CLIMATOLOGY OF SALINITY FRONTS IN THE TROPICAL ATLANTIC OCEAN

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INTRODUCTION

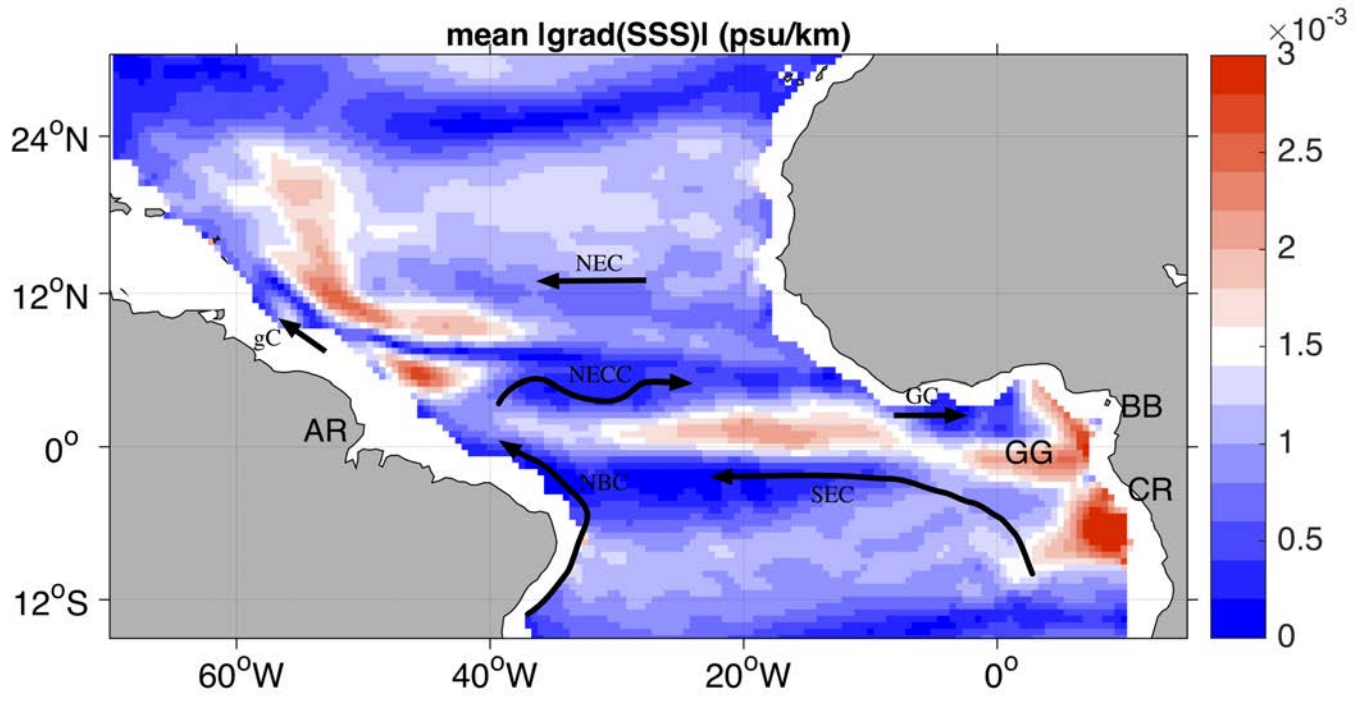
Front

What is a marine front?

Why are important the frontal systems?

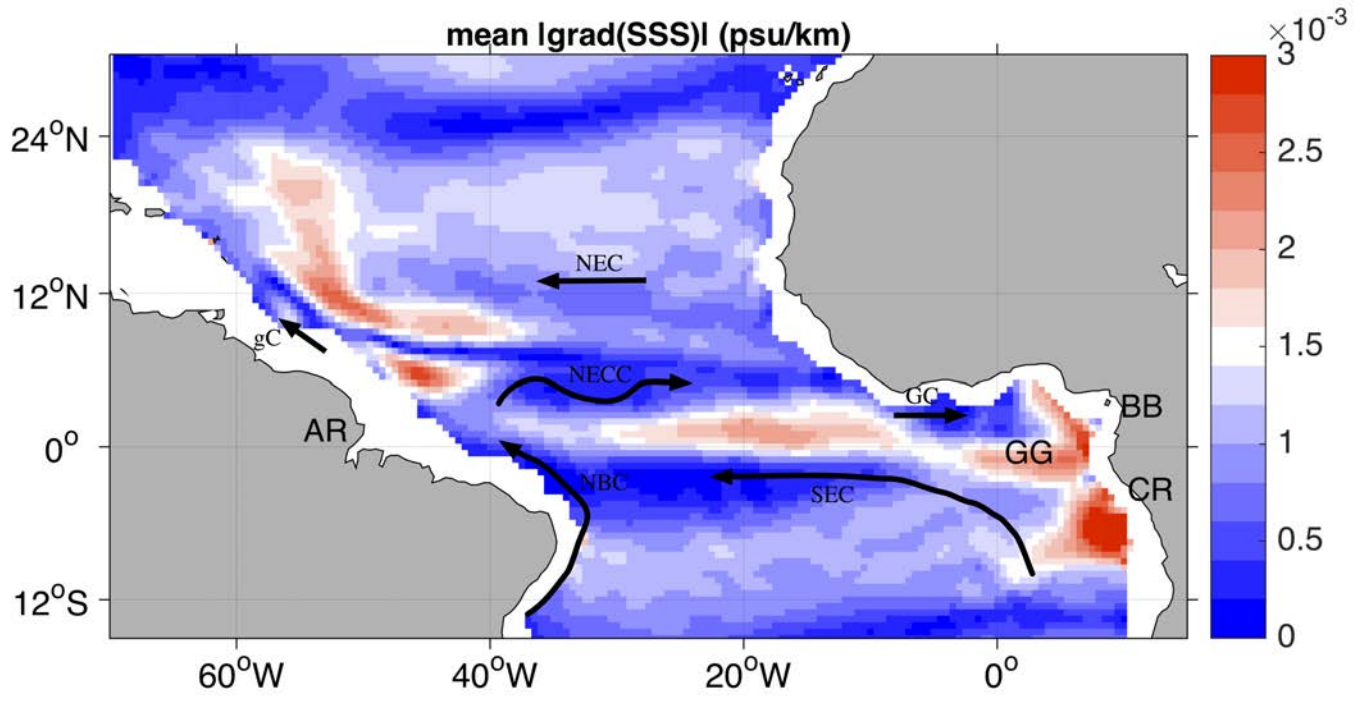
- Primary and secondary production.
- Air-sea interaction

WHY THE TROPICAL ATLANTIC?



- It plays an important role in the hydrological cycle.
- Fresh water sources: Amazon river, Congo river, precipitation ITCZ

WHY THE TROPICAL ATLANTIC?



Objectives:

- study of the temporal/spatial variation of the salinity fronts with Aquarius data.
- Analysis of the importance of the SSS gradients in the density

DATA

- Sea Surface Salinity (SSS) from Aquarius, 3 years (1/Jan/2012-31/Dec/2014), 0.5ºx0.5º spatial resolution and 7 days temporal resolution (Melnichenko et al. 2016).
- Sea Surface Temperature (SST) from Reynolds (Reynolds et al., 2002), 3 years (1/Jan/2012-31/Dec/2014), 0.25ºx0.25º spatial resolution, daily.
- Surface velocities from SCUDS (Maximenko and Hafner, 2010)
- Argo: profiles and 3x3 bin-averaged Monthly climatology on standard levels (IPRC).

METHODOLOGY

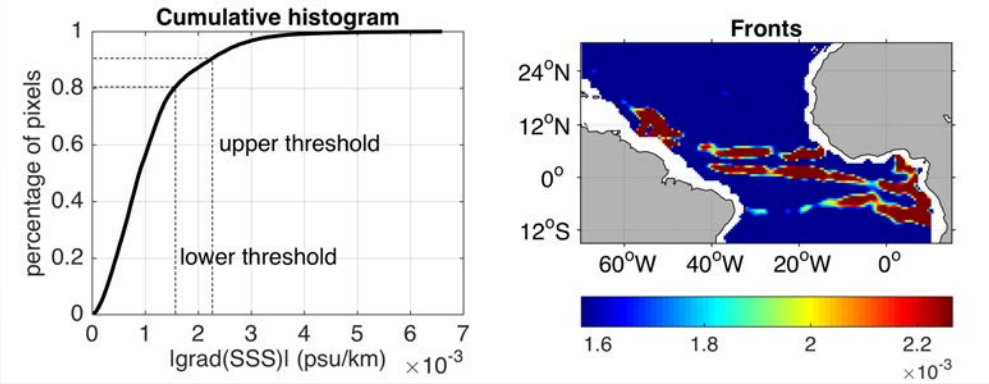
- SSS, SST and Rho fronts:

$$|\nabla F| = \sqrt{\left(\frac{\partial F}{\partial x}\right)^2 + \left(\frac{\partial F}{\partial y}\right)^2}$$

- Density ratio:

$$r = \left|\frac{\alpha \bar{\nabla} T}{\beta \bar{\nabla} S}\right|$$

Example



Based on Oram et al. (2008) and Saraceno et al. (2004)

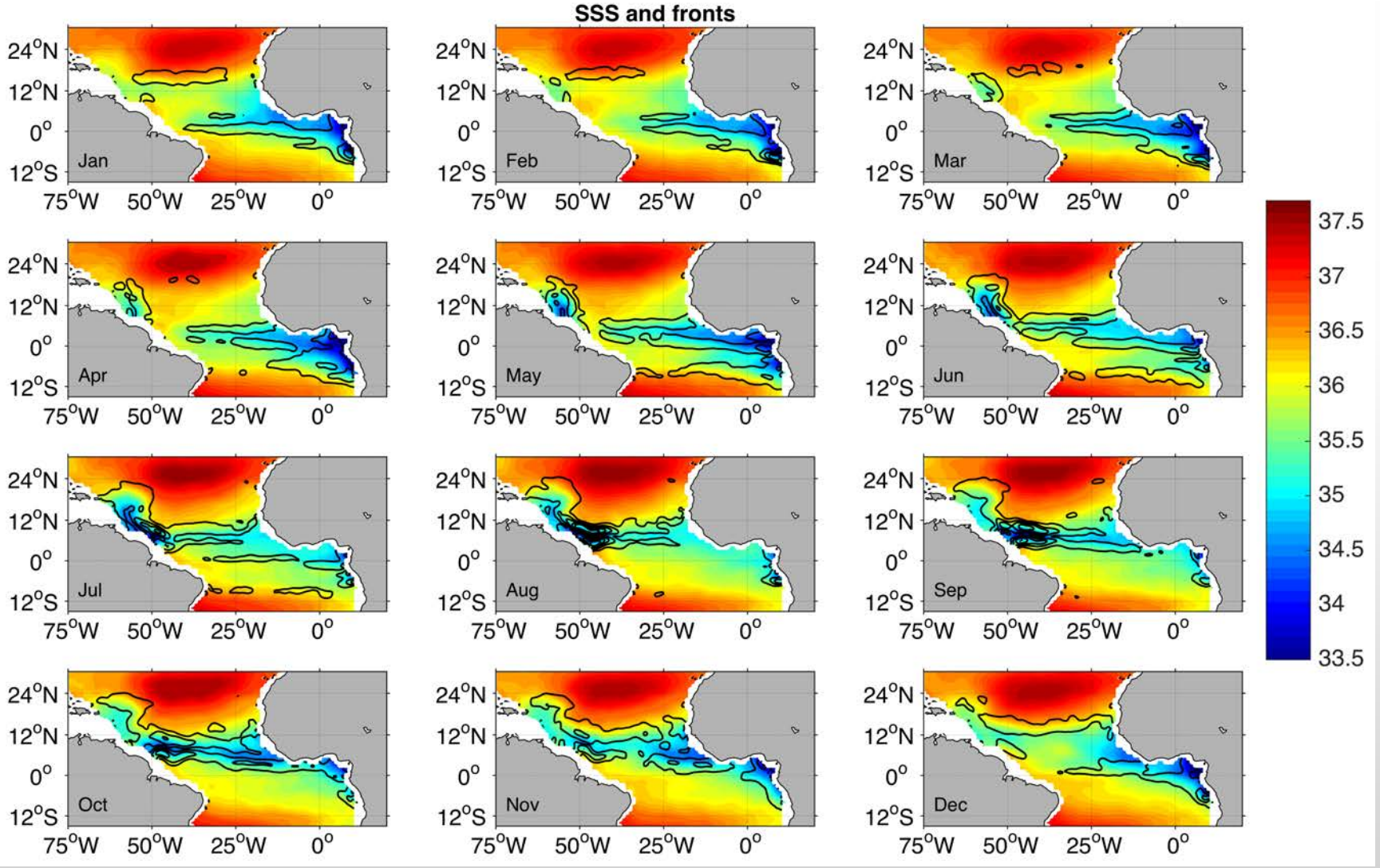
SSS front: |grad(SSS)|>0.0016 psu/km

SST front: |grad(SST)|>0.0045 °C/km

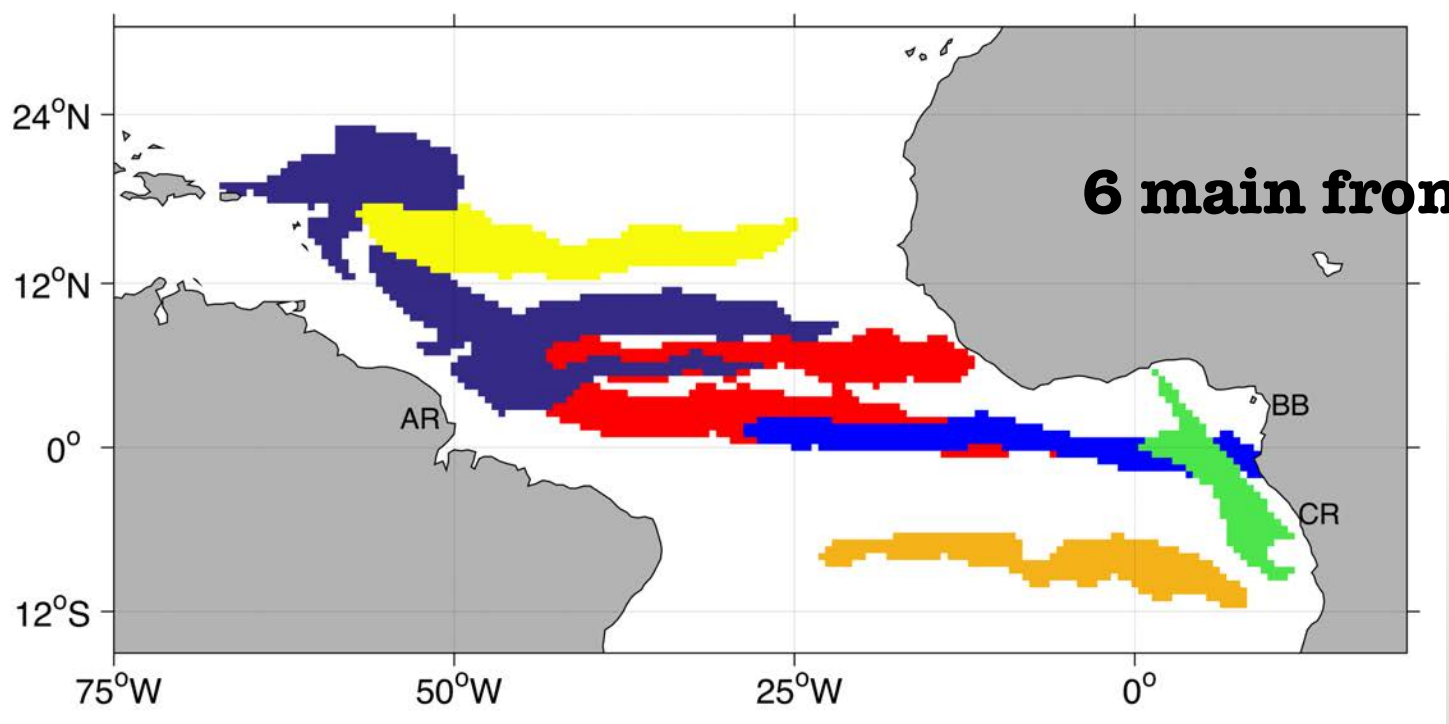
Rho front: |grad(Rho)|>0.0022 kg m^{-3} km^{-1}

RESULTS

Monthly mean SSS and |grad(SSS)|>0.0016 psu/km (Jan 2012-Dec 2014)

