Enhancement of satellite SSS evaluation:

Assessment of SSS gradients

Main focus:

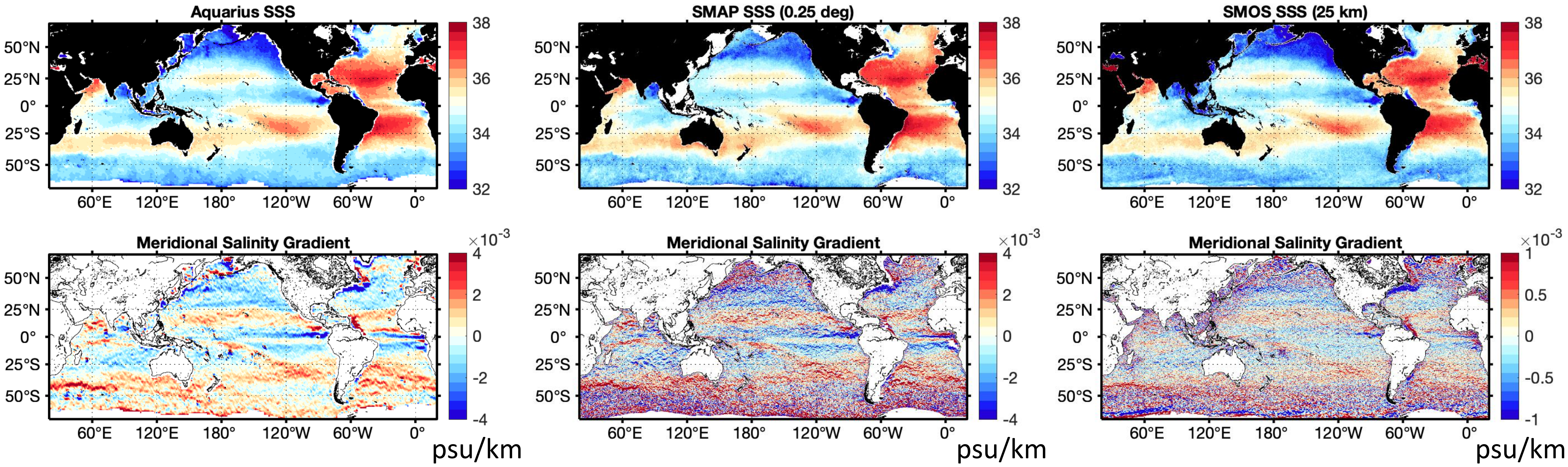
A systematic estimation and assessment of satellite SSS gradients over the global ocean, including the spatiotemporal variability. Regional analyses are within the scope of this WG.

First two principal tasks of salinity gradient assessment at ESR

- Cover regional to basin scales, and produce a global SSS gradient database including Aquarius, SMAP, SMOS and Argo gridded data for science community open-access
- Perform regional studies where SSS gradients are likely to influence ocean dynamics and air-sea interactions on synoptic to climate time scales, including Gulf Stream, Eastern and western tropical Pacific, Agulhas retroflection currents, Amazon-Orinoco river plume

Global maps of satellite SSS and meridional salinity gradients (dS/dy) on May 2015 on their original spatial resolutions

Aquarius | SMAP | SMOS

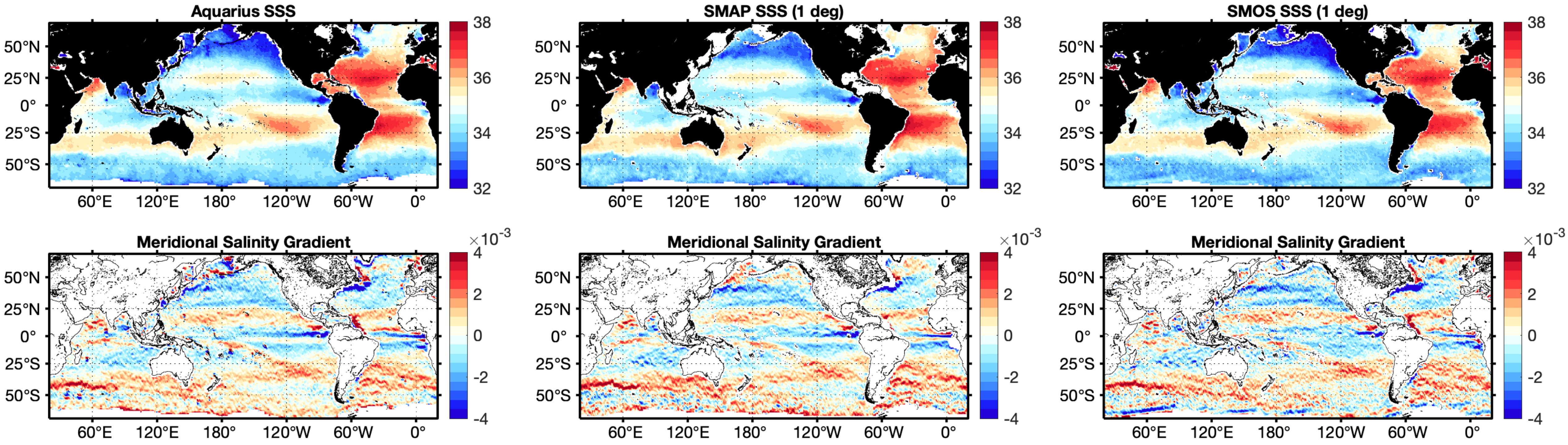


Global salinity patterns are generally similar except the coastal regions and high latitudes.

Salinity gradients are hard to compare when calculated on different spatial scale on monthly maps.

Global maps of satellite SSS and meridional salinity gradients on May 2015

with the same spatial resolution (1deg)

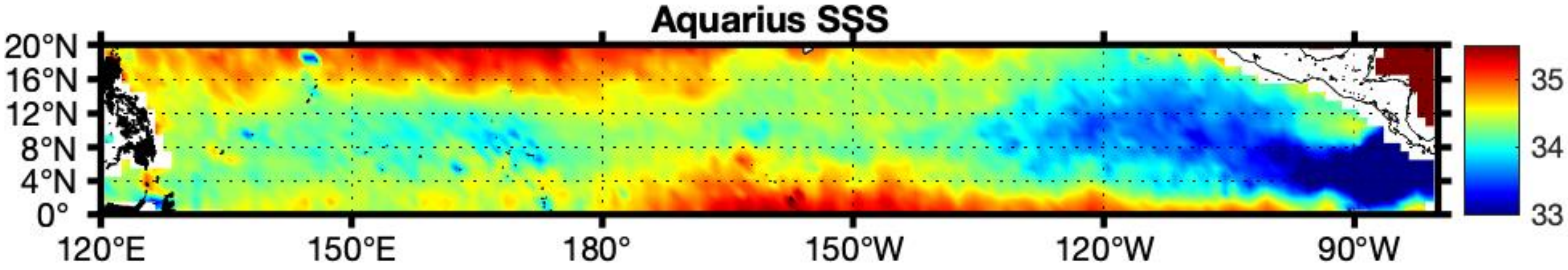


Similar salinity gradient patterns are observed on same spatial resolution for monthly maps.

