salinity of 30 pss
  - Air-sea fCO2 of 70 microatm
  - After 14 days, reaches an extend of 100 000 km^2
  - Very stratified; small MLD

CO2 variability :

Strong influence of mesoscale structures :

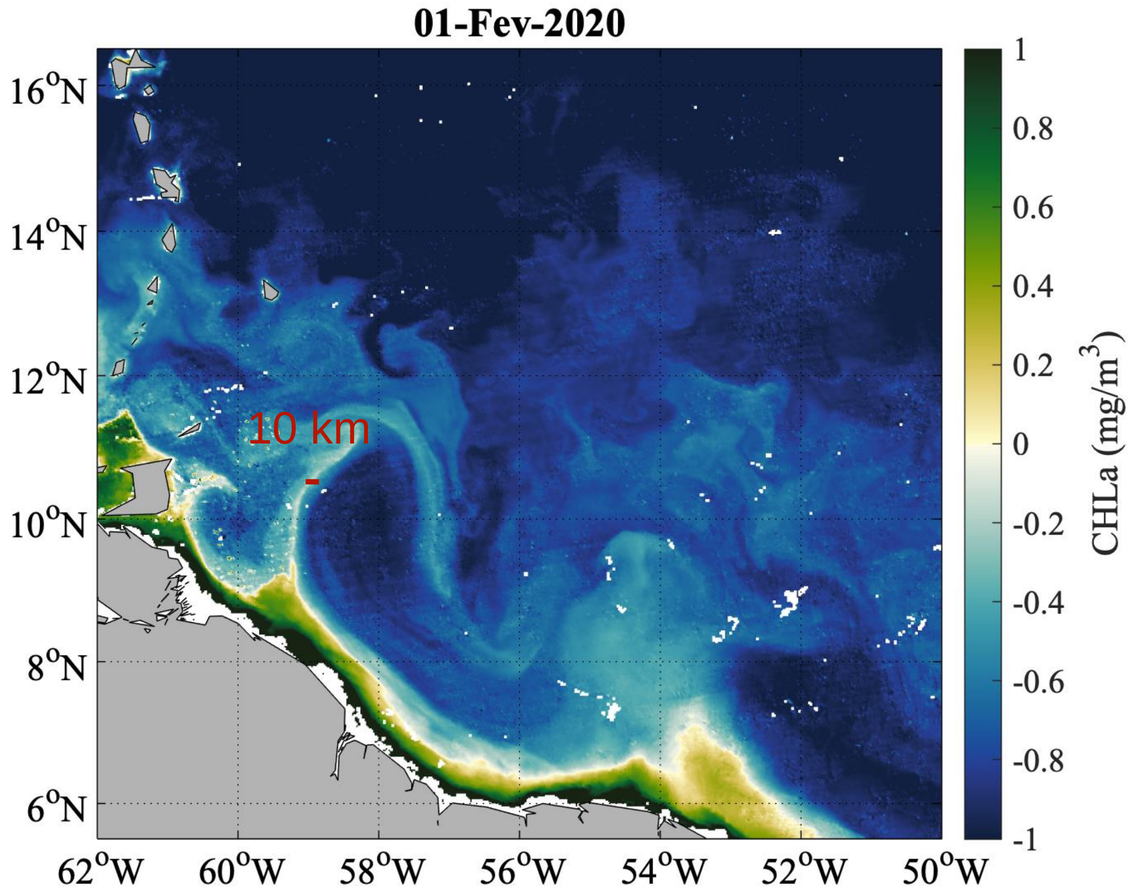
- Anticyclonic eddies rich in surface DIC,
  but signal eroded over time
- Eddies steer filaments, that can either act as a strong sink of source of CO2 depending on their origin
- Other seasons will have very different behavior
(aging of surface water, stratif, productivity; SST/SSS)

https://doi.org/10.1029/2020JC016981

Conclusions

Limitations :

- 50 km SSS provides a good characterization of mesoscale structures but is not sufficient for all submesoscale structures
- CCI SSS products still have some issues of inter-satellite calibrations (thus, interannual variability)
- Chla has a resolution more adapted for finer scale, and TSG data suggest also a signal in salinity, but not captured by the satellite products