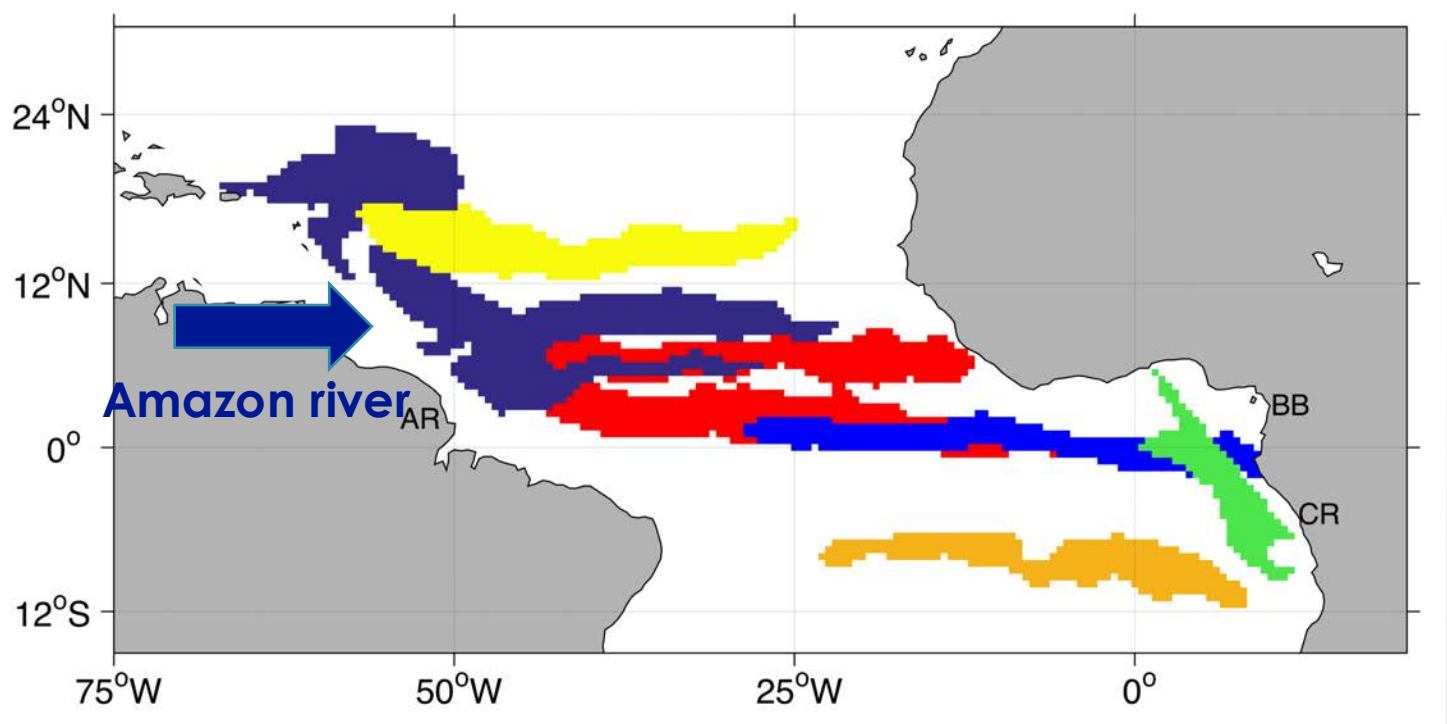


Classification



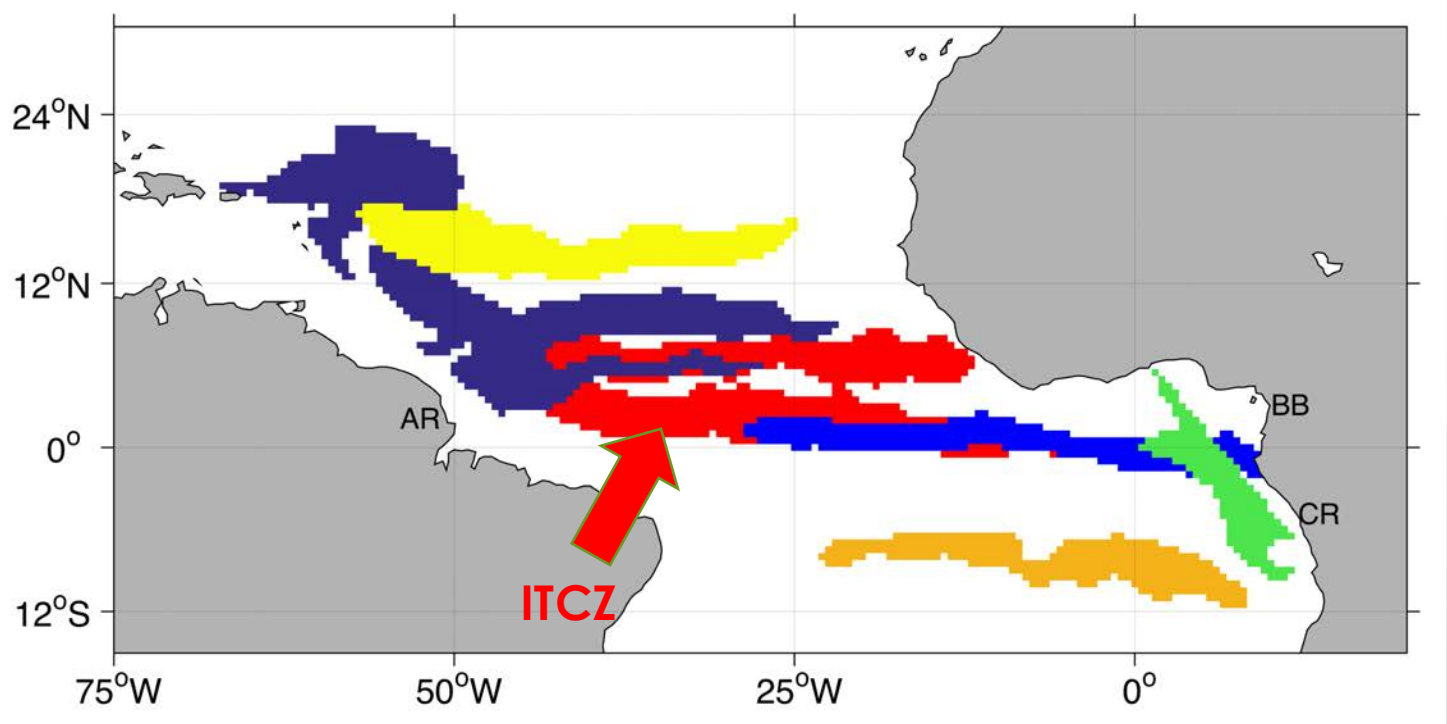
6 main frontal system!