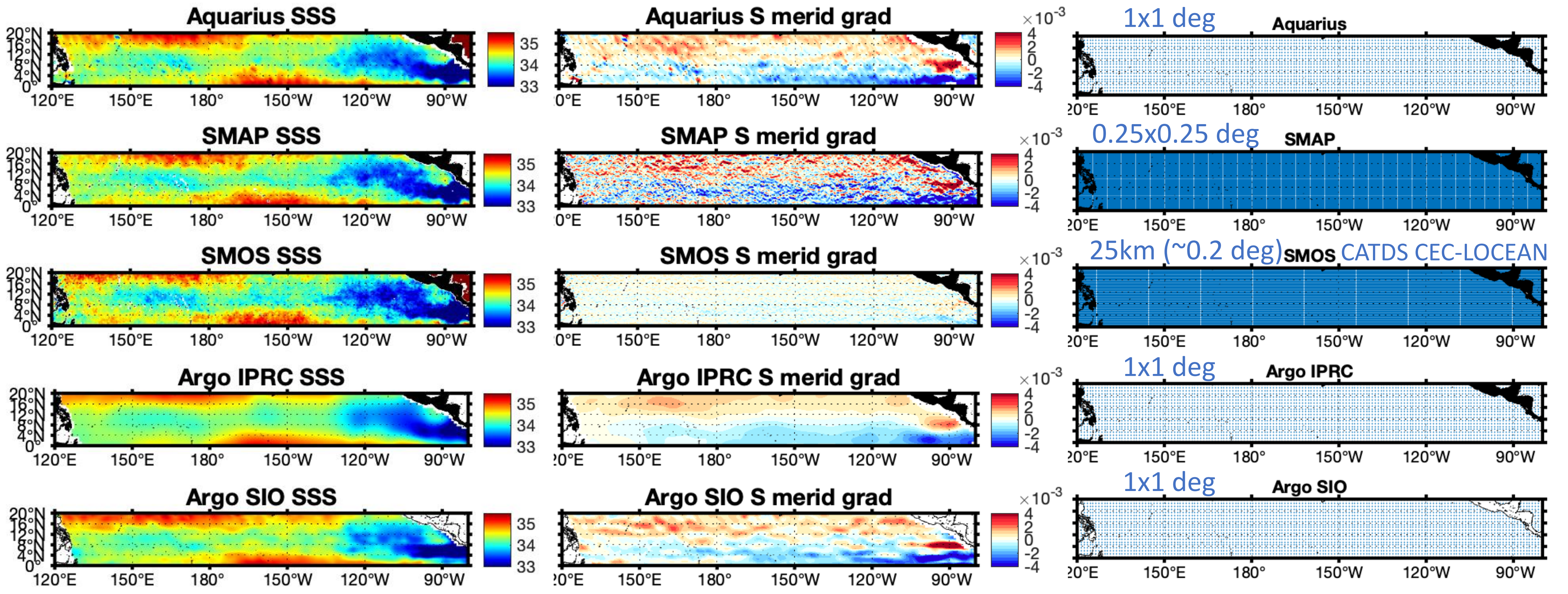
Regional analysis of some interest areas

- Tropical Pacific (monthly variation associated with ENSO)
  1. ITCZ
  2. Eastern Pacific
  3. Western Pacific
- Amazon-Orinoco Plume (daily variations)
- Western boundary currents (daily variations)
  1. Gulf Stream
  2. Kuroshio
  3. Agulhas Currents

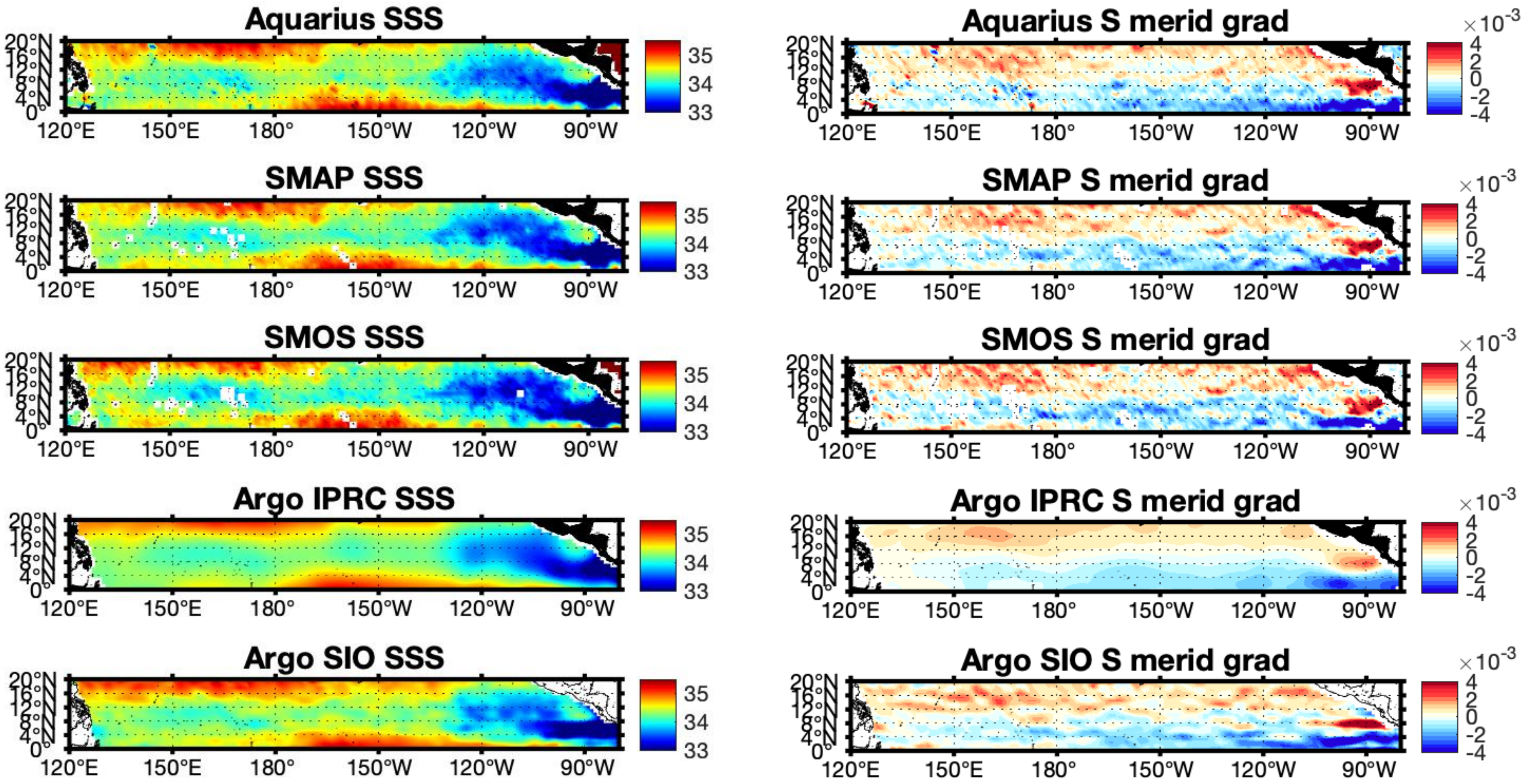
Monthly Variations of SSS and Salinity Fronts under Pacific ITCZ