Perspectives

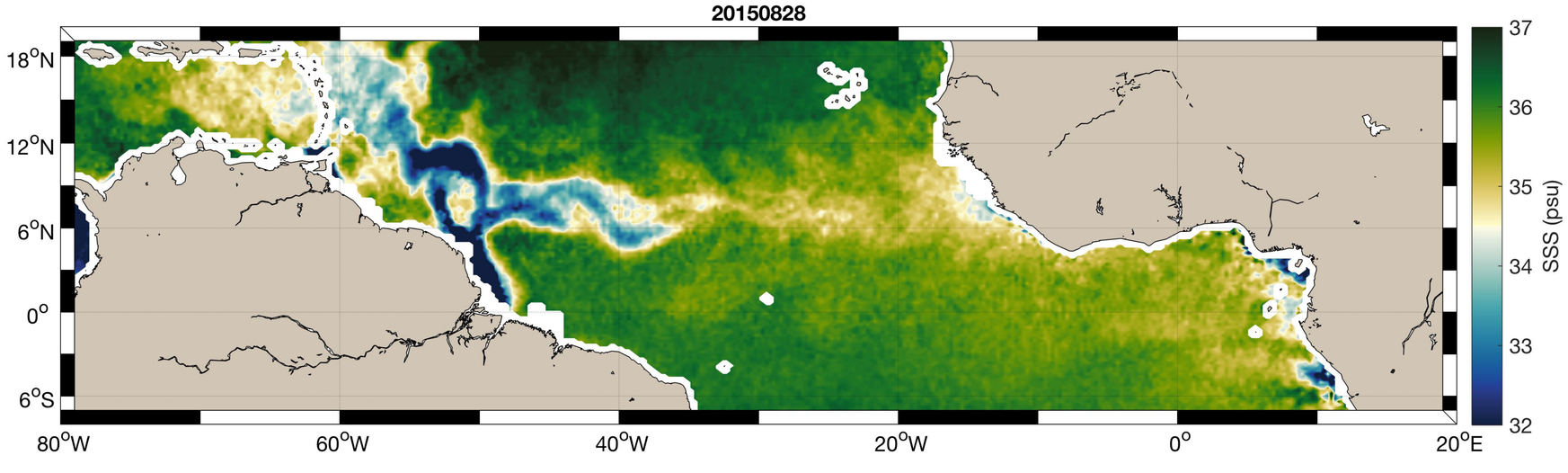
Further investigations of seasonal variability (but also see Anacondas results):

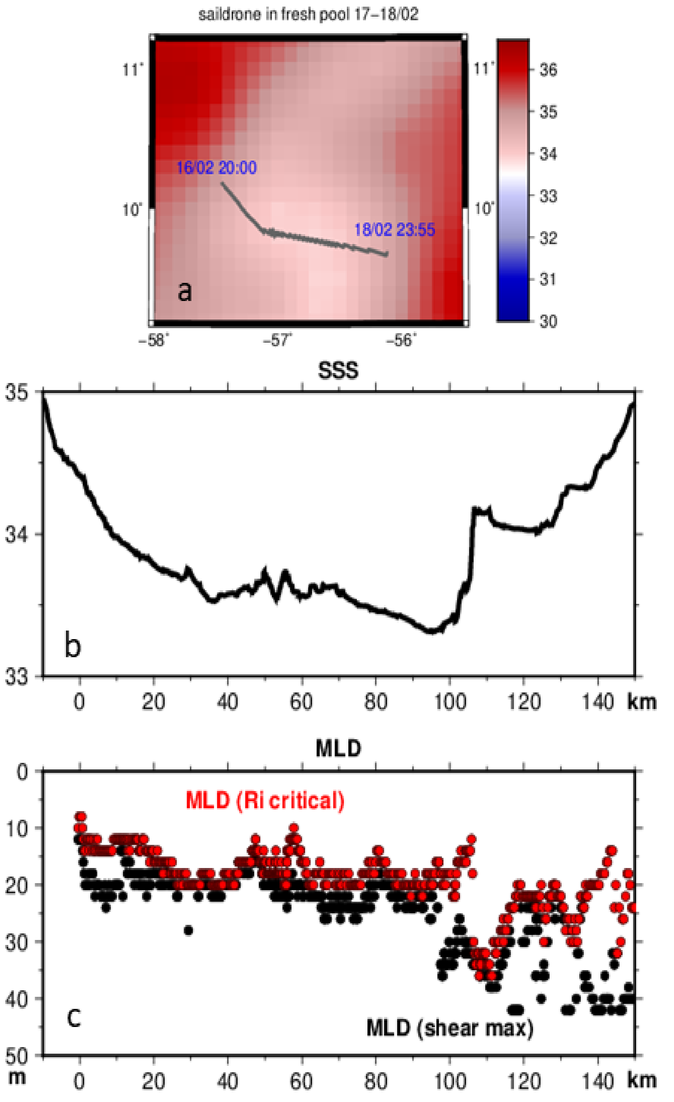
- Tara Microbiomes: end of July – September 2021