Classification



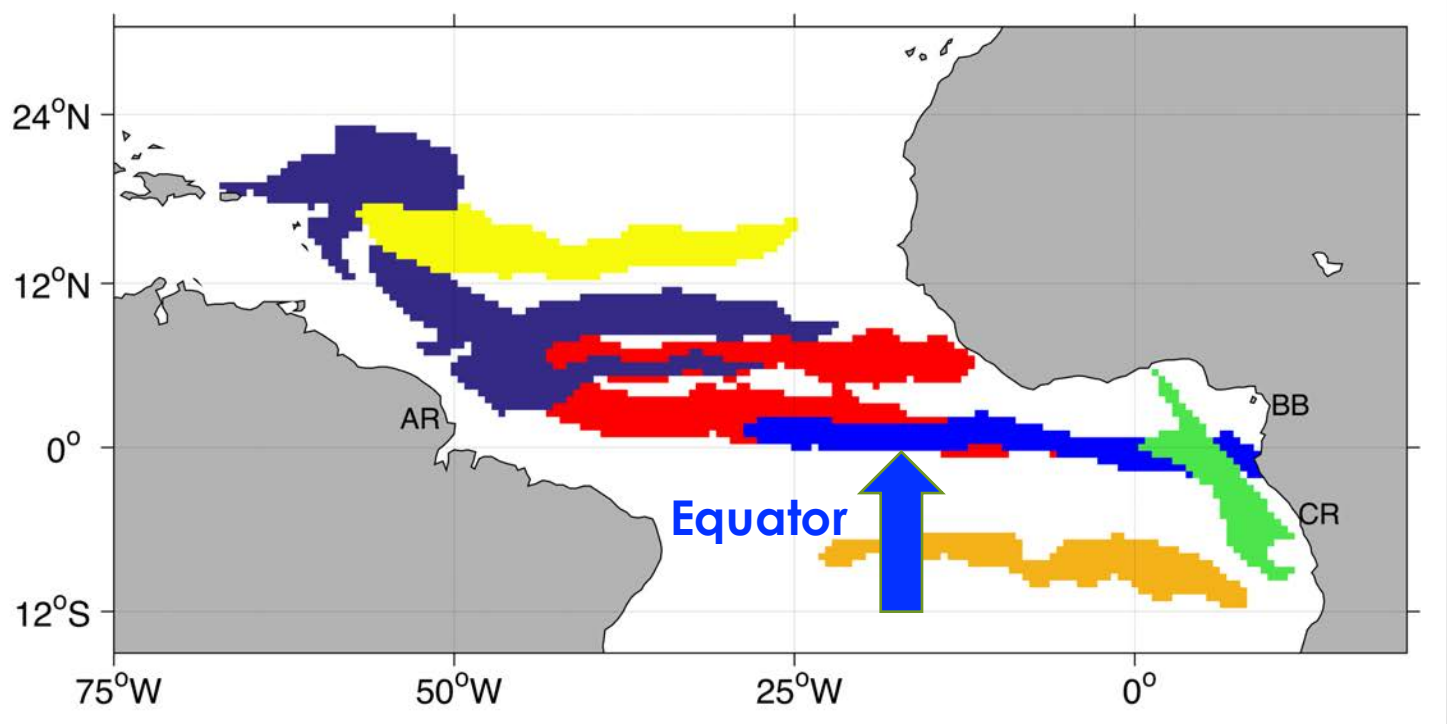
Front 1

Classification



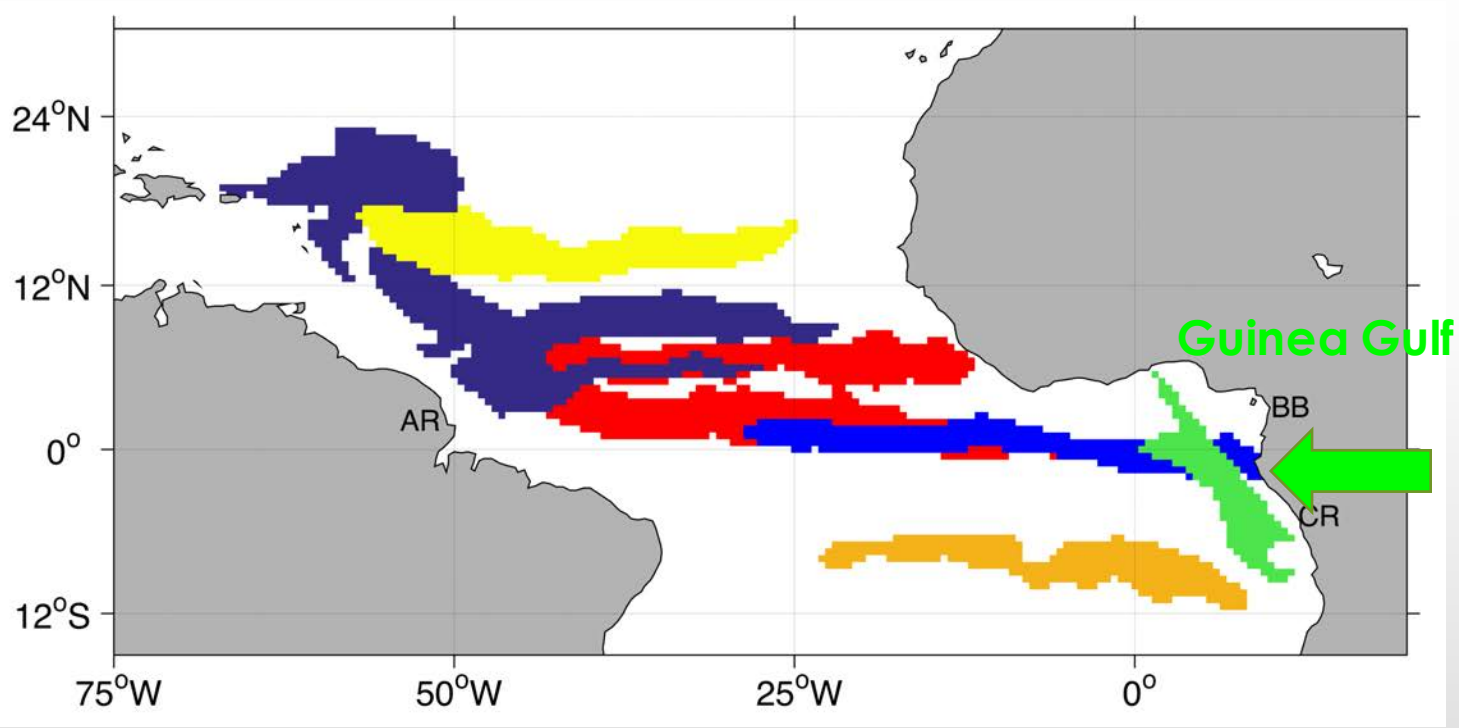
Front 2

Classification



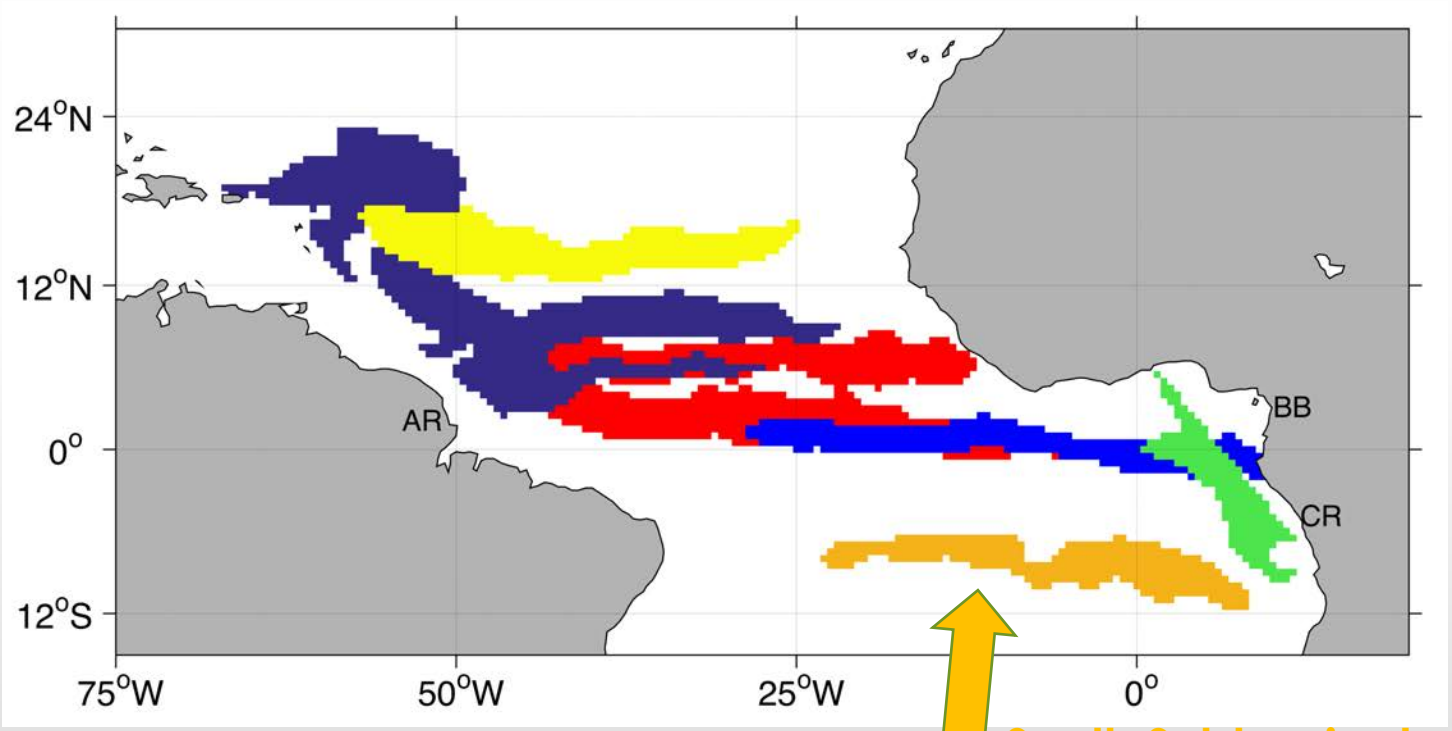
Front 3

Classification



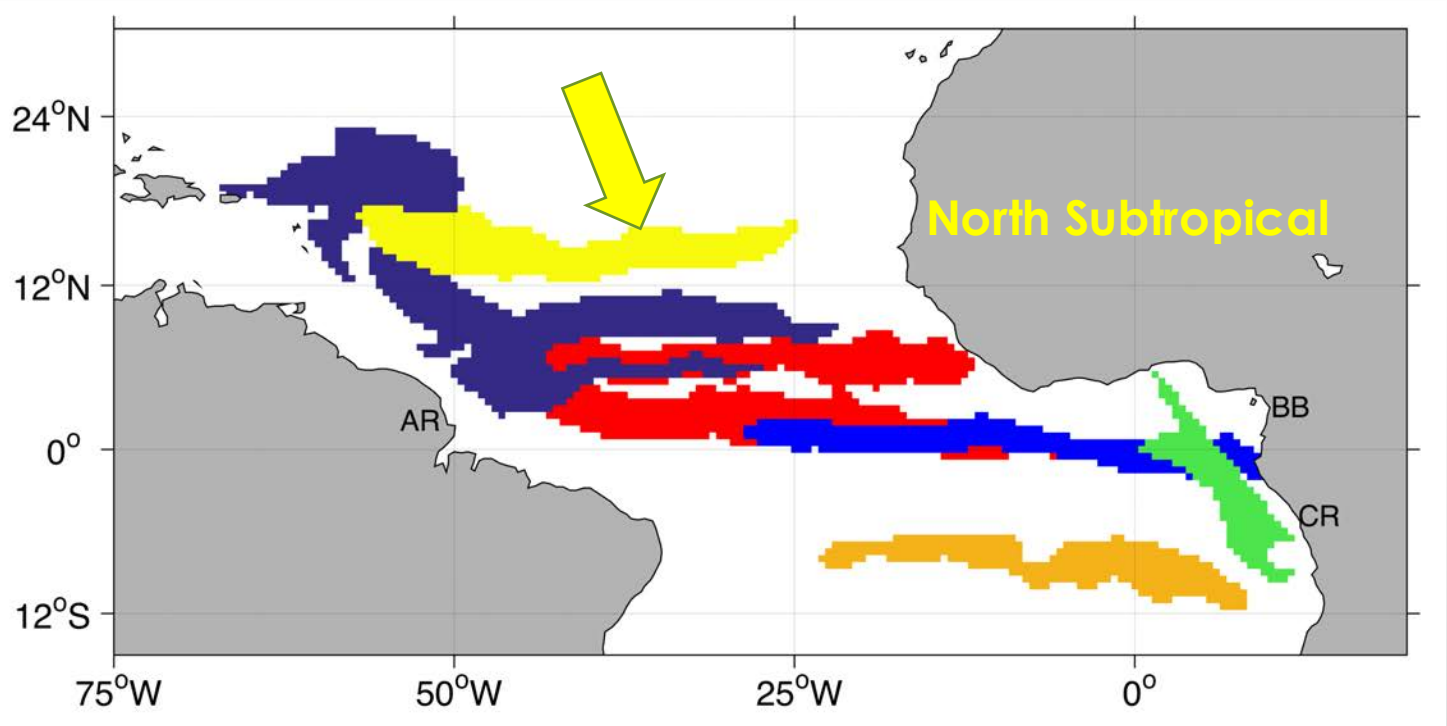
Front 4

Classification



Front 5

Classification



Front 6

Front 1: Amazon River plume

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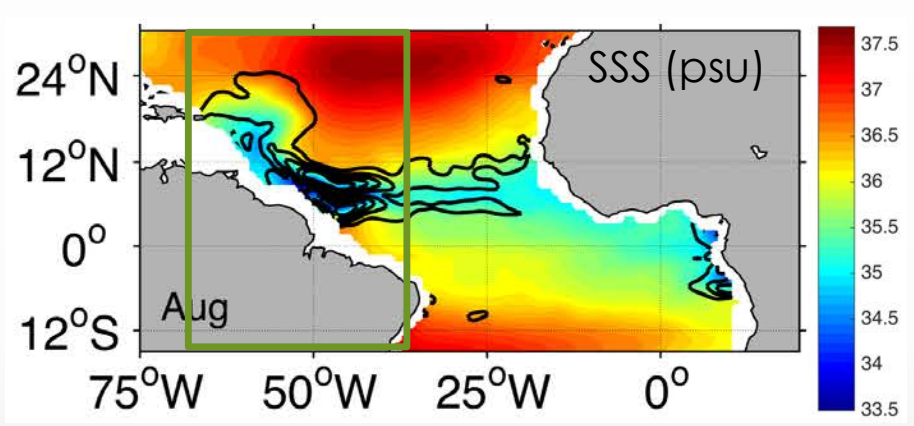
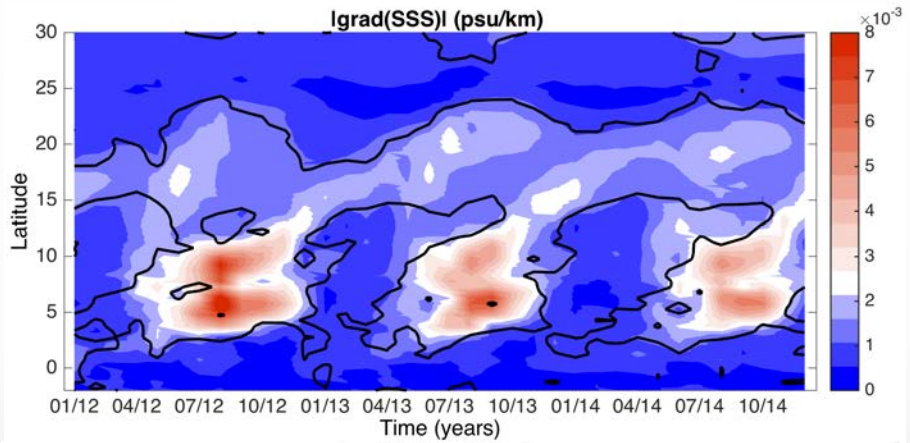
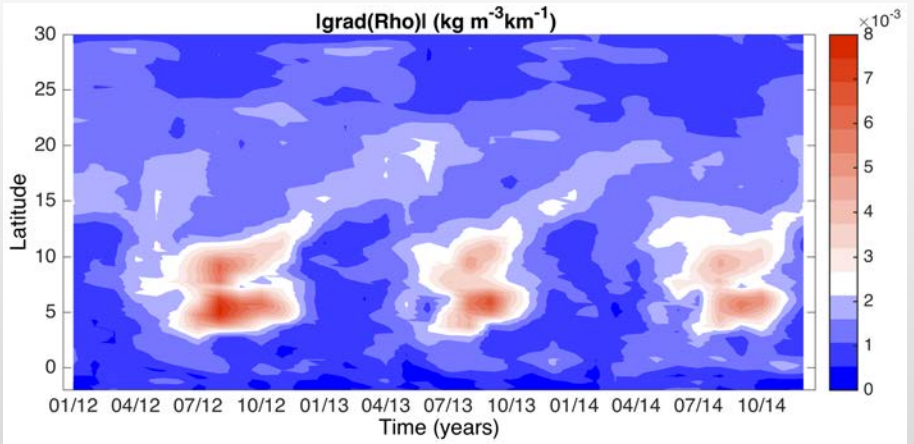
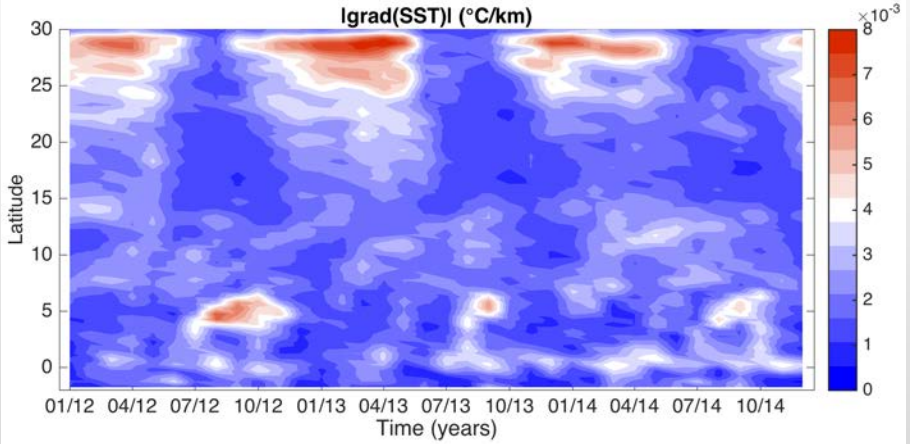
Hovmoller (lat vs time)





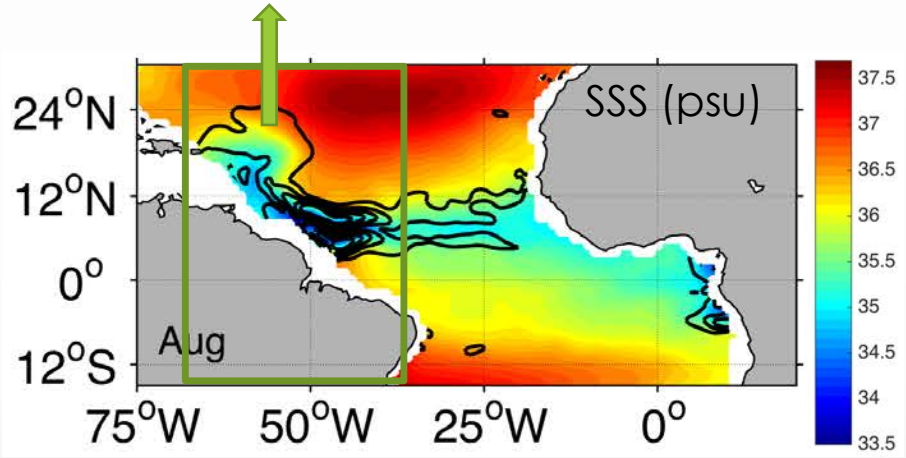




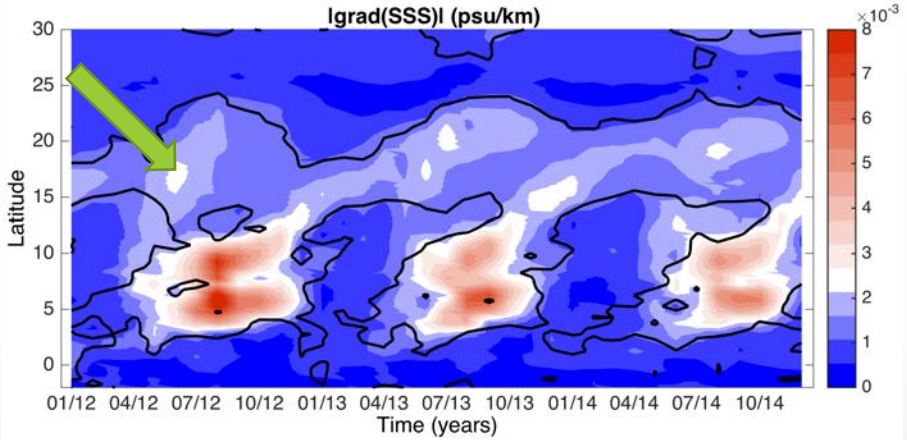
Mark seasonal cycle

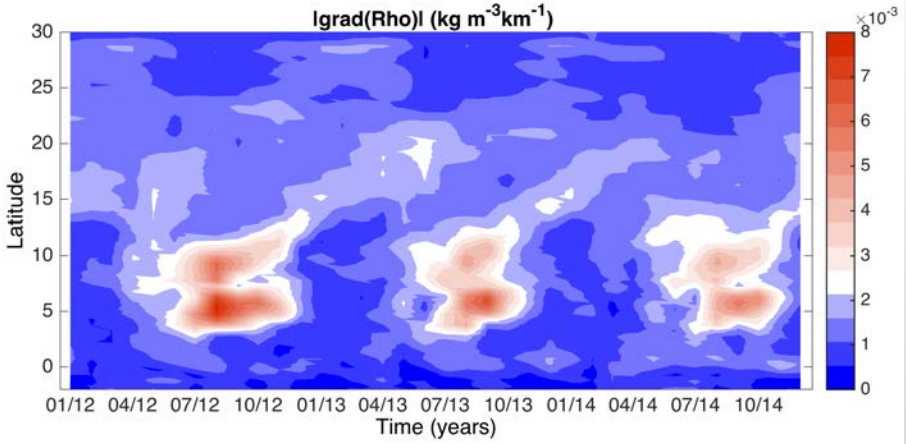
Front 1: Amazon River plume

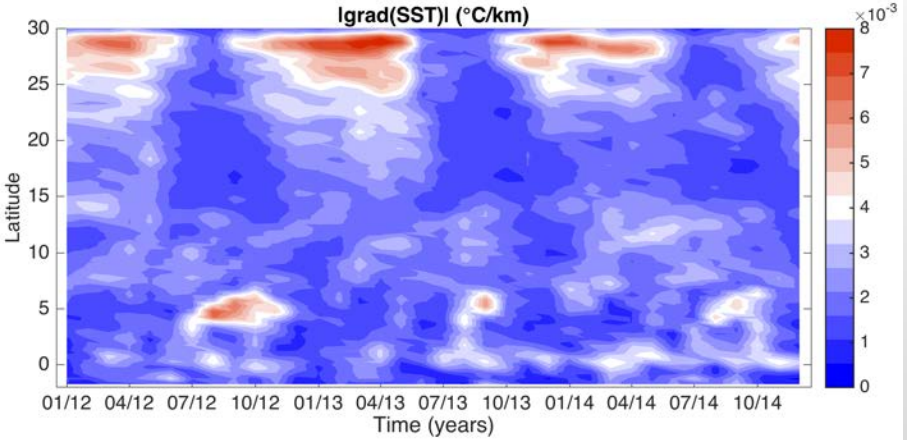
Northward front



Hovmoller (lat vs time)



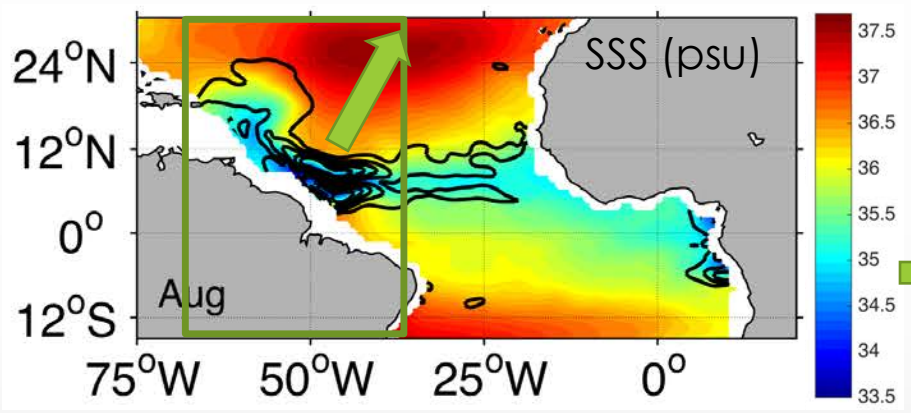




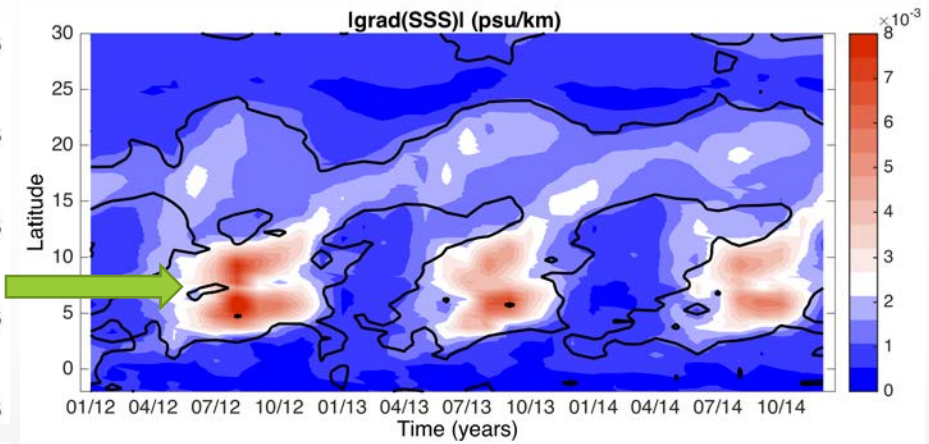
2 SSS Fronts: **northward (March-July)** and **eastward** front **(July-October)**.

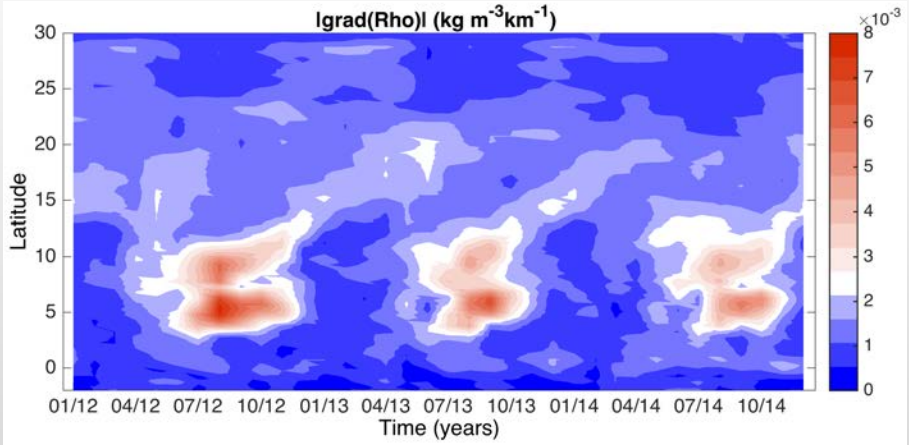
Front 1: Amazon River plume

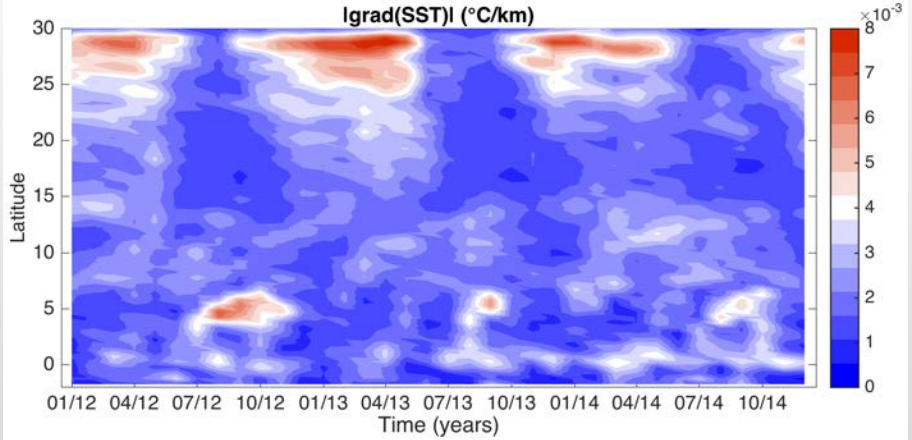
Eastward front



Hovmoller (lat vs time)





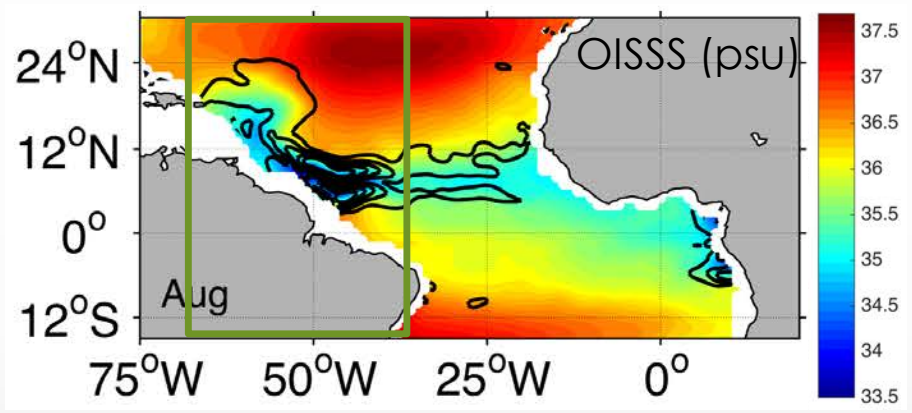


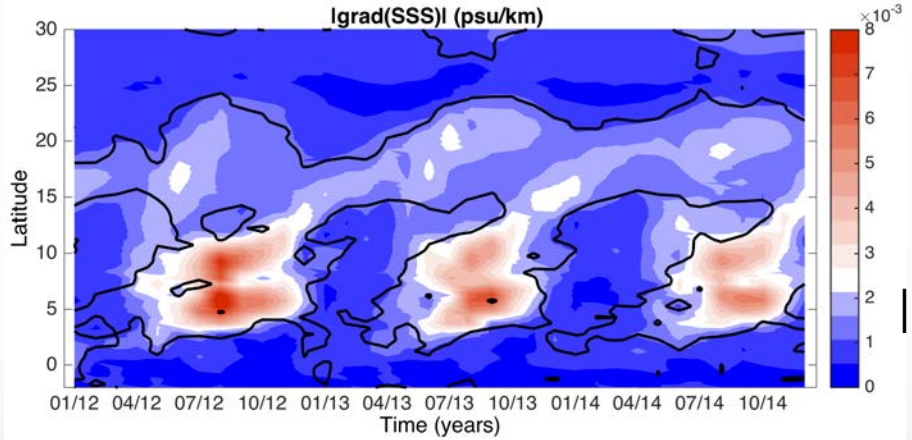
2 SSS Fronts: **northward (March-July)** and **eastward** front **(July-October)** and eastward front.