Comparisons of 5 datasets on 5/2015 over ITCZ
with different spatial resolutions



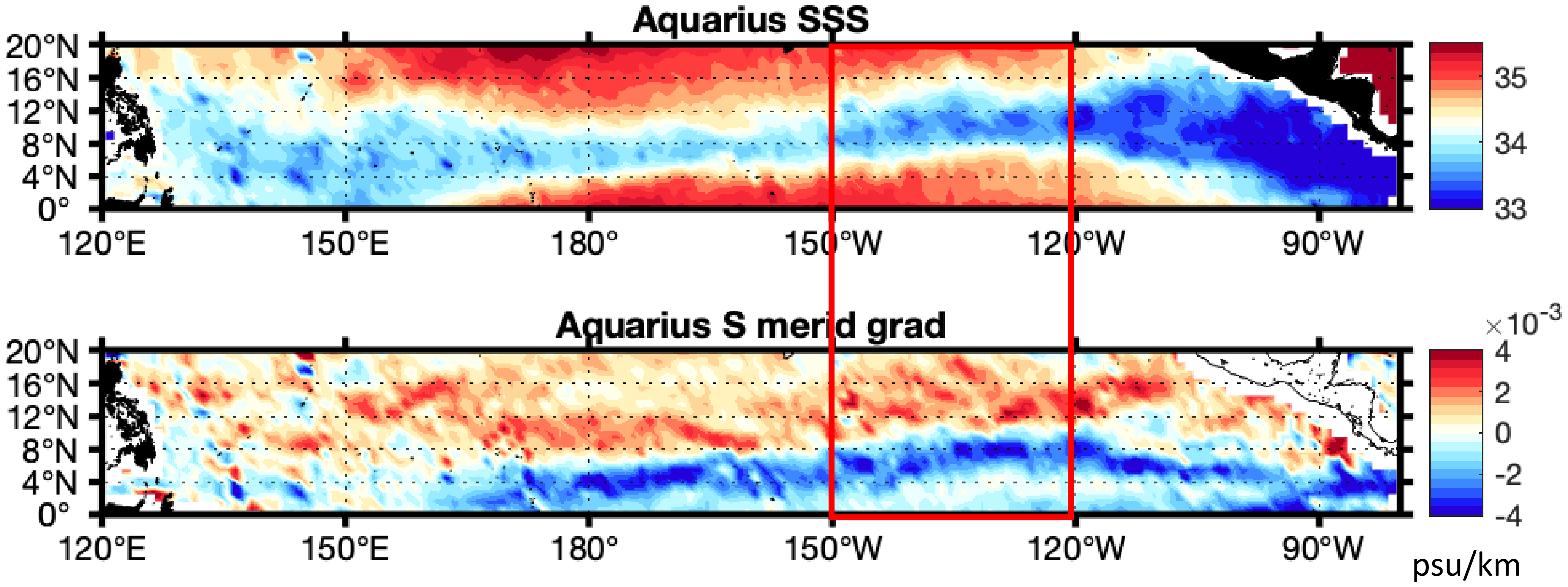
Comparisons of 5 datasets on 5/2015 over ITCZ *with the same spatial resolutions*



Salinity gradients should be compared with the same spatial resolutions

Salinity fronts under Pacific ITCZ in September 2014

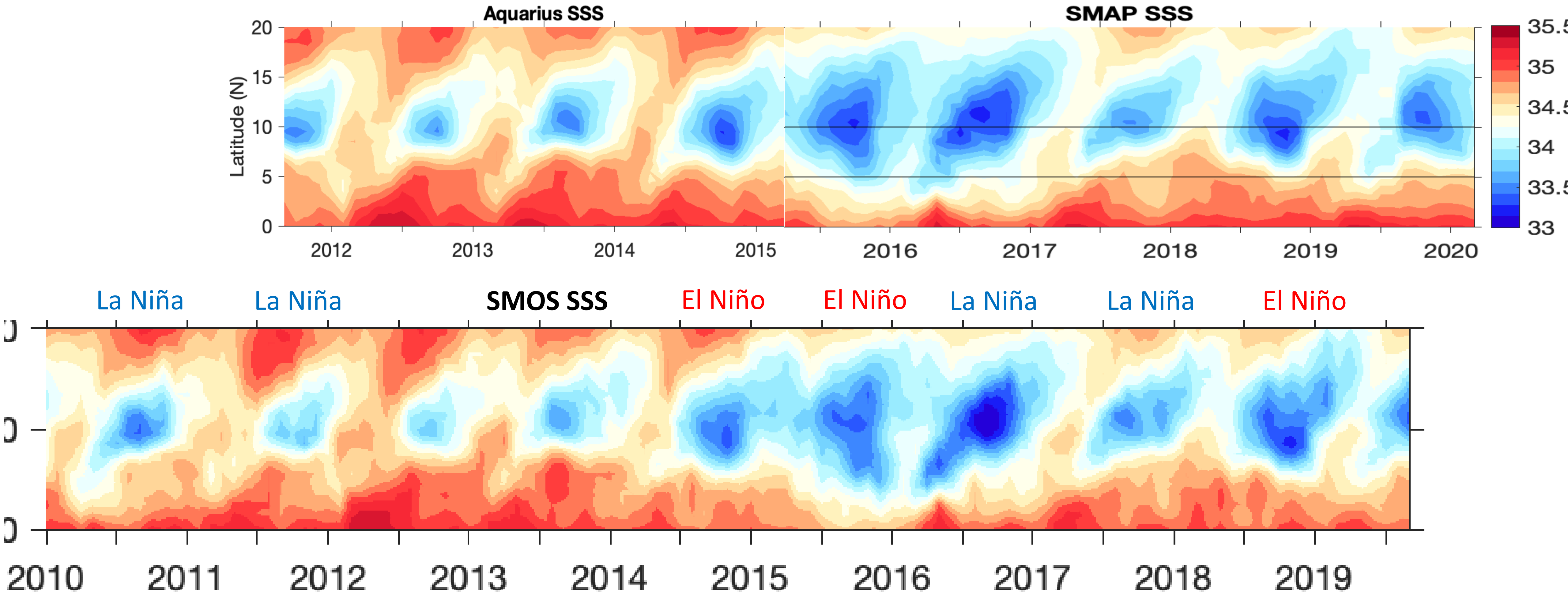
It is known that Pacific ITCZ are strongest in September with a band of freshwater underneath with positive/negative meridional salinity gradients at the north/south bound.



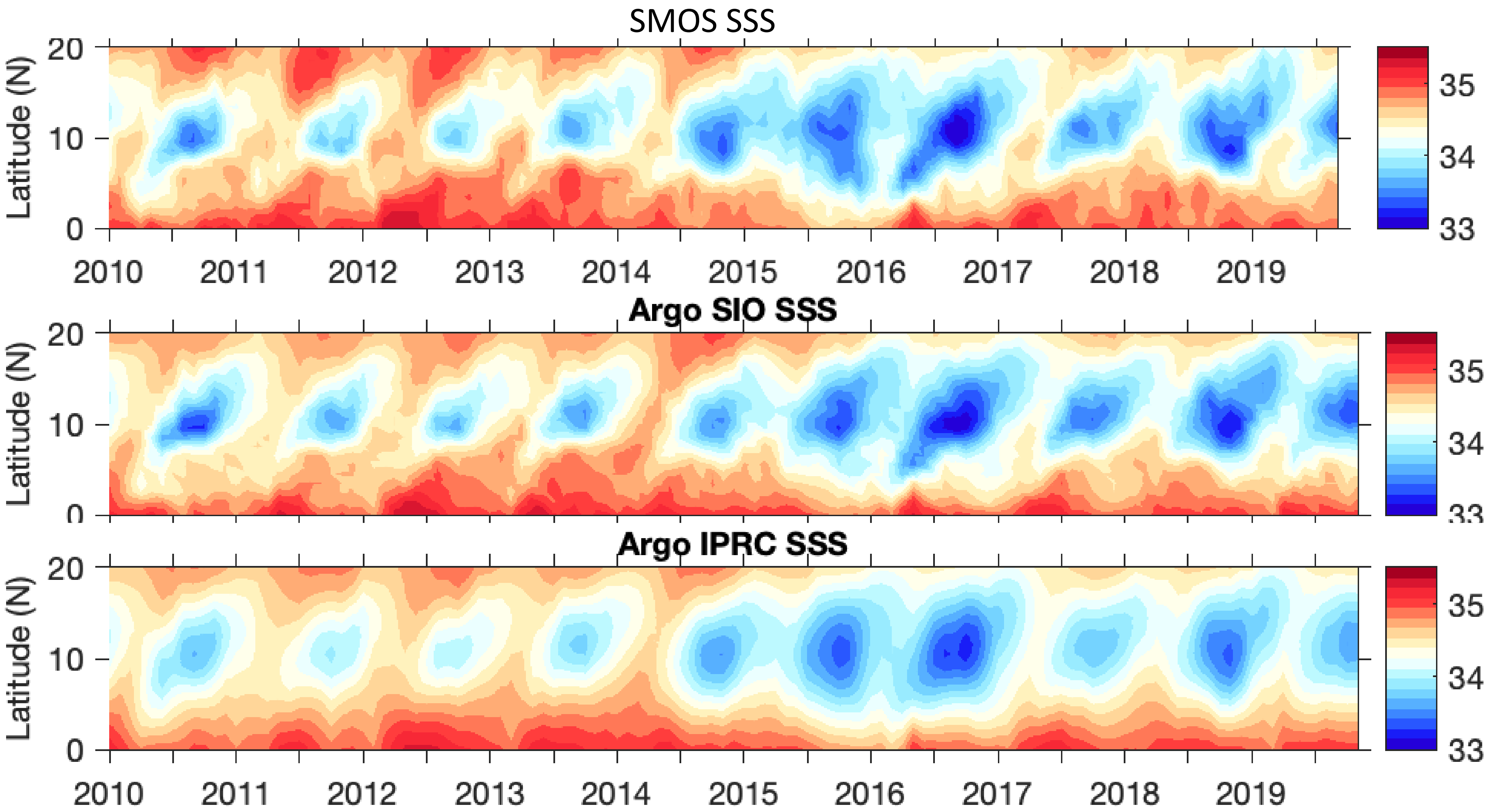
We average the SSS and salinity gradients between 120˚W to 150˚W to see their latitudinal variations related to the ENSO activities.