  Focus on individual NBC rings, NBC retroflection and Amazon Plume

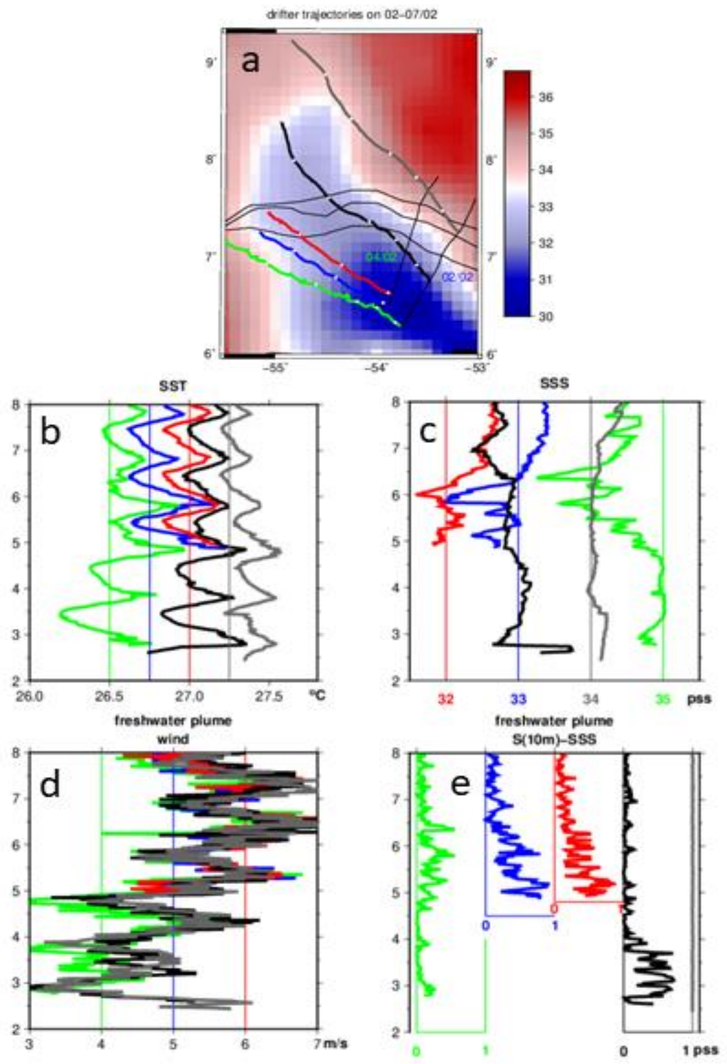
- Amaryllis (Marion Dufresnes): May - June 2022