Double front

Front 1: Amazon River plume

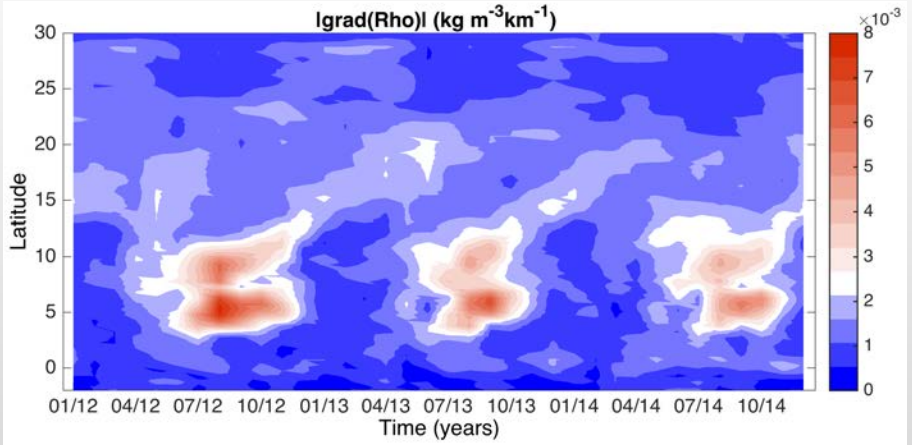
Hovmoller (lat vs time)

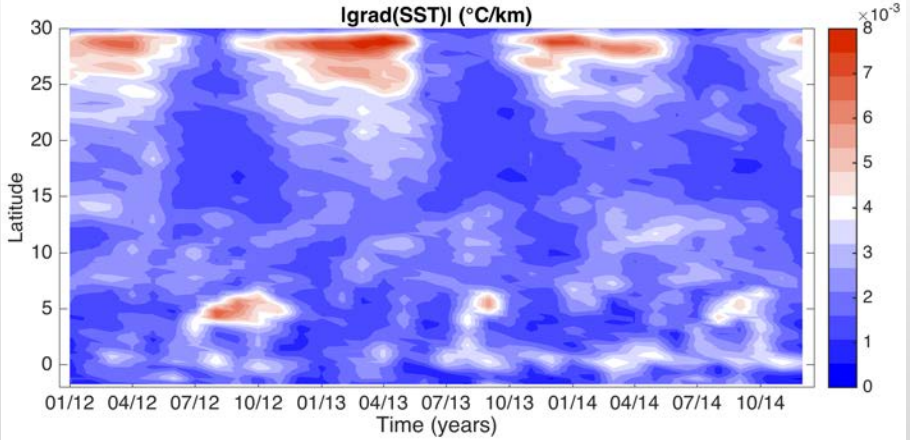




|grad(Rho)| ~ |grad(SSS)|

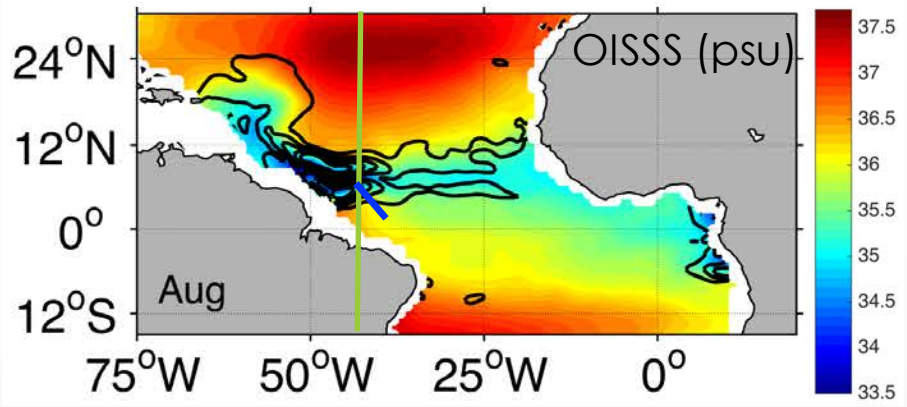
(R<1)



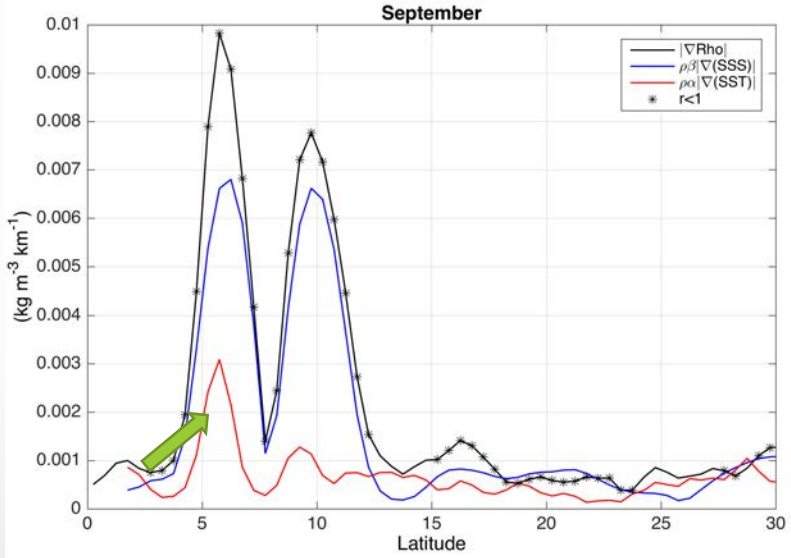


SST front at ~5°N

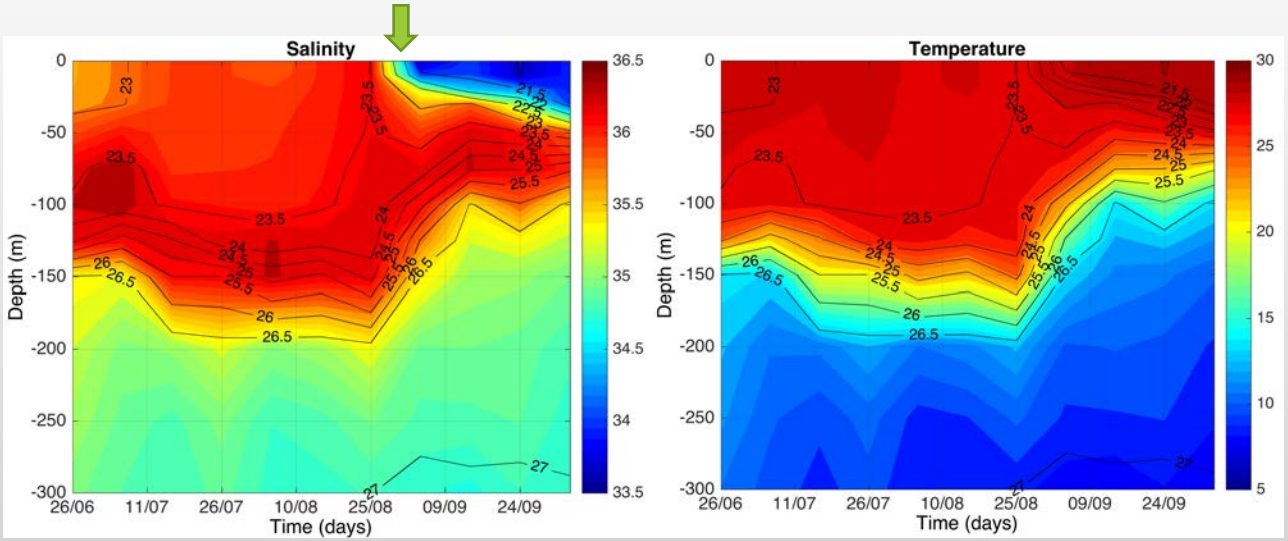
Front 1: Amazon River plume



Southern edge density front stronger than northern edge => SST front



The SST front due to NBC retroflection (Ffield, 2005)



Argo vertical section across southern edge of eastward SSS front

Front 2: ITCZ

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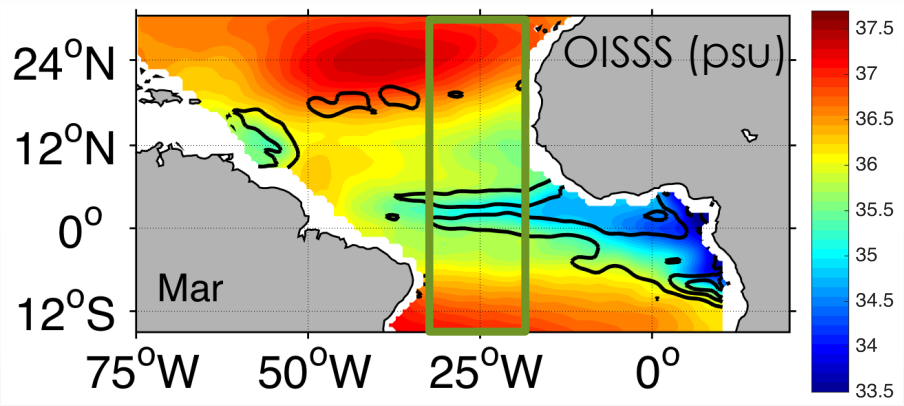
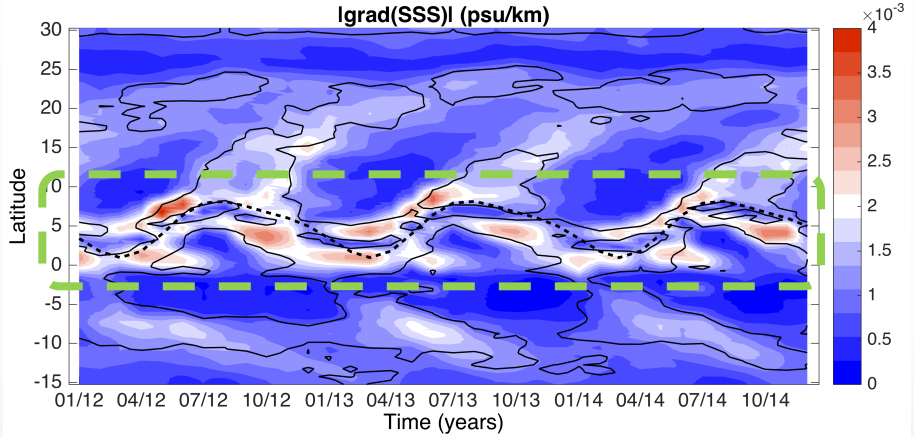
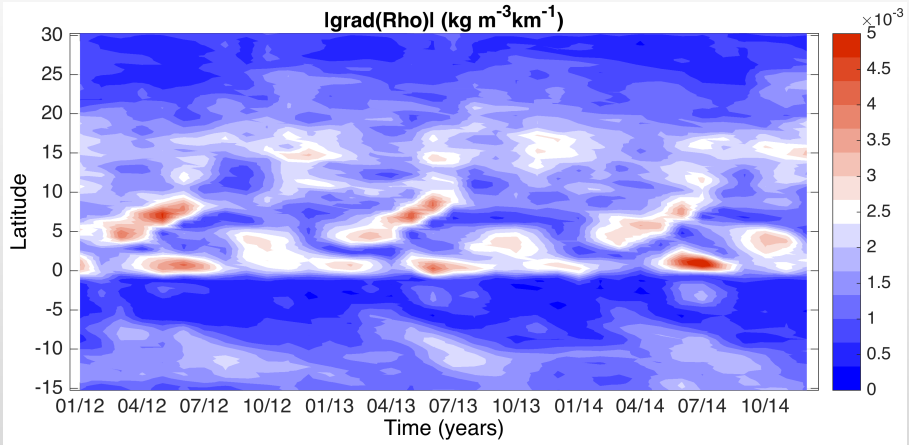
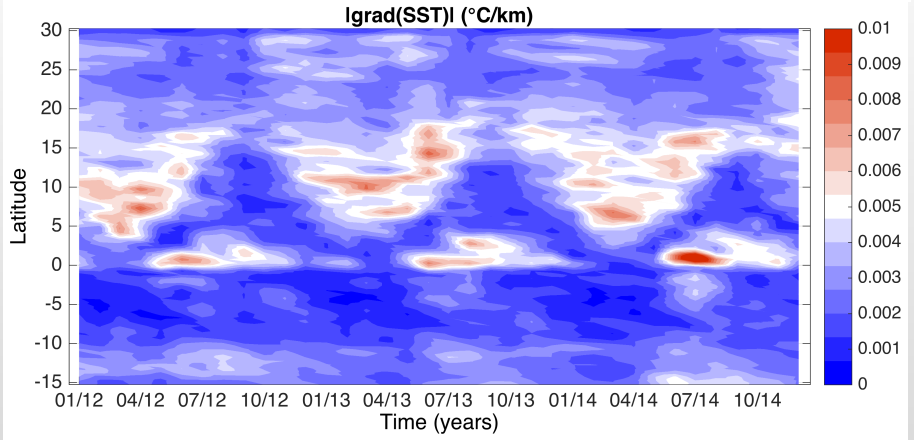


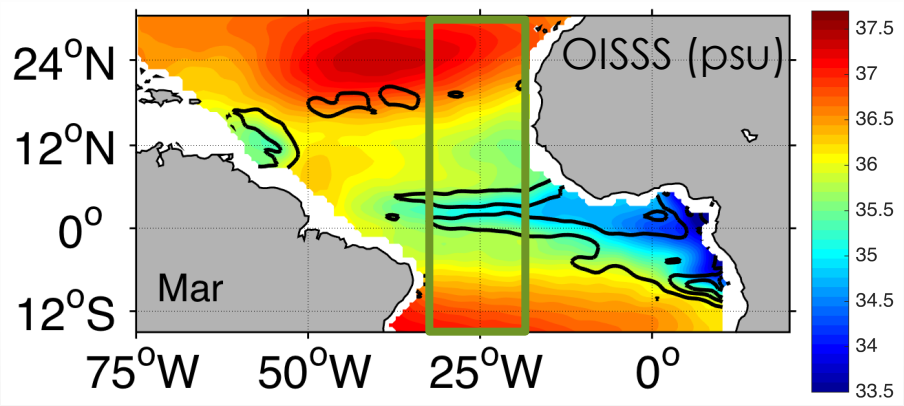
Hovmoller (lat vs time)