Hovmöller diagrams of SSS averaged between 120˚W and 150˚W

The salinity differences between Aquarius and SMAP under Pacific ITCZ is due to the ***interannual variations*** not biases.



Latitudinal SSS variations (SMOS and Argo)

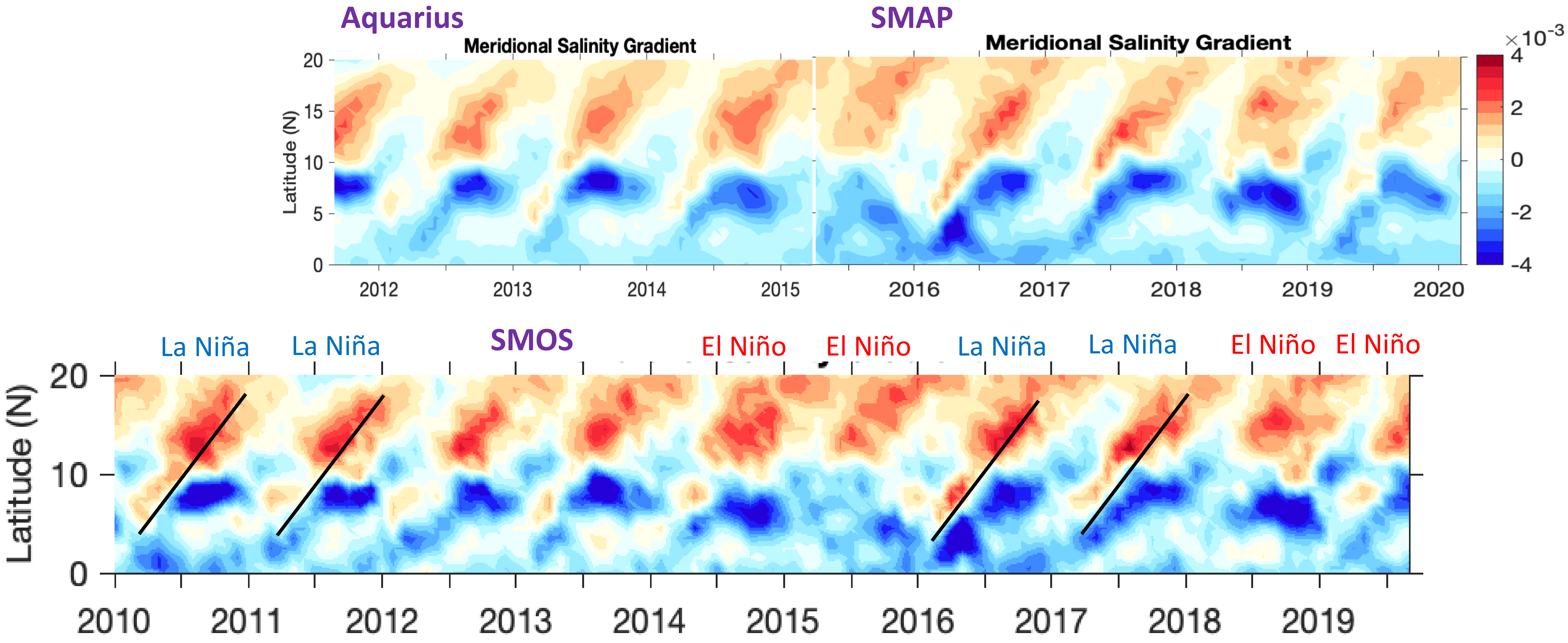


Argo data also show that the SSS under Pacific ITCZ are fresher in the later five years than the early five years.

Seasonal variations of ITCZ in satellite SSS

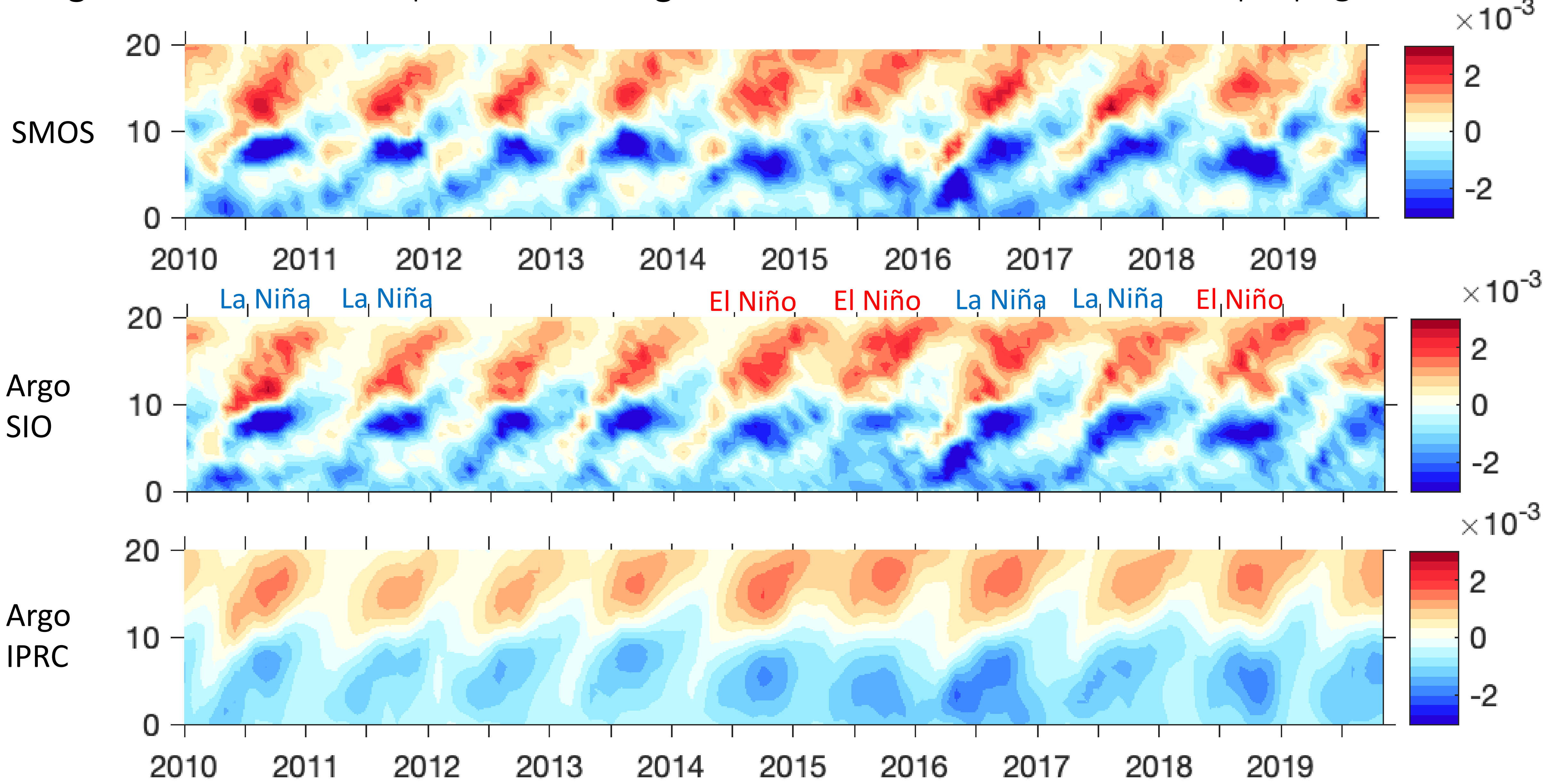
Meridional salinity gradients

Northward propagation of Salinity fronts are more obvious in La Niña years.