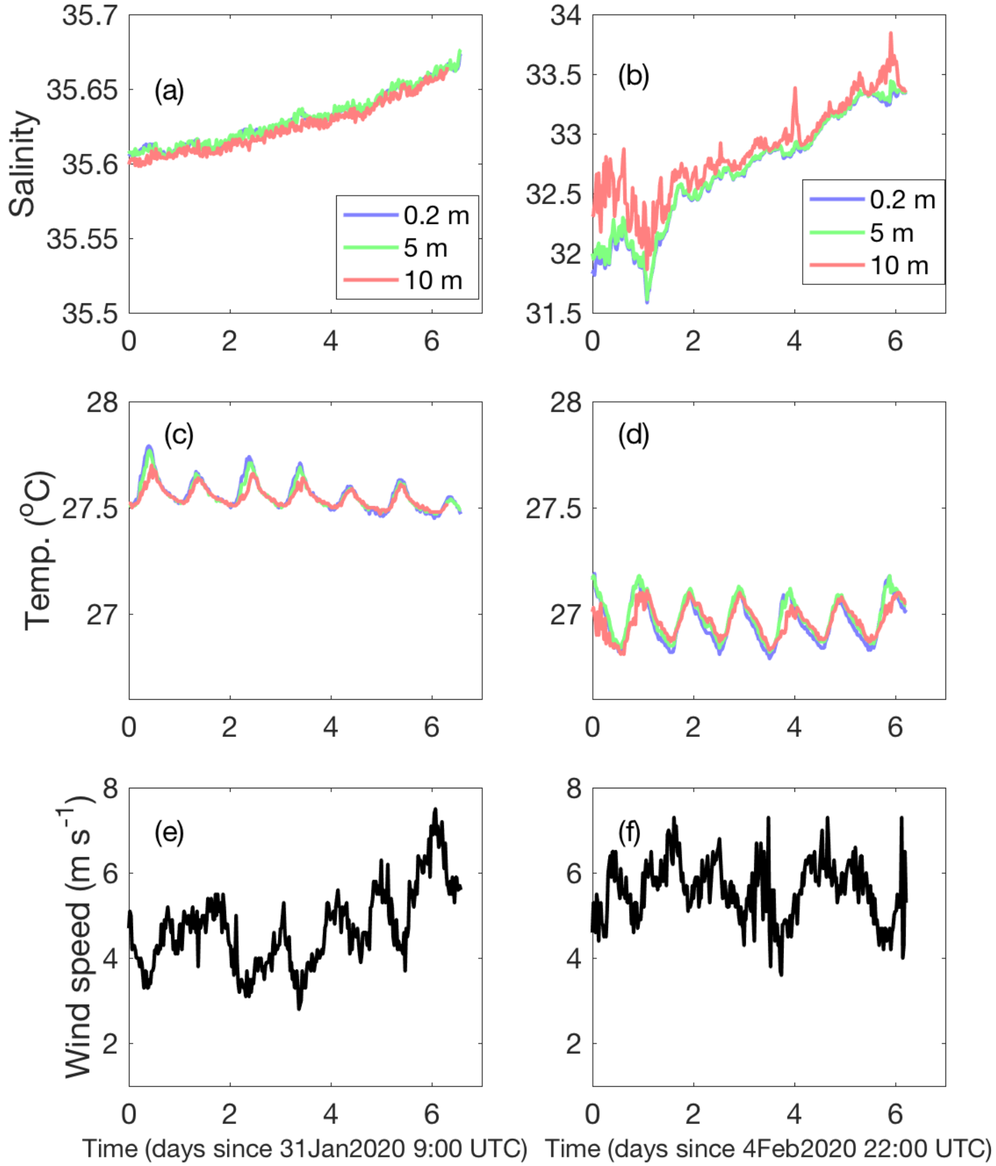
  Focus on the shelf break and slope near French Guyana and near the equator





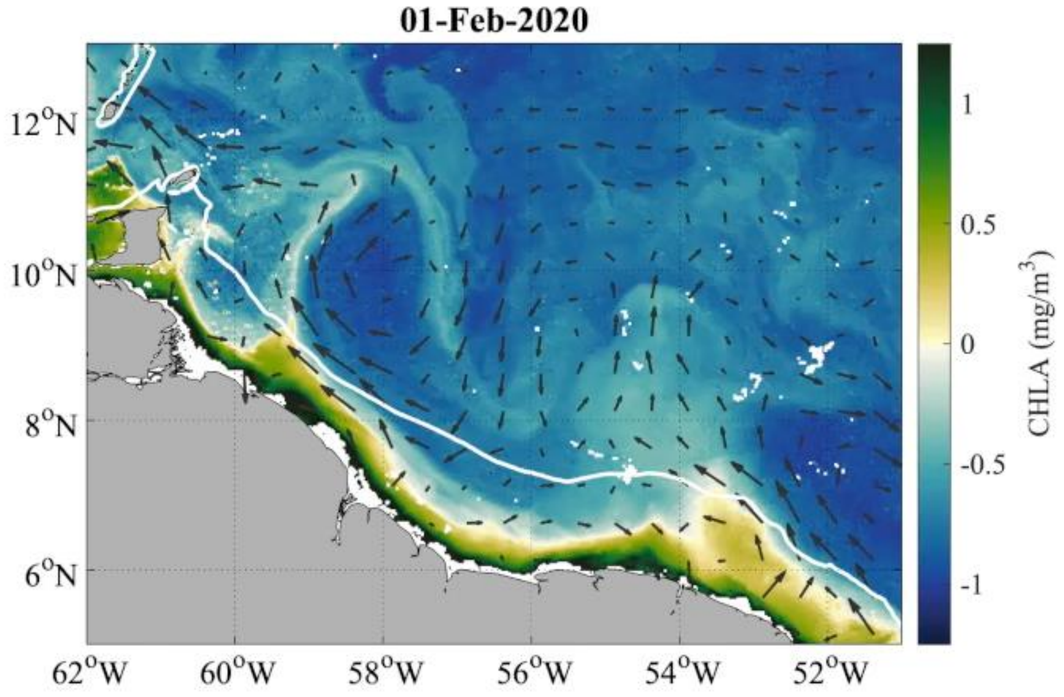
Saildrone section 17/02





Drifter-based stratif and daily cycle

Submesoscale structures in Feb. 2020



Mesoscale structures in Feb. 2020