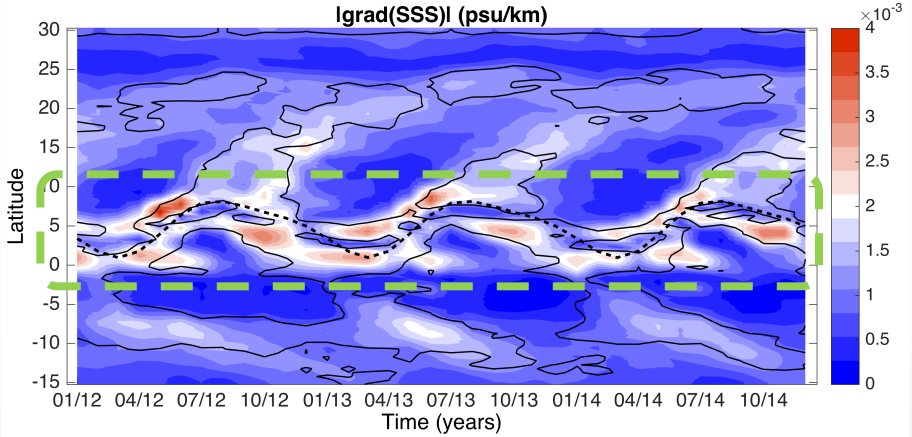


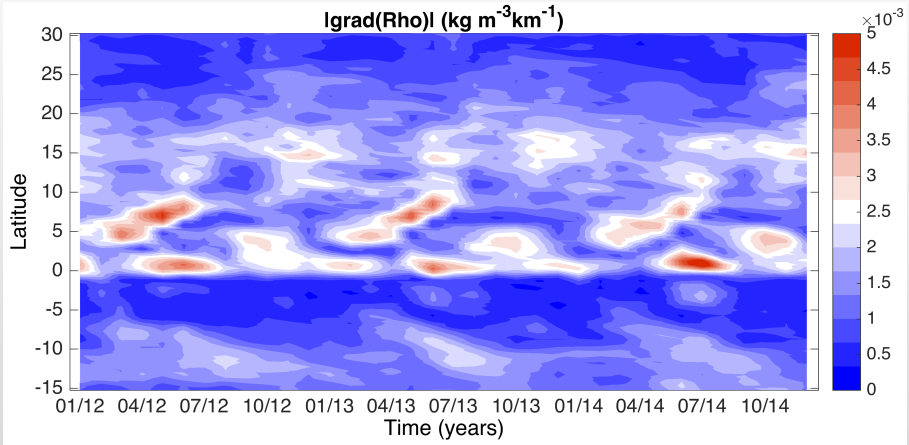


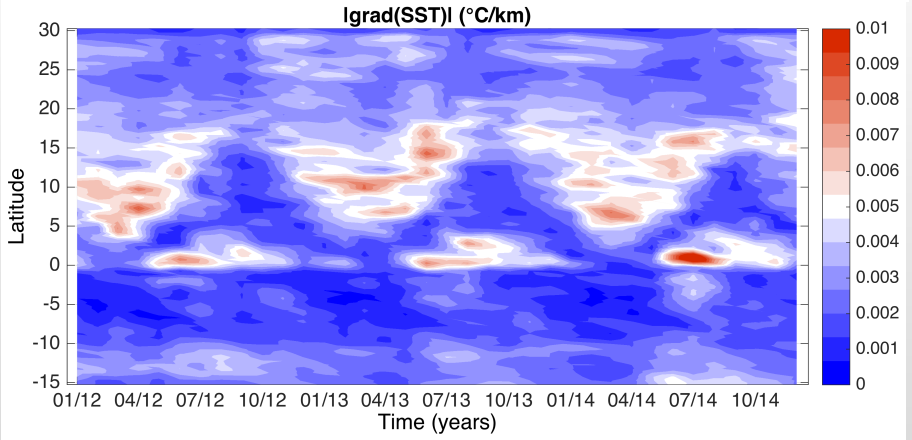
Front 2: ITCZ



Hovmoller (lat vs time)



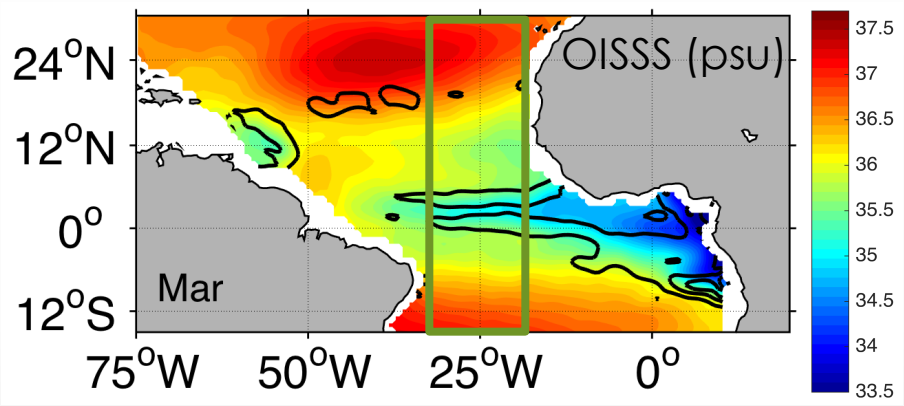




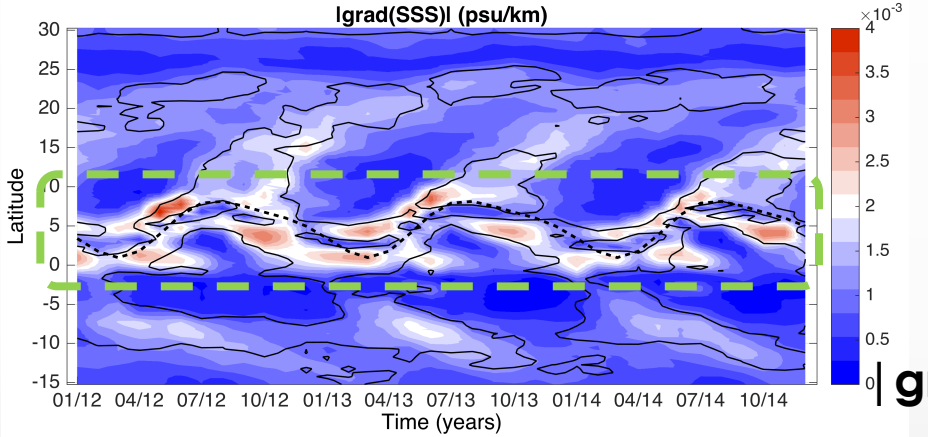
Seasonal cycle of SSS front follows the maximum PP

0°-5°N during **January-April** starts to move to the north reaching the northern position (5°-10°N) in **July**.

Front 2: ITCZ



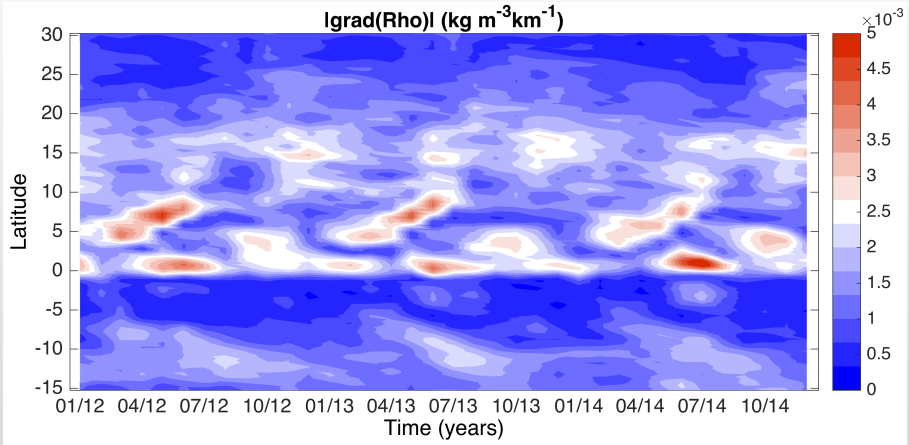
Hovmoller (lat vs time)

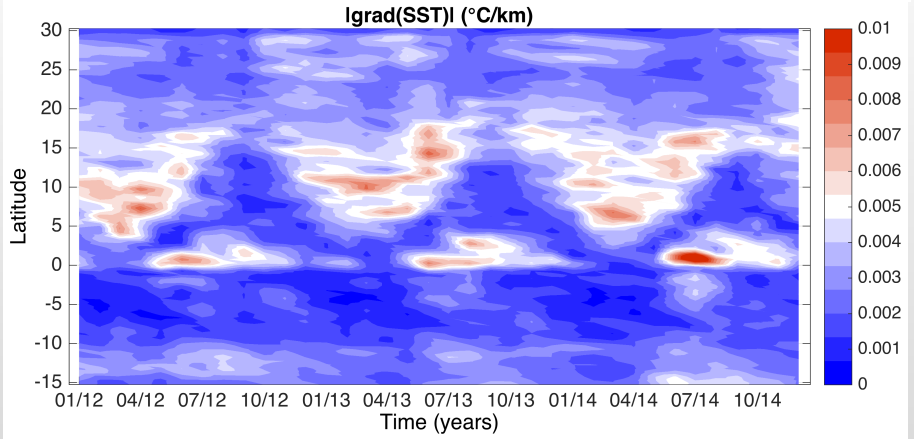


Seasonal cycle of SSS front follows the maximum PP

|grad(Rho)| ~ |grad(SSS)|

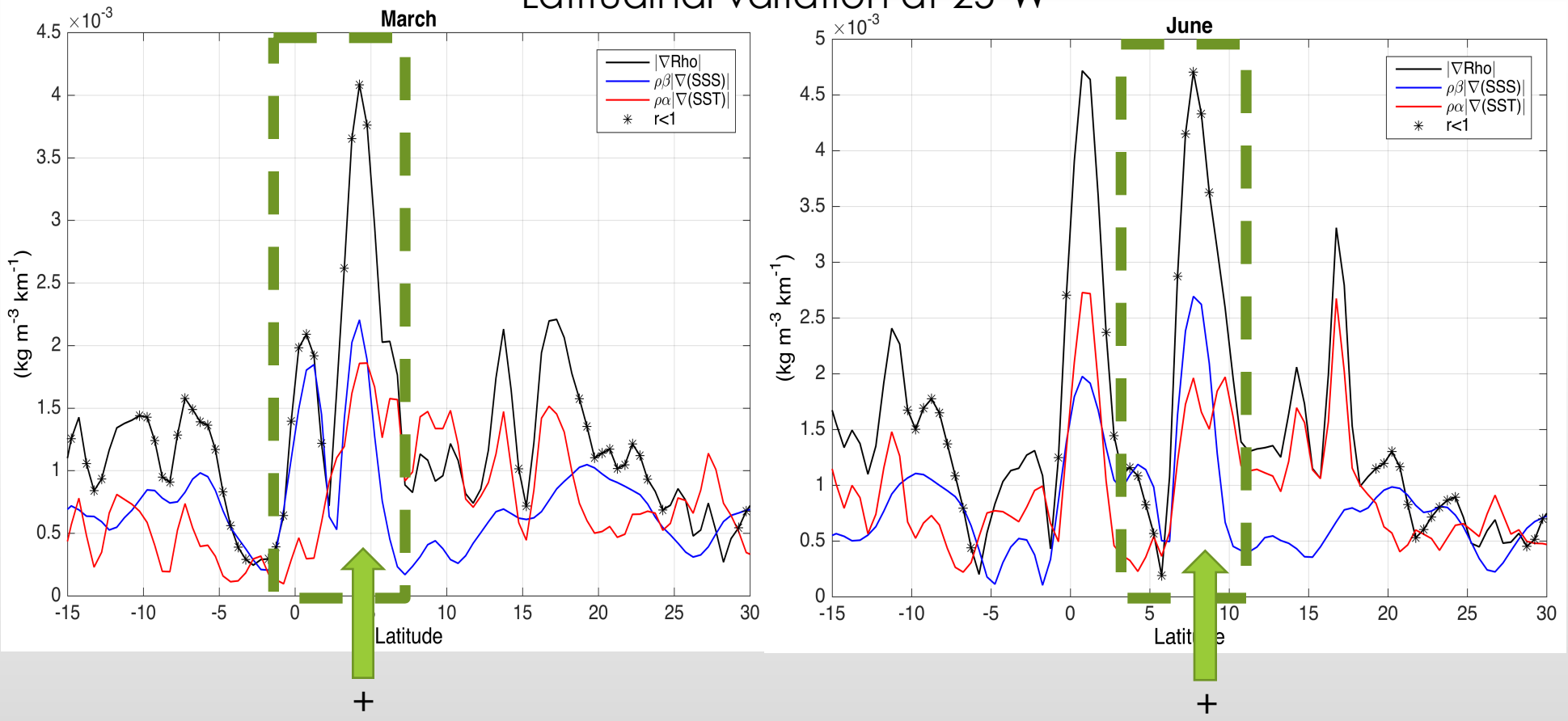
(R<1)





Front 2: ITCZ

Latitudinal variation at 25°W

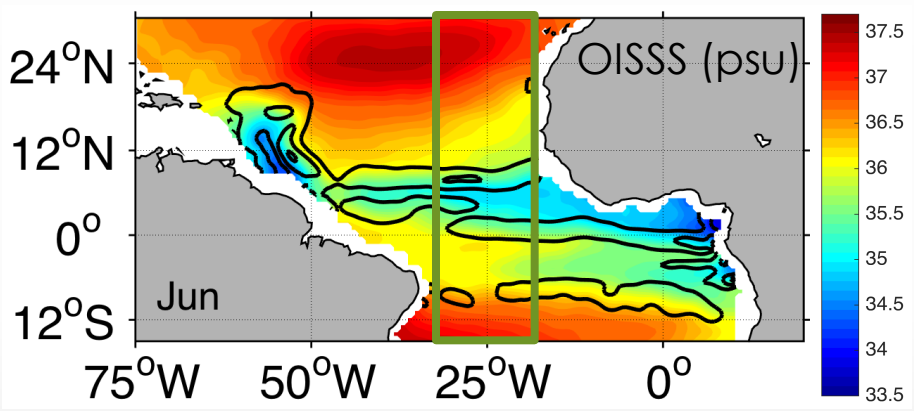


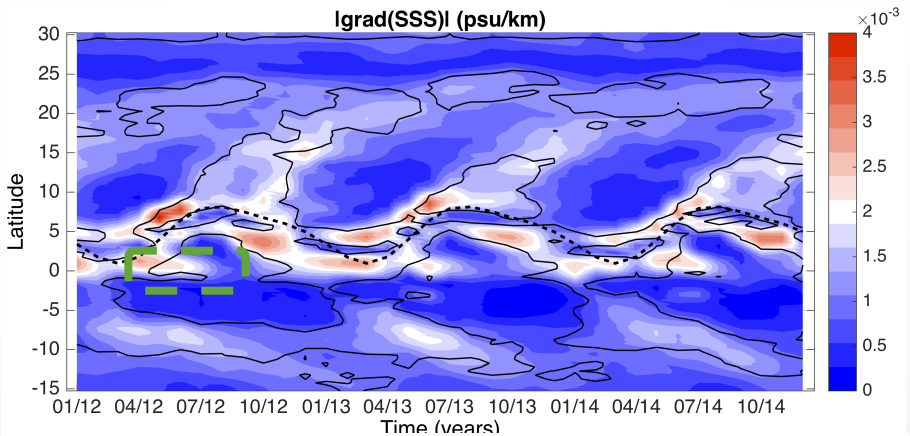
Northern edge is stronger and wider than the southern edge
Northern edge is a thermohaline front

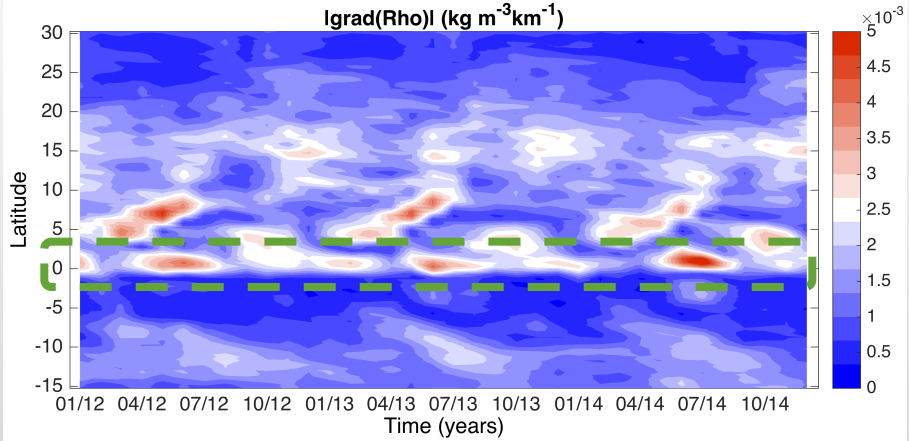
Front 3: Equator

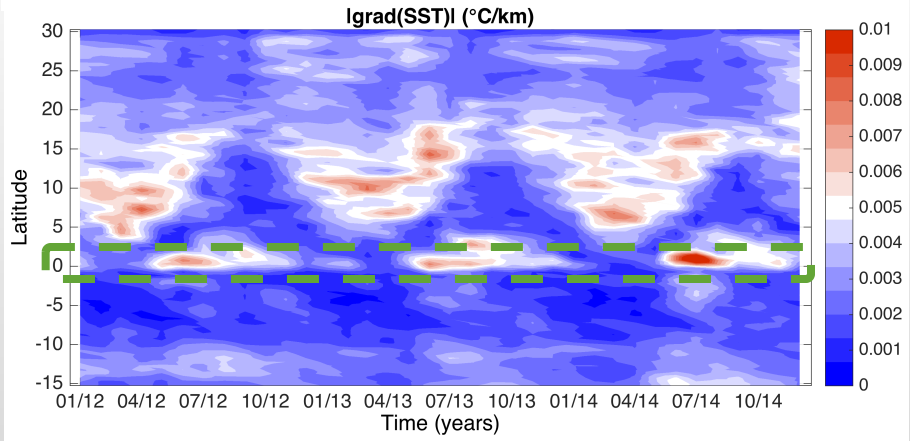
Front 3: Equator

Hovmoller (lat vs time)