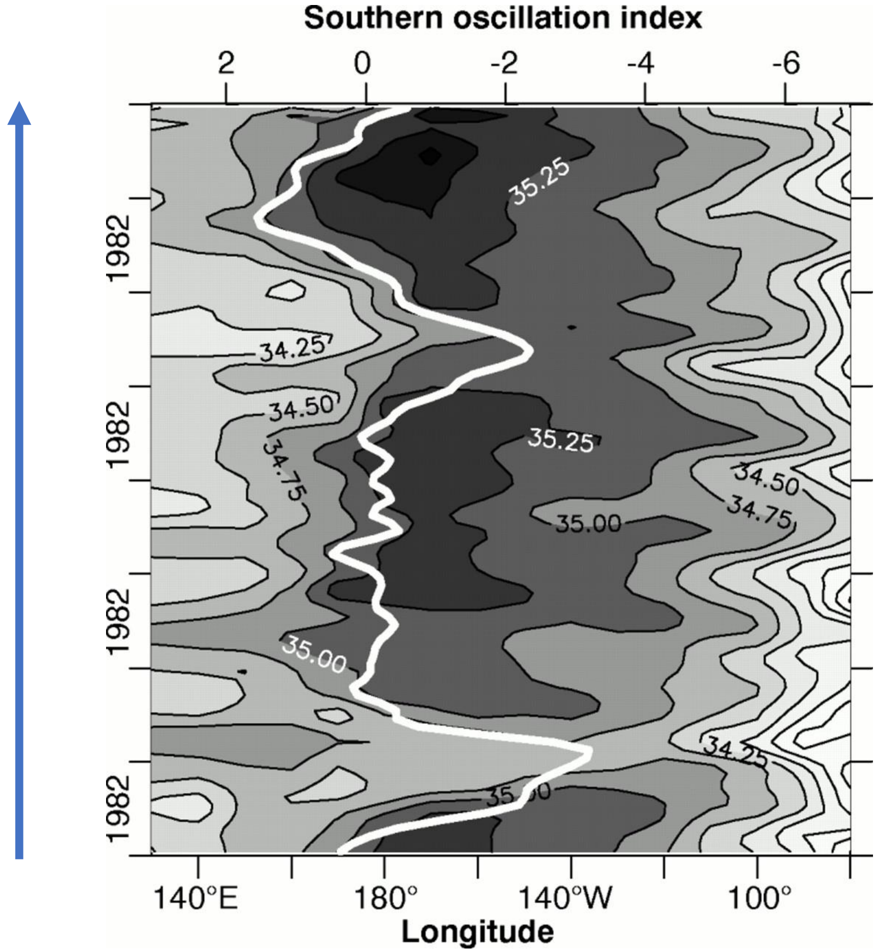


10-year variations of salinity gradients under ITCZ in SMOS and Argo

Argo-SIO shows similar pattern, but **Argo-IPRC** is too smoothed to see the propagation



Monthly Variations of Salinity Fronts in the *Western Equatorial Pacific*



Picaut et al. 1996 *Science*

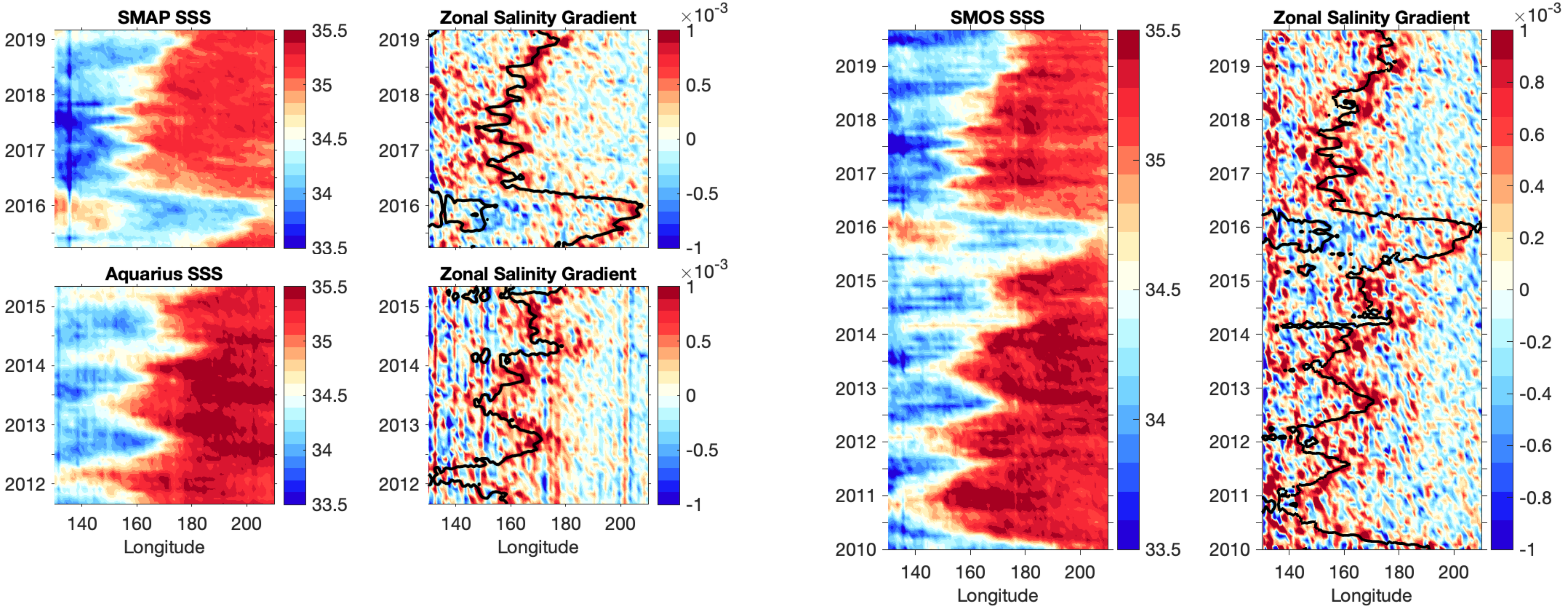
Longitude-time distribution of 4˚N-4˚S averaged sea-surface salinity obtained from a ship-of-opportunity network and sparse hydrological data. The southern oscillation index (SOI) is superimposed as a thick white line.

The zonal advection of the salinity fronts are highly correlated with ENSO activities.