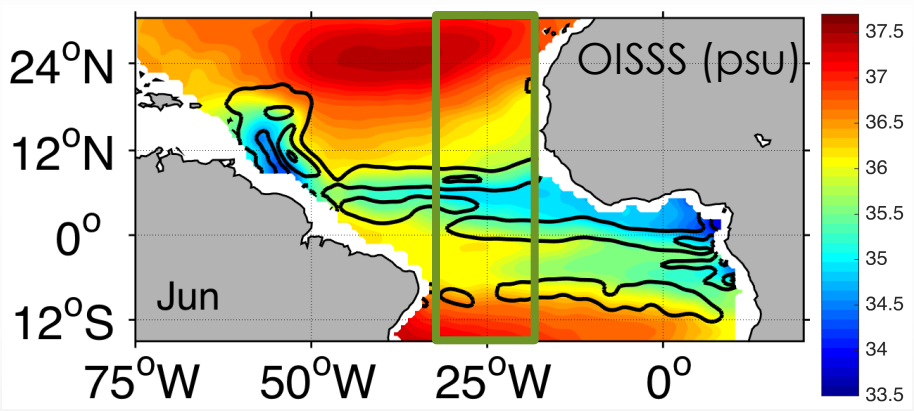


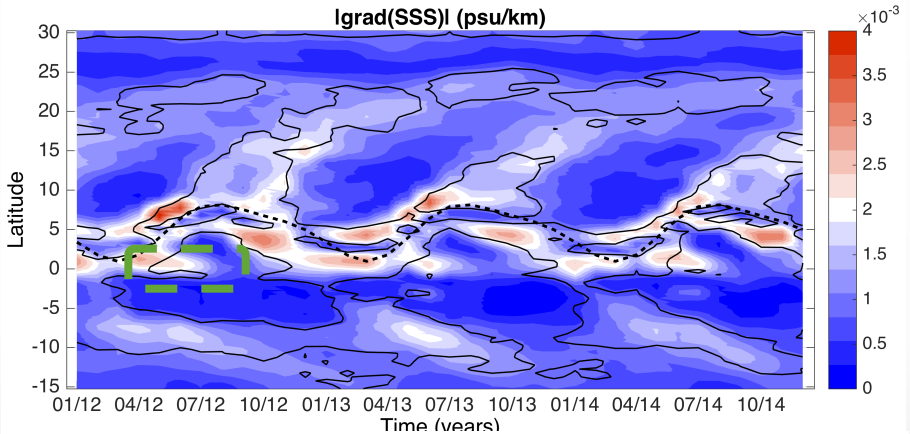


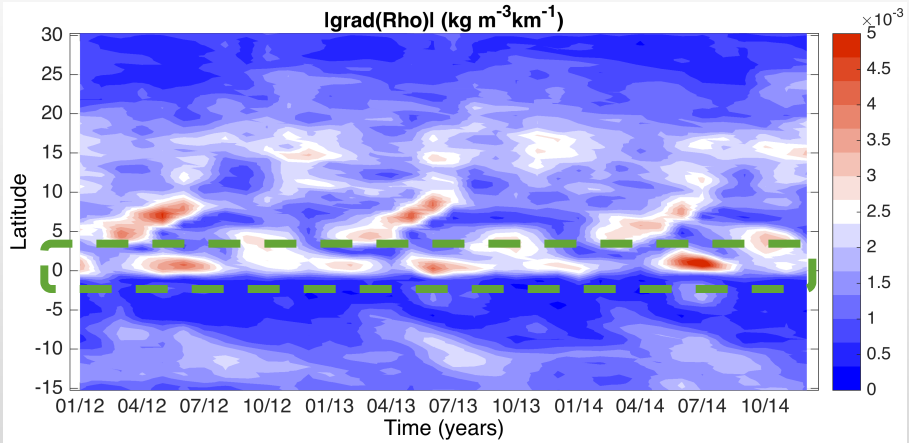


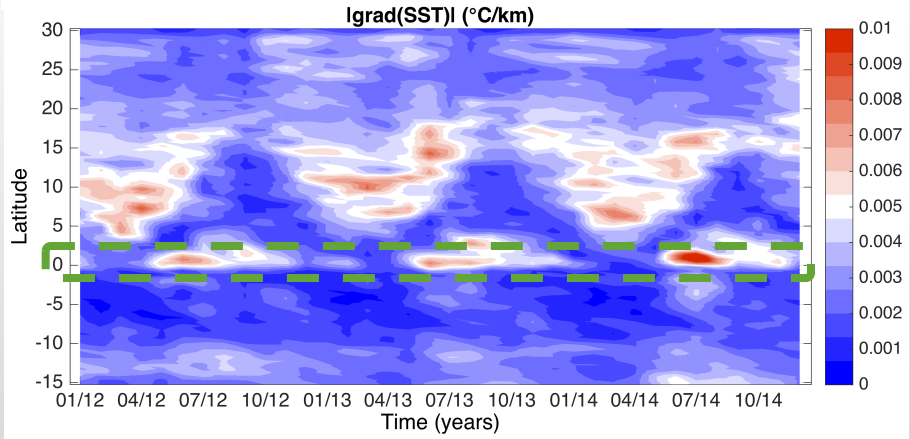
Front 3: Equator

Hovmoller (lat vs time)





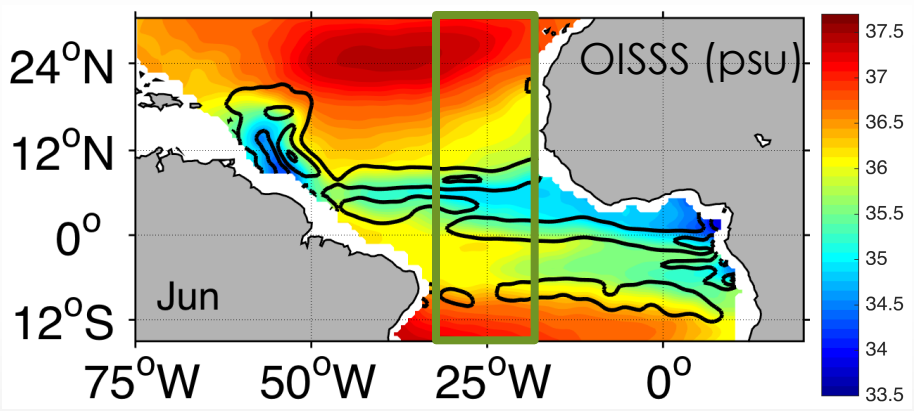


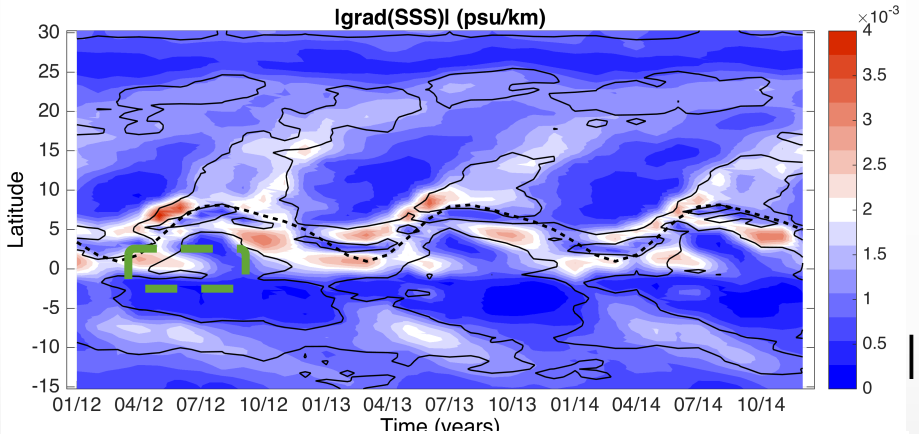


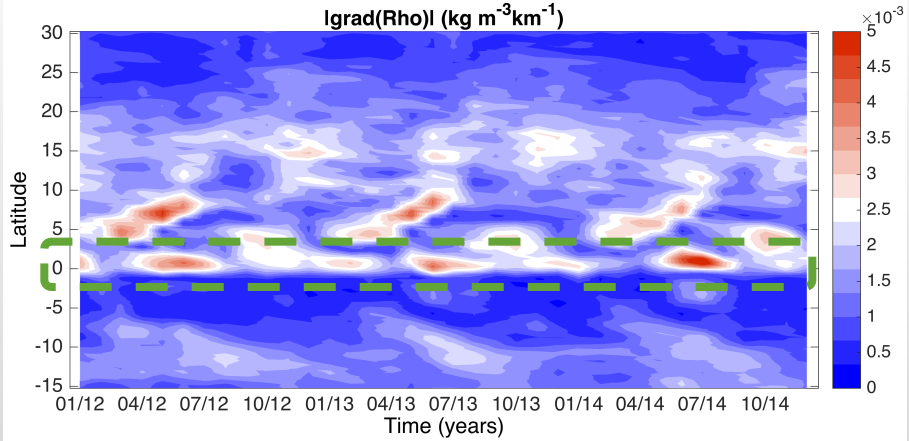
SSS front exists during **boreal summer (MJJ)**

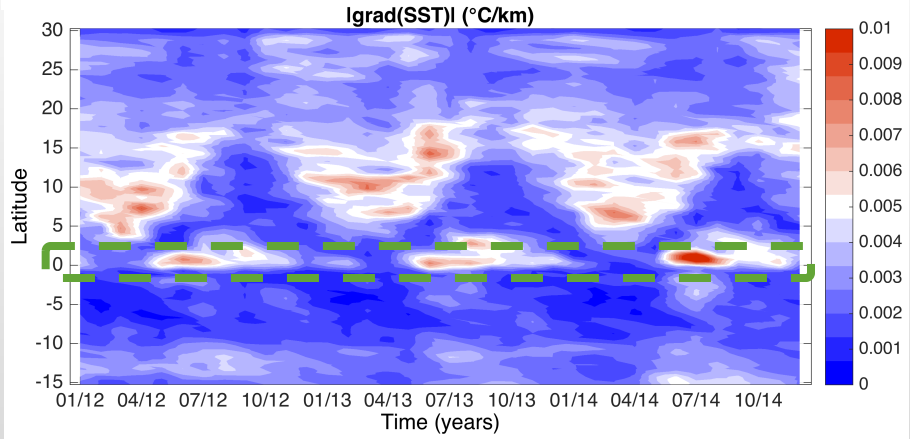
Front 3: Equator

Hovmoller (lat vs time)





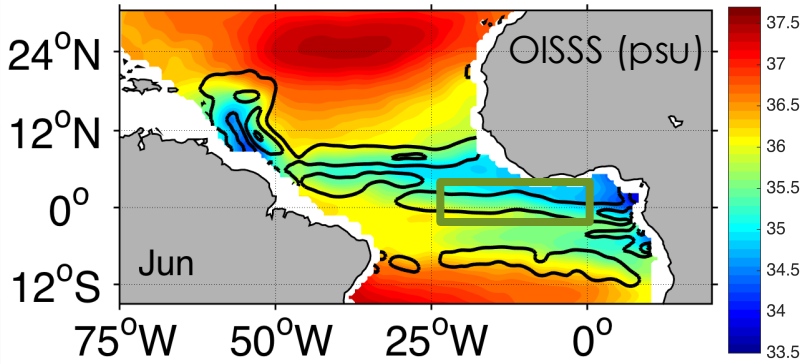




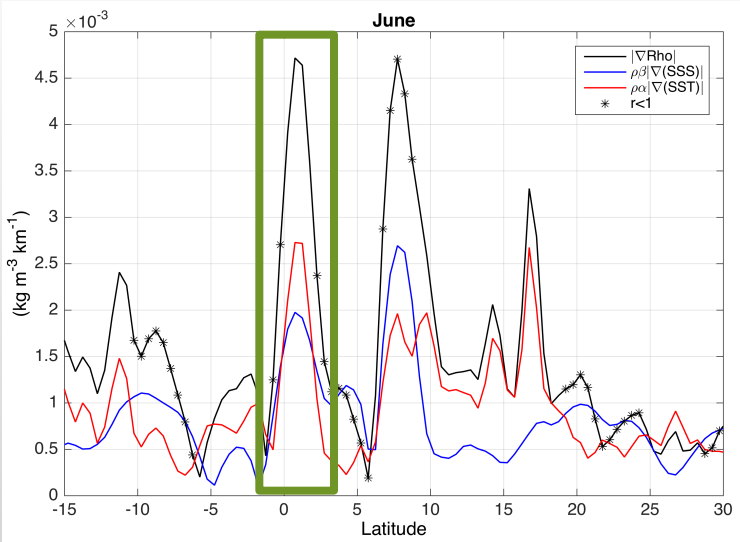
|grad(Rho)| ~ |grad(SST)|

(R>1)

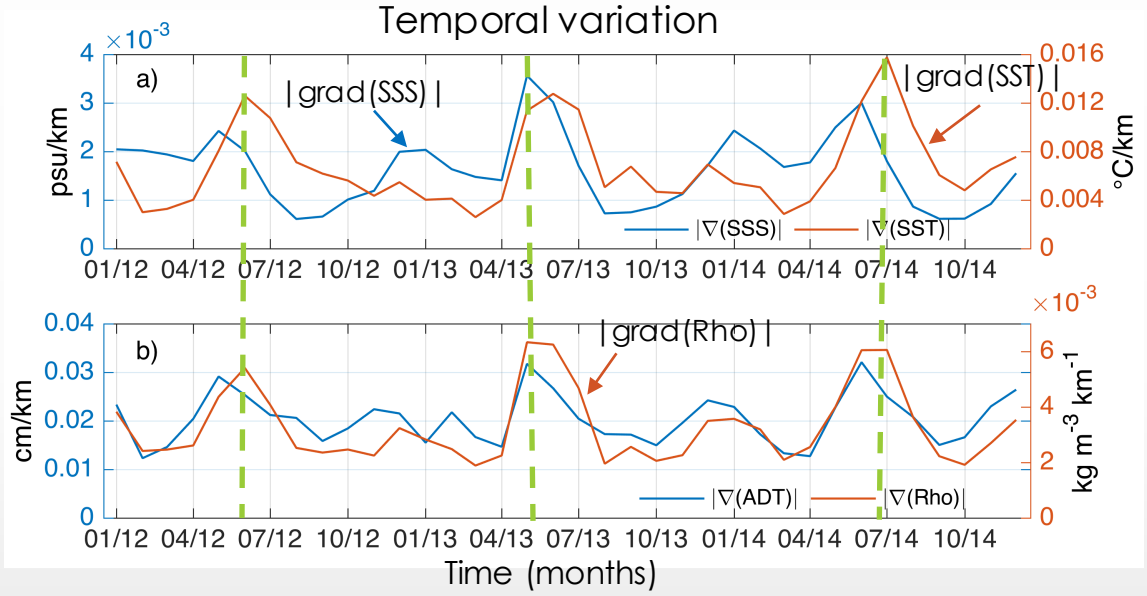
Front 3: Equator



Latitudinal variation at 25°W



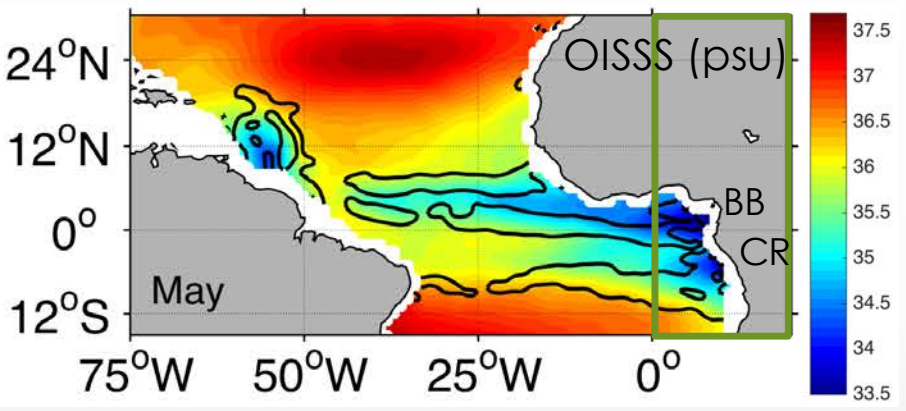
Strong density front



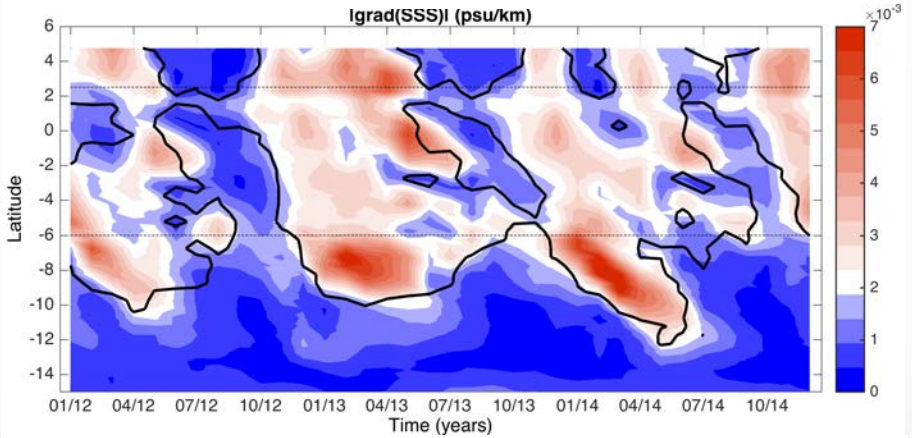
Upwelling brings salty water from EUC
(e.g. Da Allada et al., 2017)