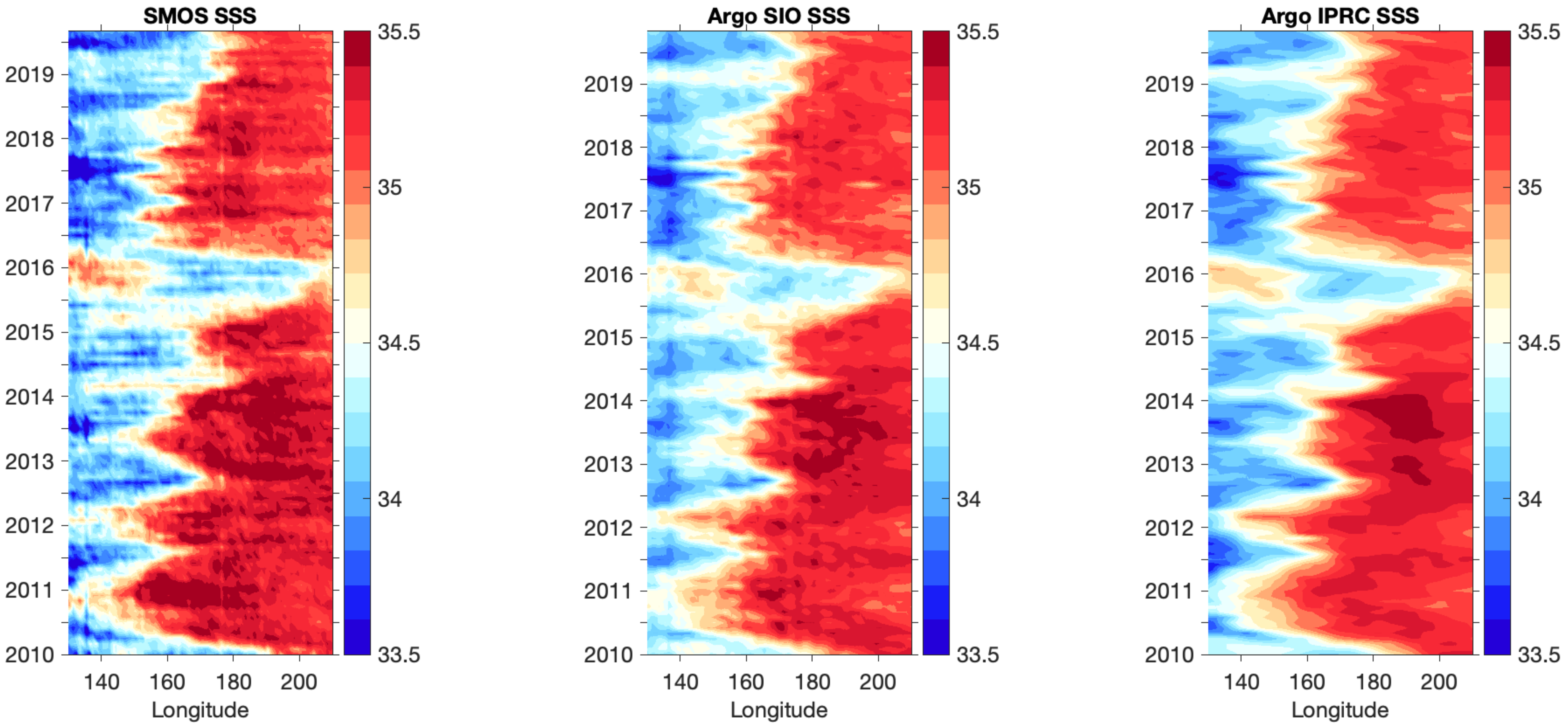
Zonal salinity advections in the western equatorial Pacific

Salinity fronts shift eastward during El Niño years and westward during La Niña years due to the changes of the trade winds.

Black contour shows 34.6 psu isohaline



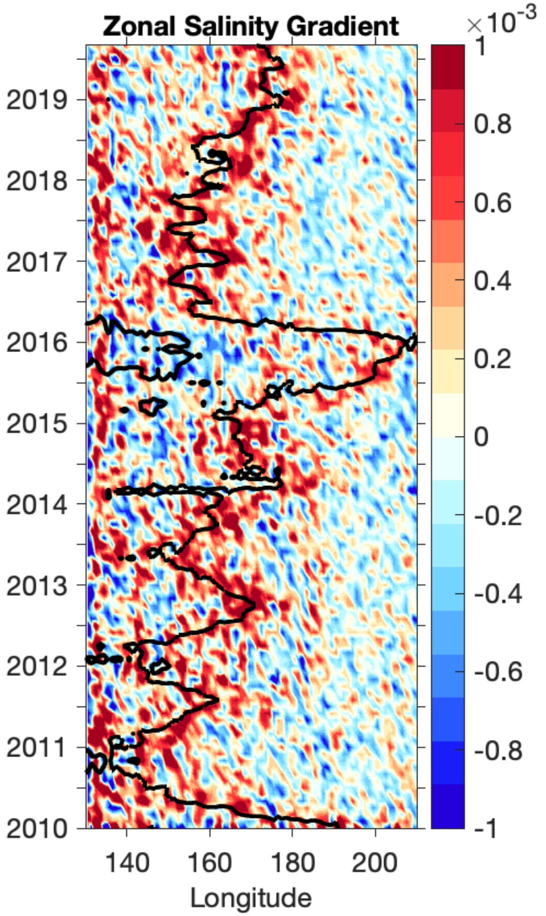
SSS zonal advections in the western equatorial Pacific



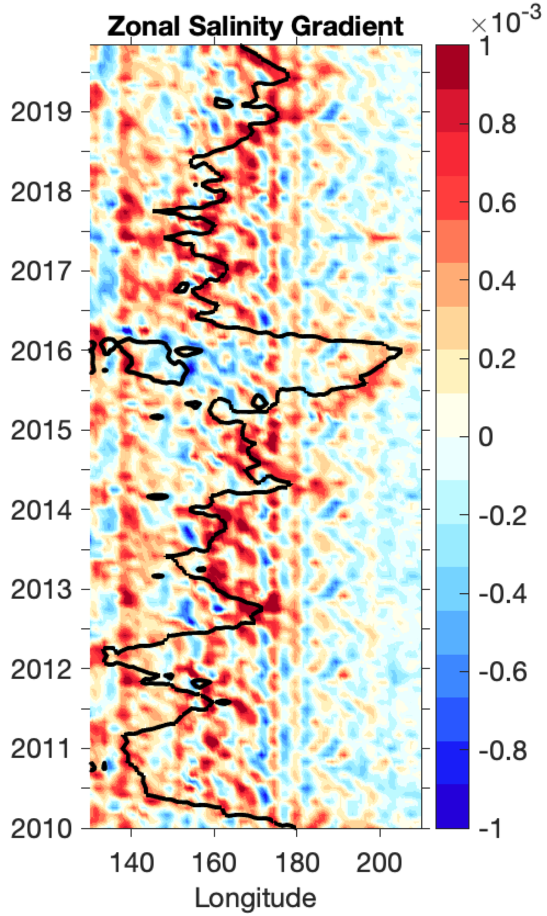
Zonal salinity advections in the western equatorial Pacific