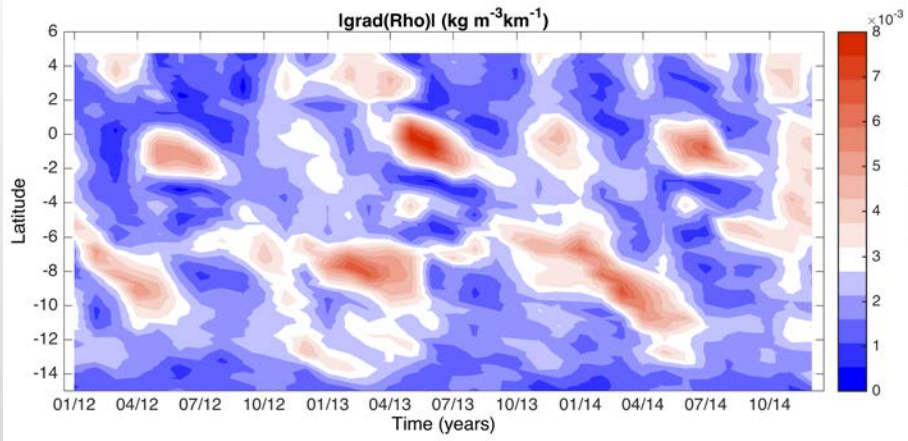
Front 4: Guinea Gulf

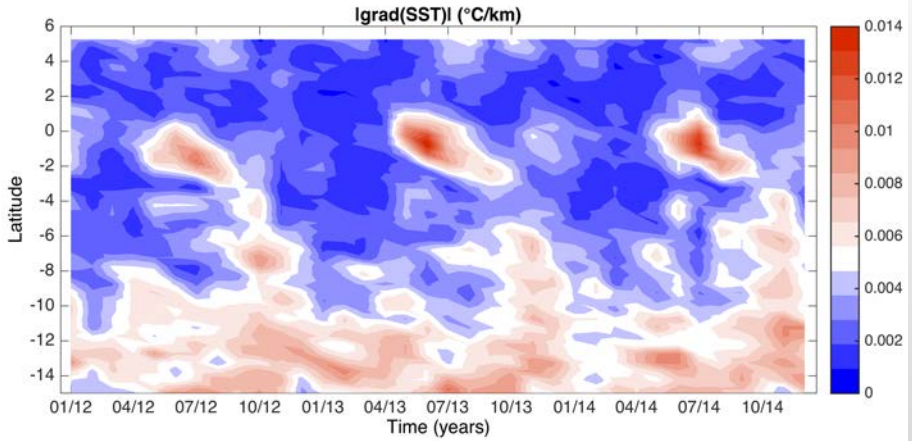
Front 4: Guinea Gulf



Hovmoller (lat vs time)



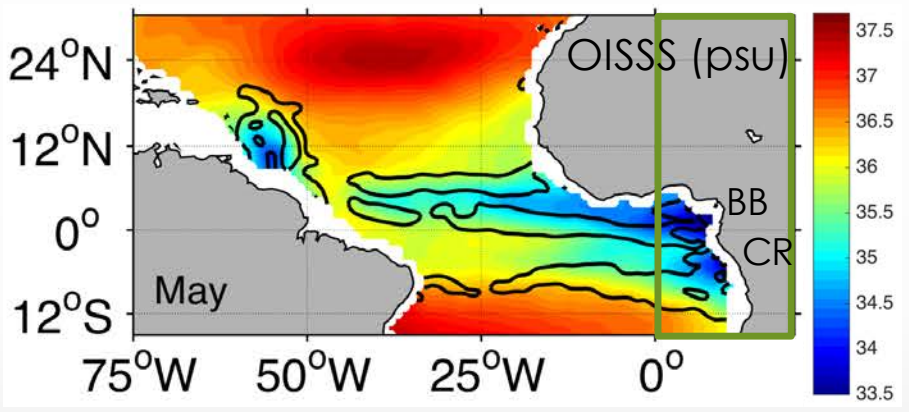


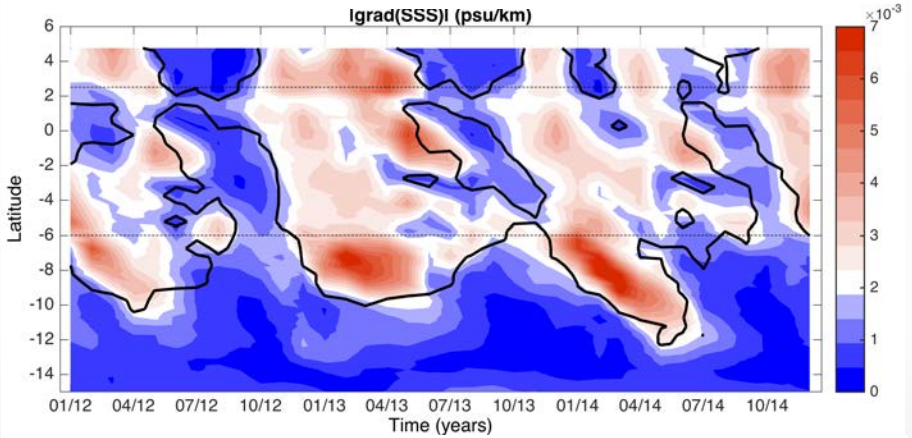


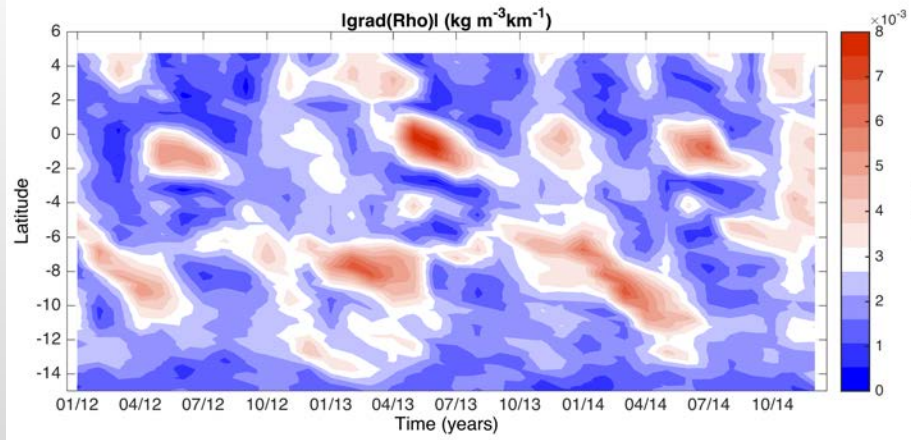
The SSS fronts separate the BB fresh waters and the CR from the ocean salty water.

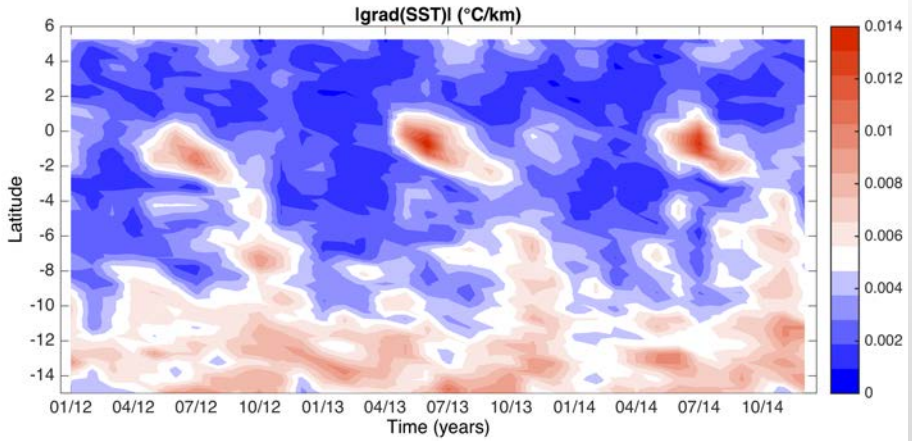
Front 4: Guinea Gulf

Hovmoller (lat vs time)







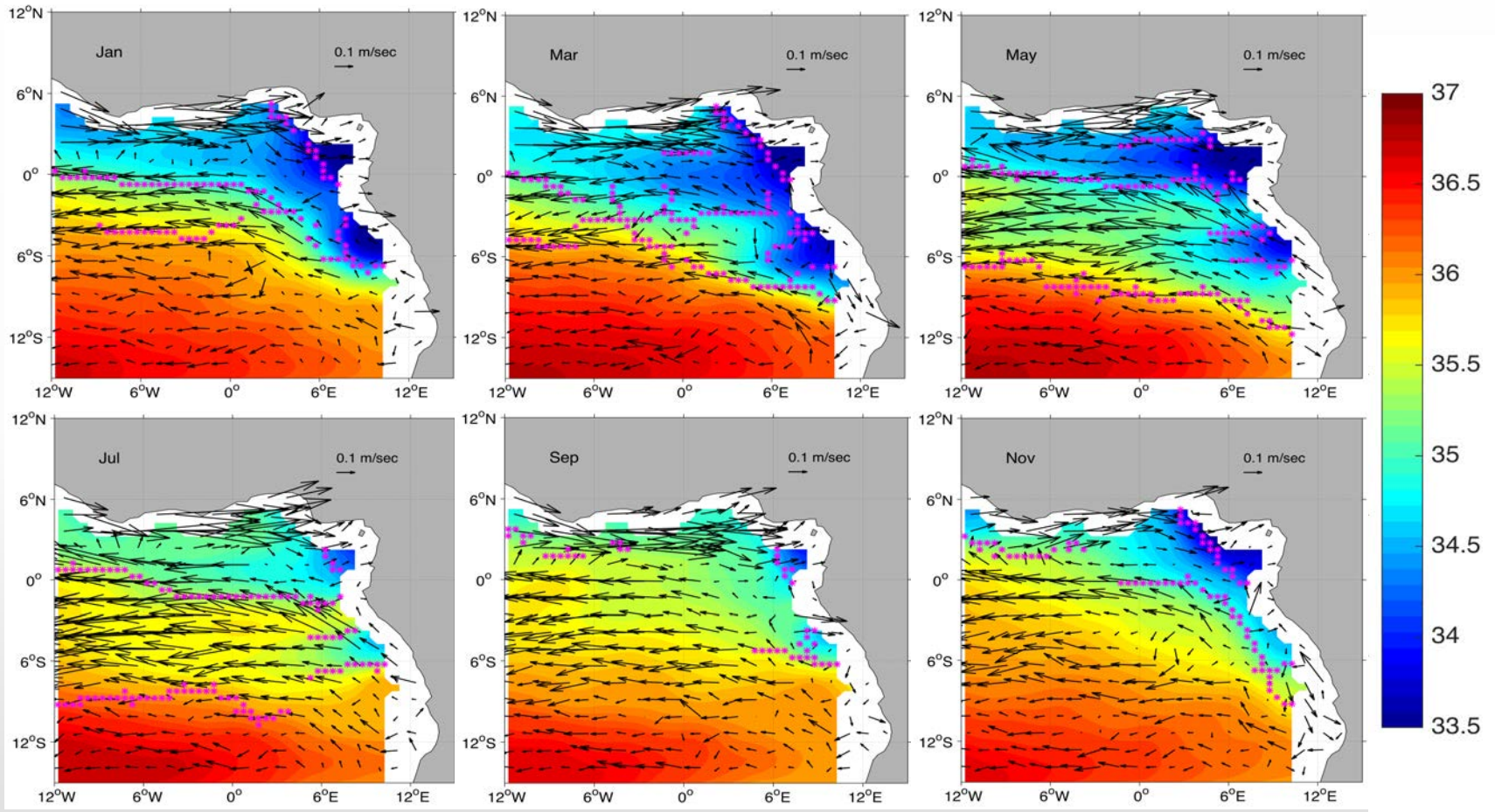


Main three period: 1) High |grad(SSS)| between CR and the northern coast (Nov-January).
2) |grad(SSS)| decreases in July-October.
3) More than one front at the same time (Feb-June).

The strongest CR and Eq.

OISSS (psu) climatology, currents vectors, SSS front

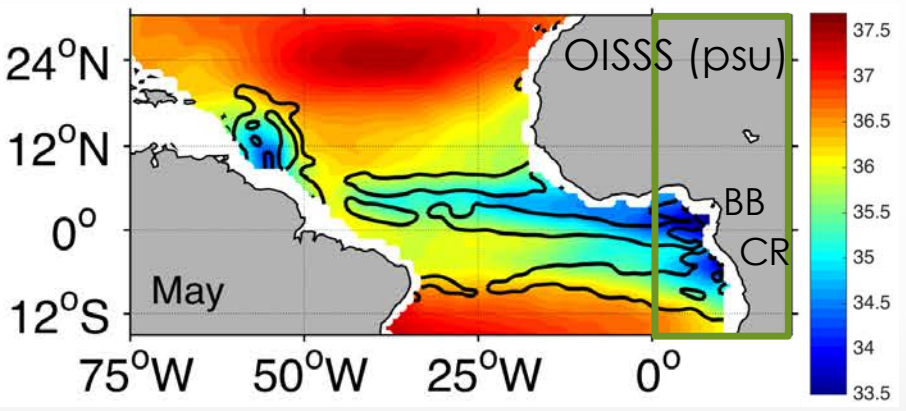
Coherence between the currents and the position of the SSS fronts.

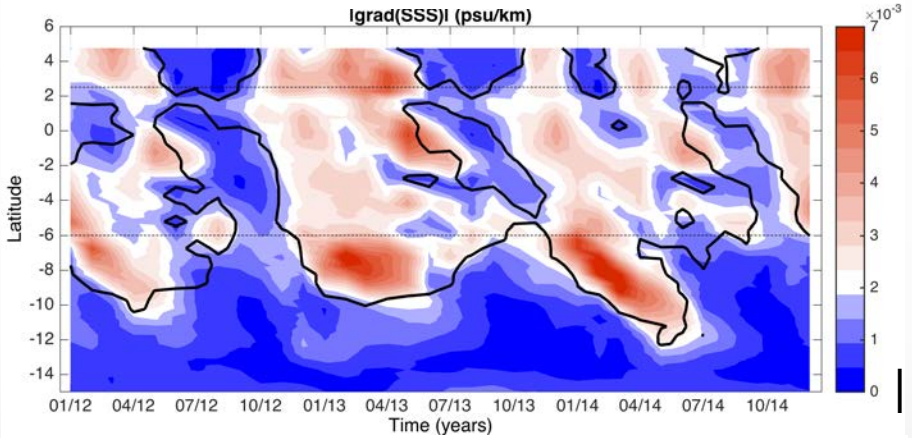


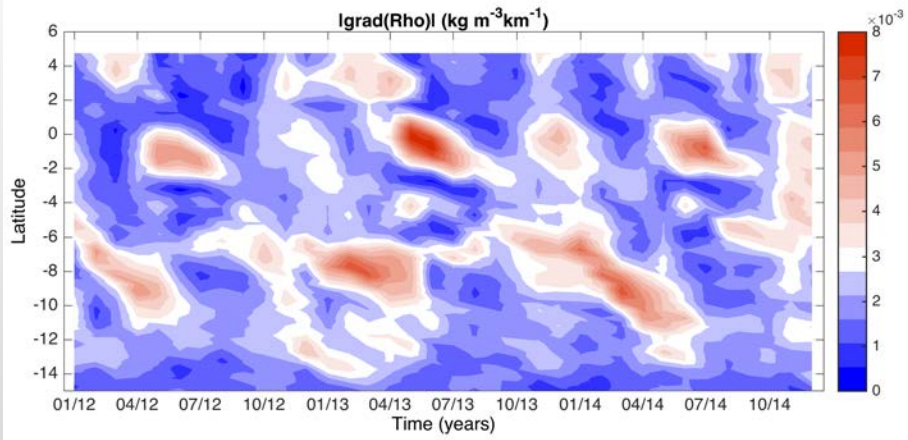
The variability of the CR plume position is driven by the surface current forced by the wind stress [Hopkins et al., 2013].

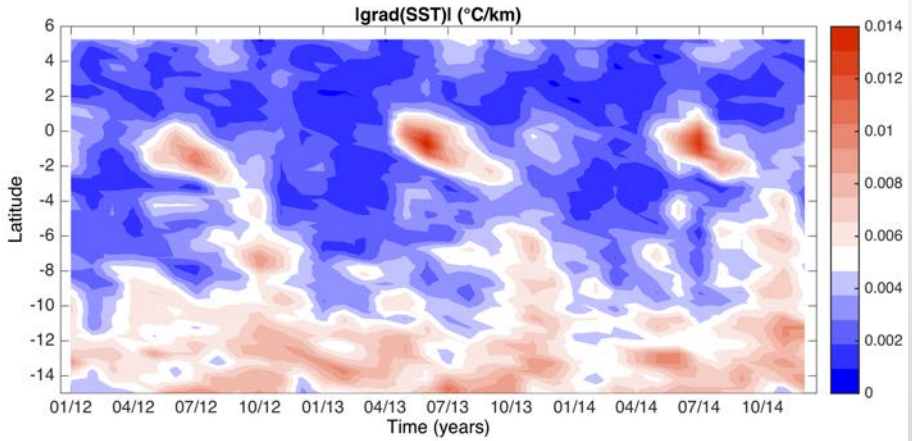
Front 4: Guinea Gulf

Hovmoller (lat vs time)









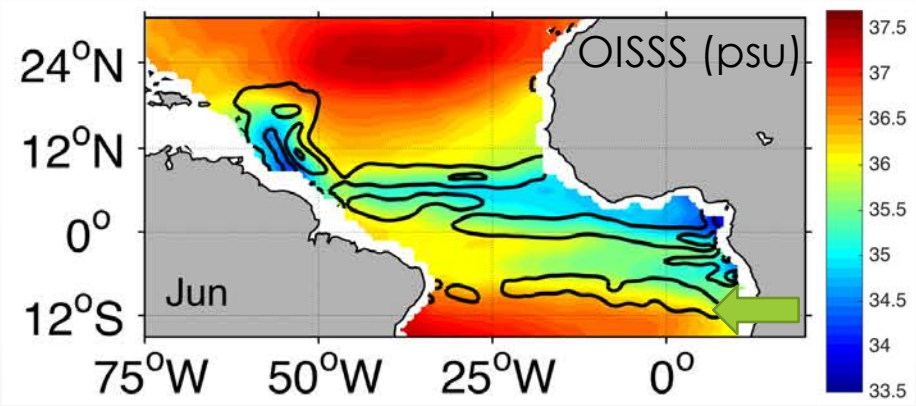
|grad(Rho)| ~ |grad(SSS)|

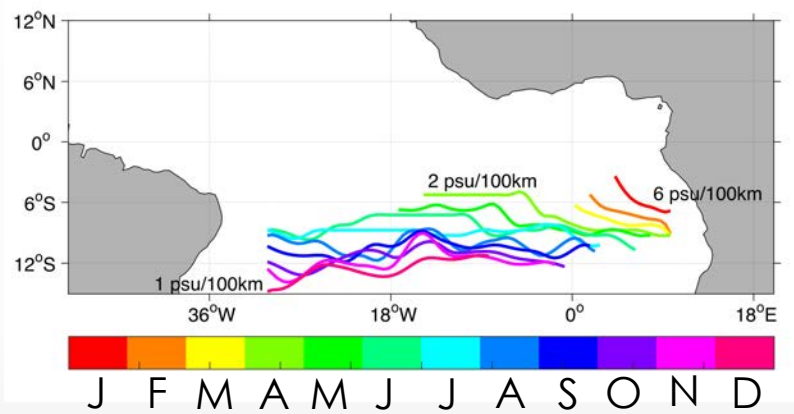
(R>1)

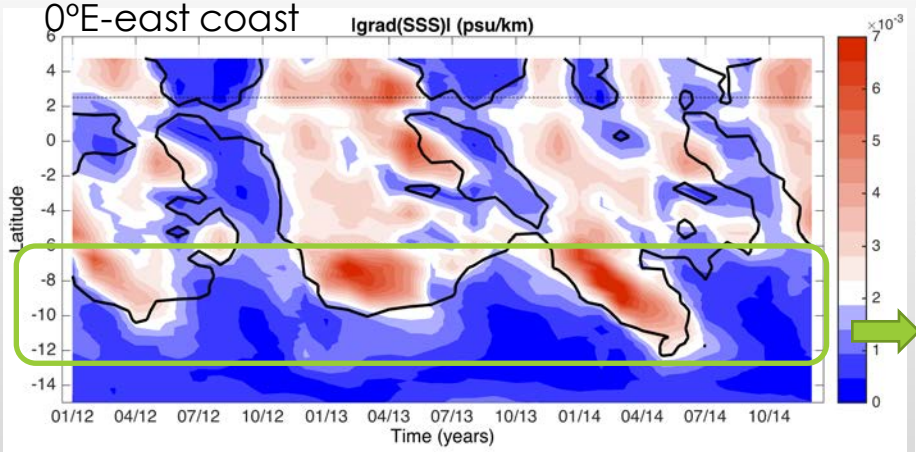
|grad(SST)| negative effect in the density

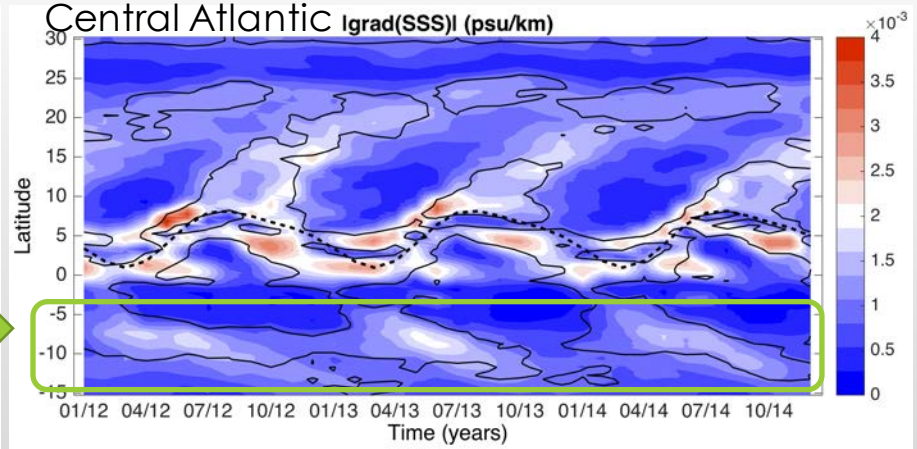
Front 5: South Subtropical

Front 5: South Subtropical





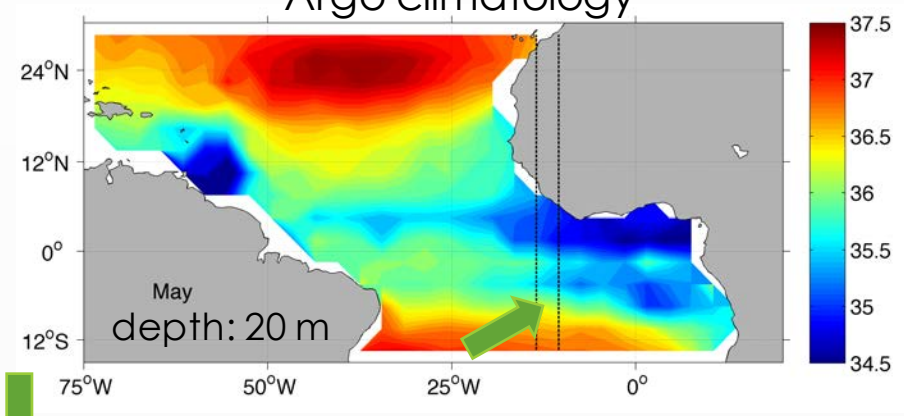


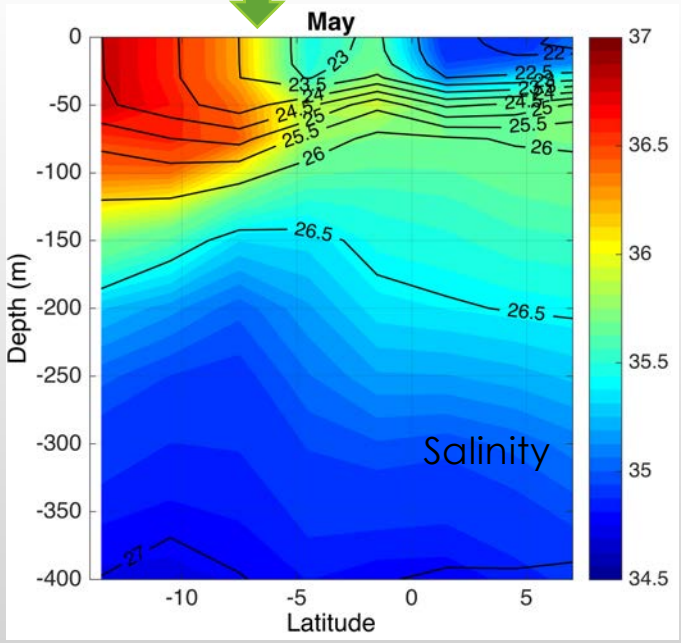


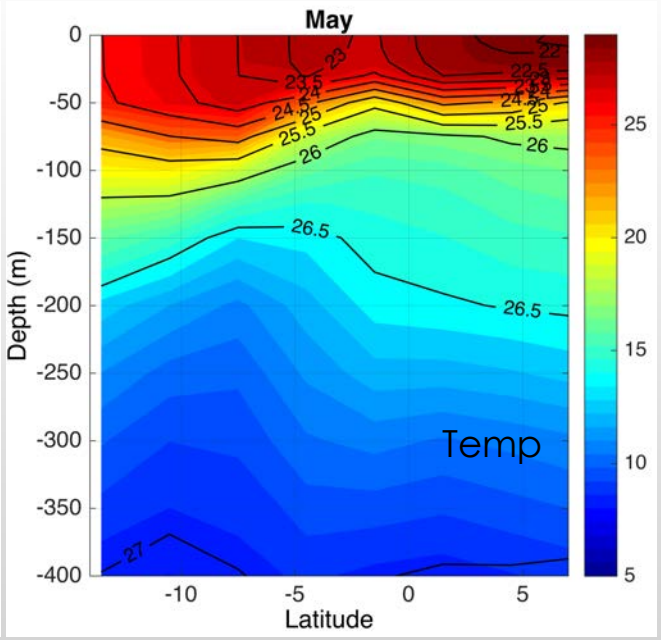
The SSS front is observed from **February to July** and while it is moving to the west decreases its intensity.

Front 5: South Subtropical

Argo climatology

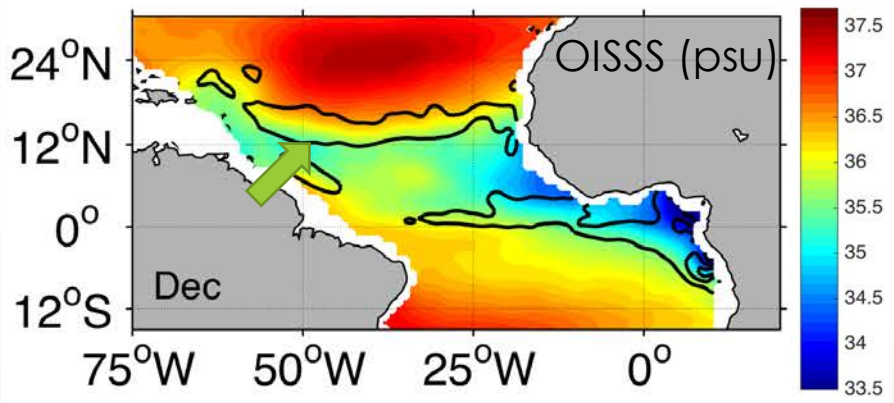


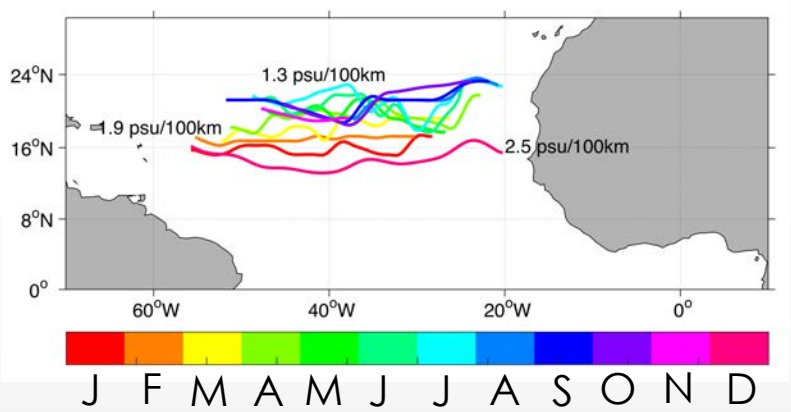


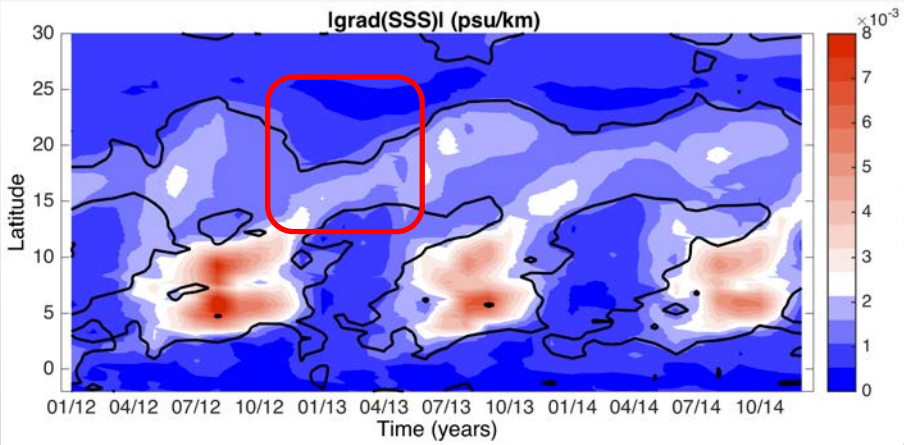


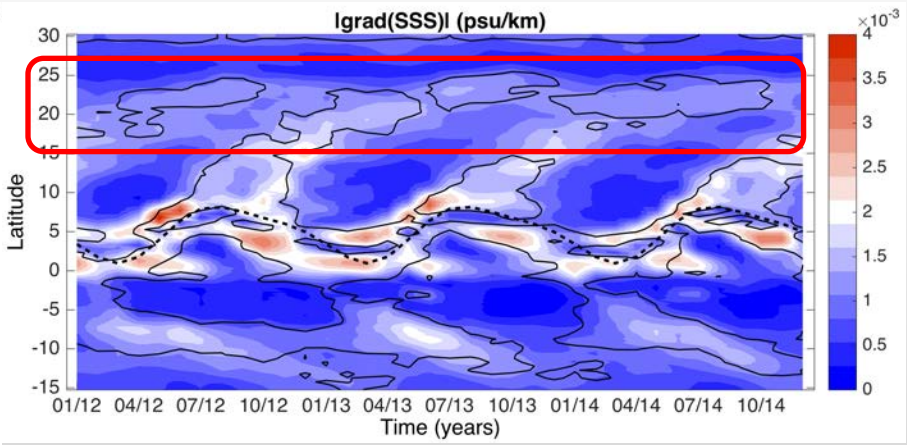
Front 6: North Subtropical

Front 6: North Subtropical



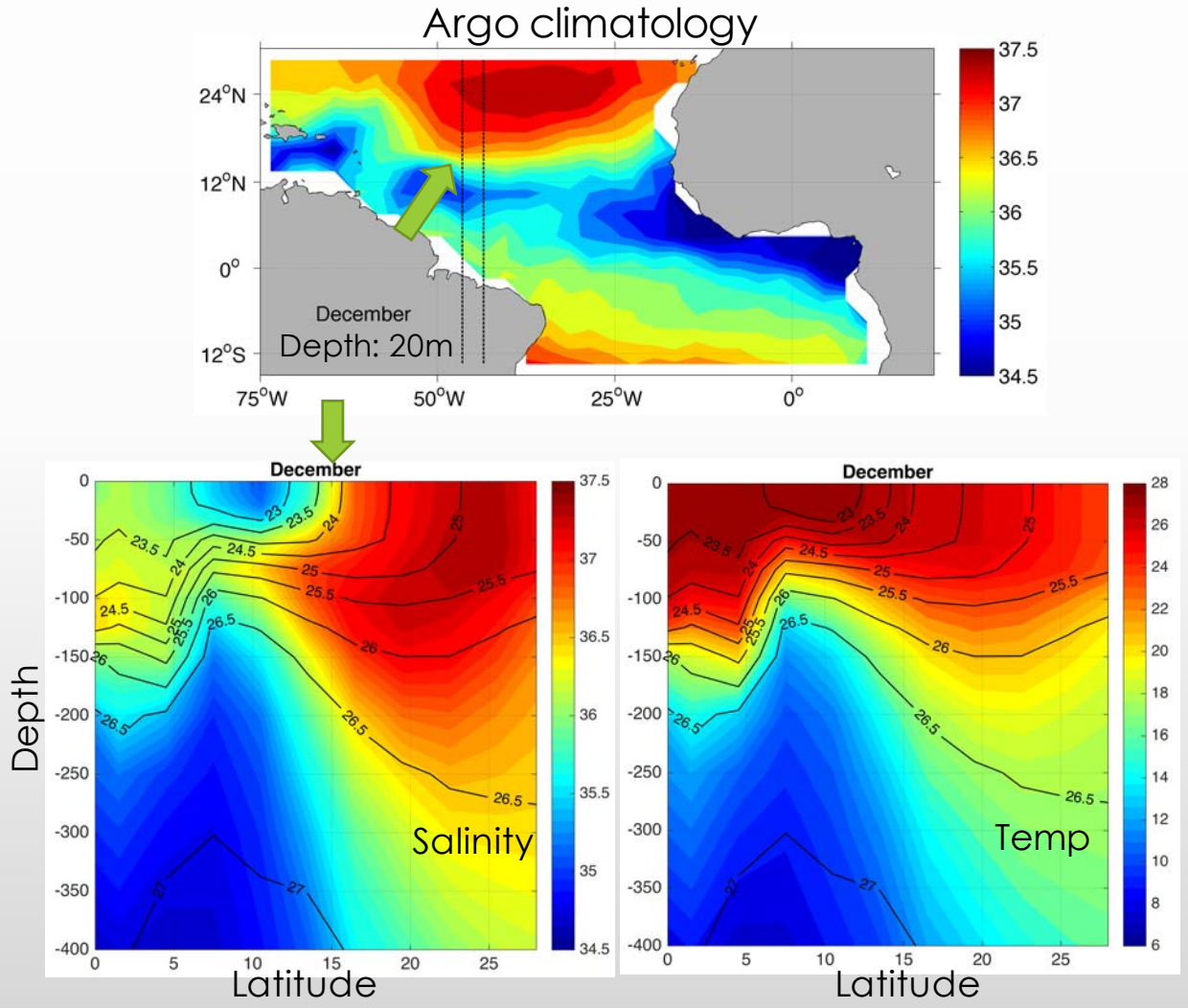






Detachment of Front 2. Starts in **September** and meets the northern edge of the SSS front associated with the AR, and practically disappears in **April**. The front moves poleward due to the trade wind driven Ekman processes [Yu, 2015].

Front 6: North Subtropical



CONCLUSIONS

- From the |grad(SSS)| are observed six frontal system: Amazon river, ITCZ, Equator, Gulf of Guinea, south subtropical and north subtropical.
- All the SSS fronts present a seasonal variation related with the variability of the surface salinity.
- The strongest salinity fronts are associated to the AR plume and CR plume. And the weakest with the advection.
- The salinity gradient dominates the density, except at the Equator.
- The strongest density fronts are observed when the salinity and temperature variations contribute each other.

Thank you for your attention

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