black contour line shows the 34.6 isohaline

SMOS

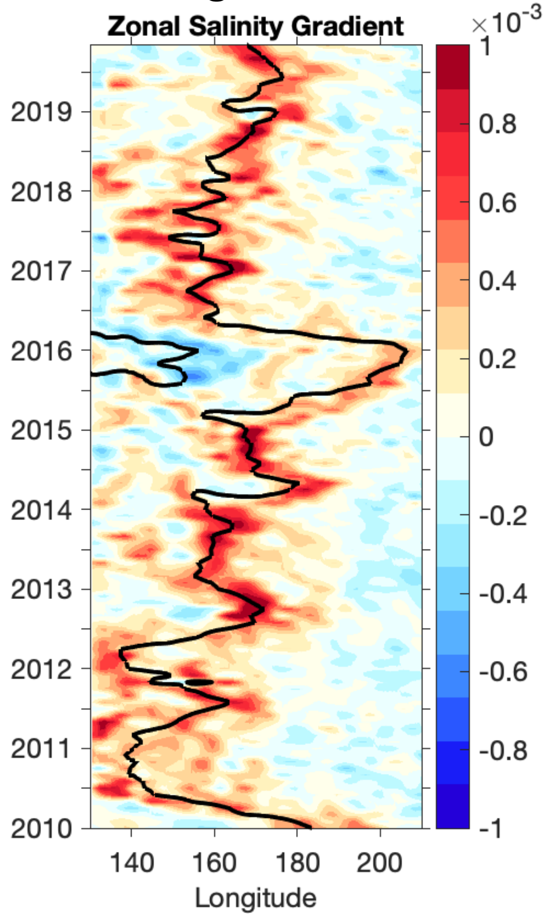


Argo SIO



Some strange patterns may be caused by islands

Argo IPRC

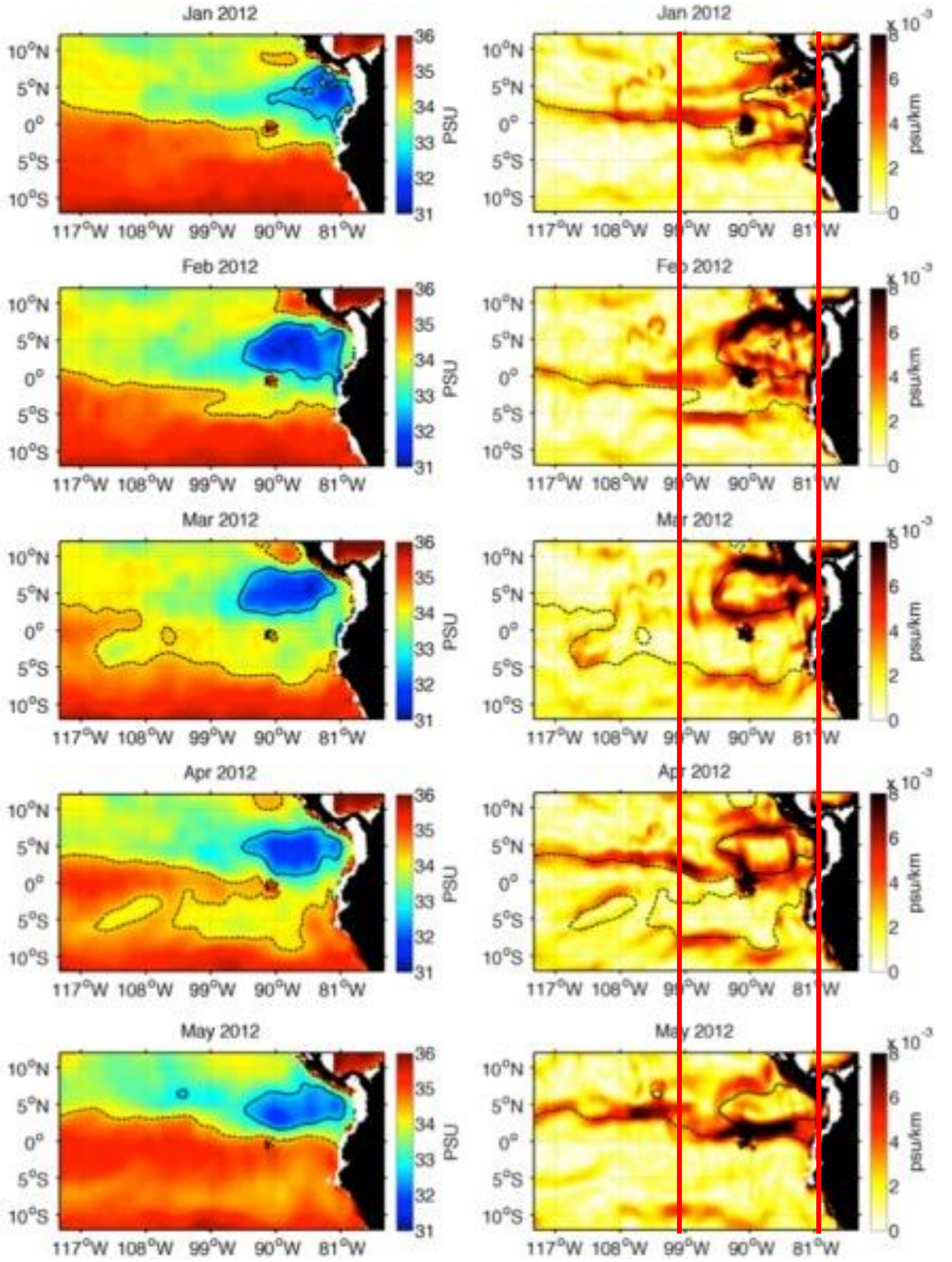


Too smooth to show finer-scale structures.

Monthly Variations of Salinity Fronts in the *Eastern Equatorial Pacific*

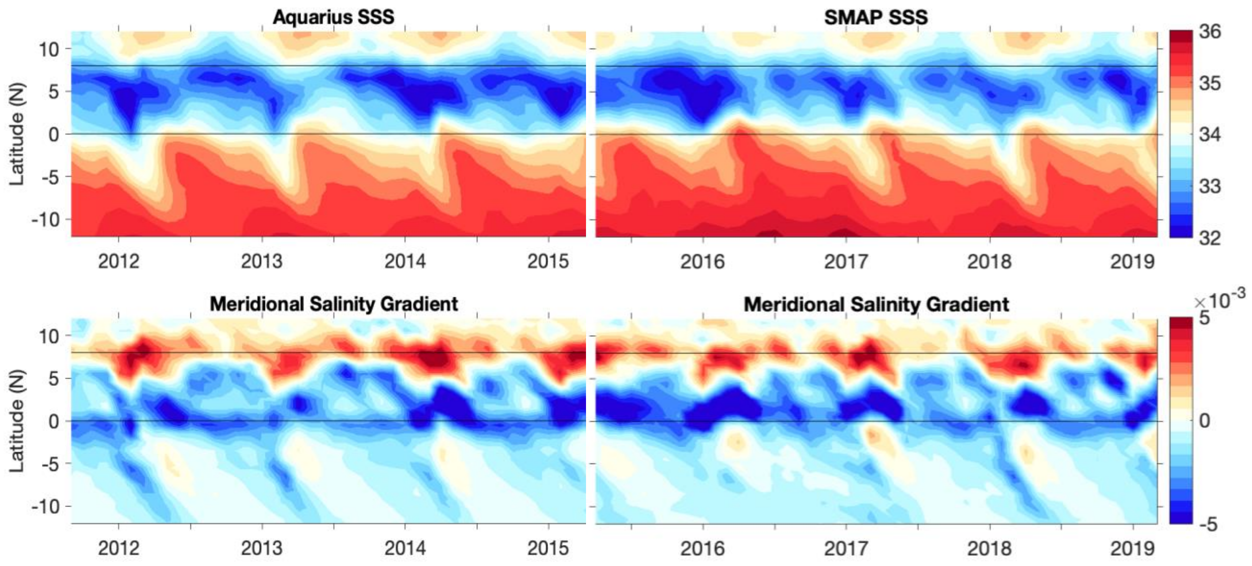
Kao and Lagerloef, 2015 *JGR, Ocean*

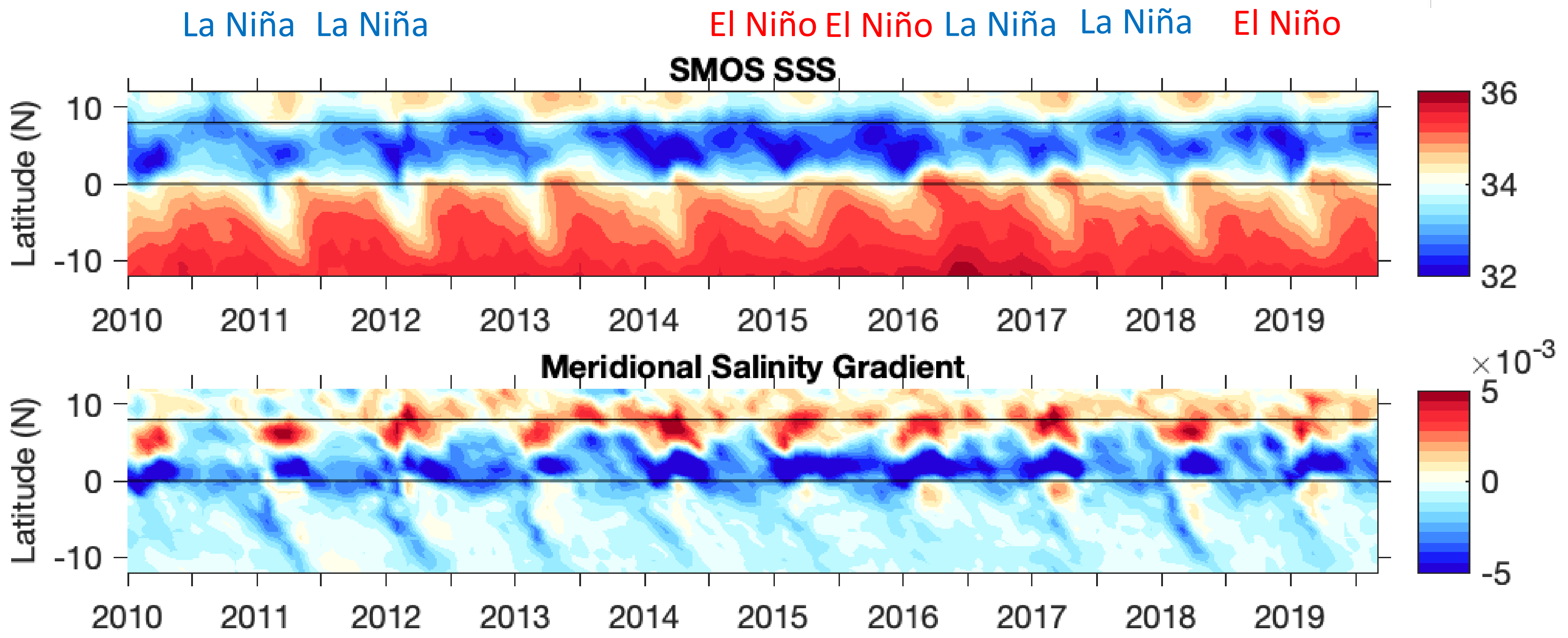
Horizonal salinity gradients contour the eastern Pacific fresh-pool and show the southward propagation of double ITCZ from February to May



Hovmöller diagrams of SSS
averaged between 80˚W and 100˚W

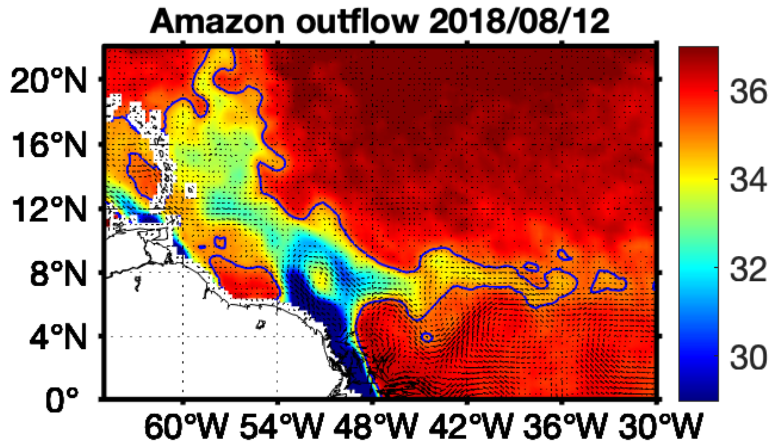
The southward propagation of second ITCZ in the eastern Pacific is more obvious during La Niña years.





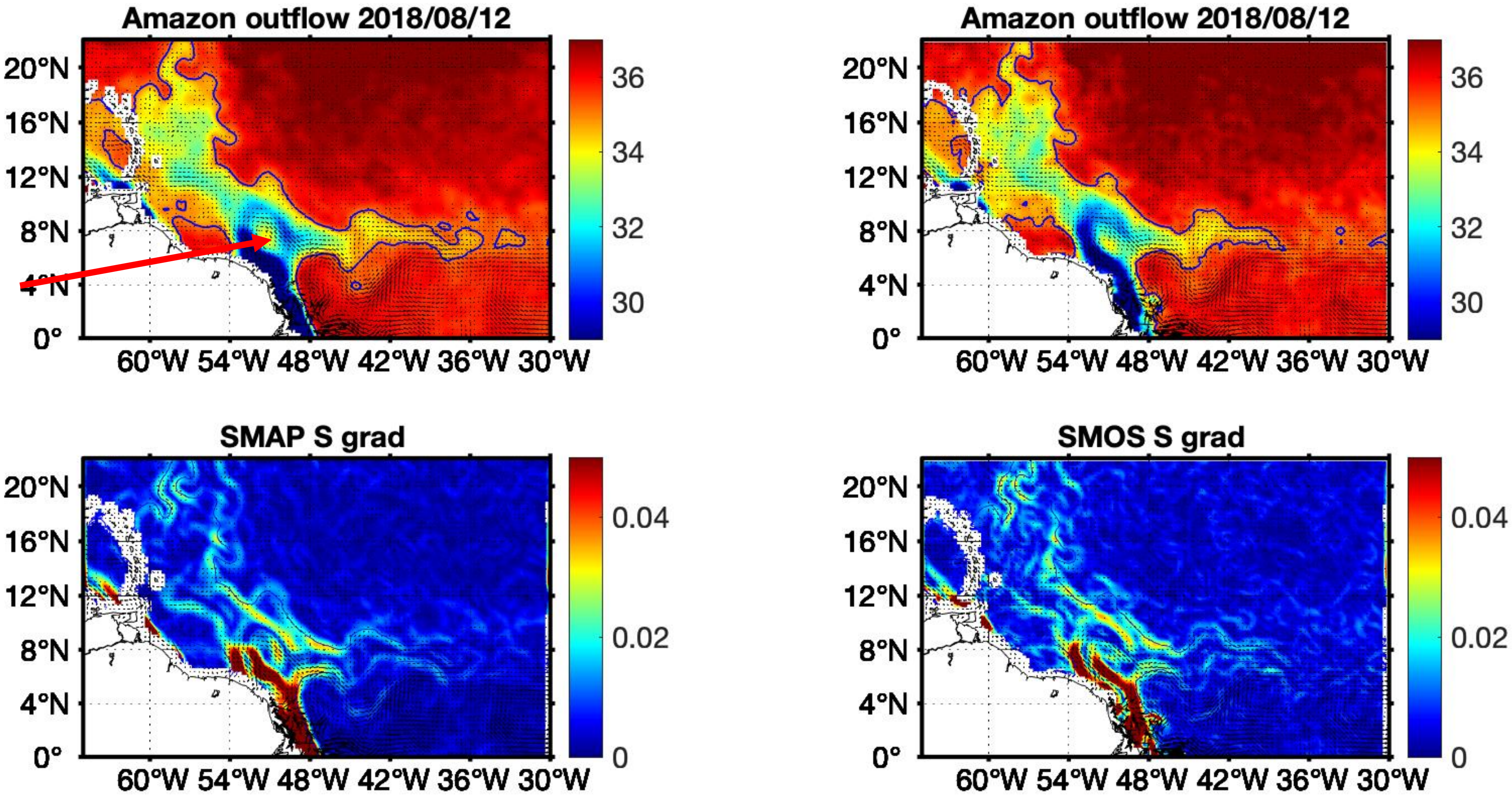
Daily Variations of Salinity Fronts at Amazon-Orinoco Plume

SMAP and SMOS

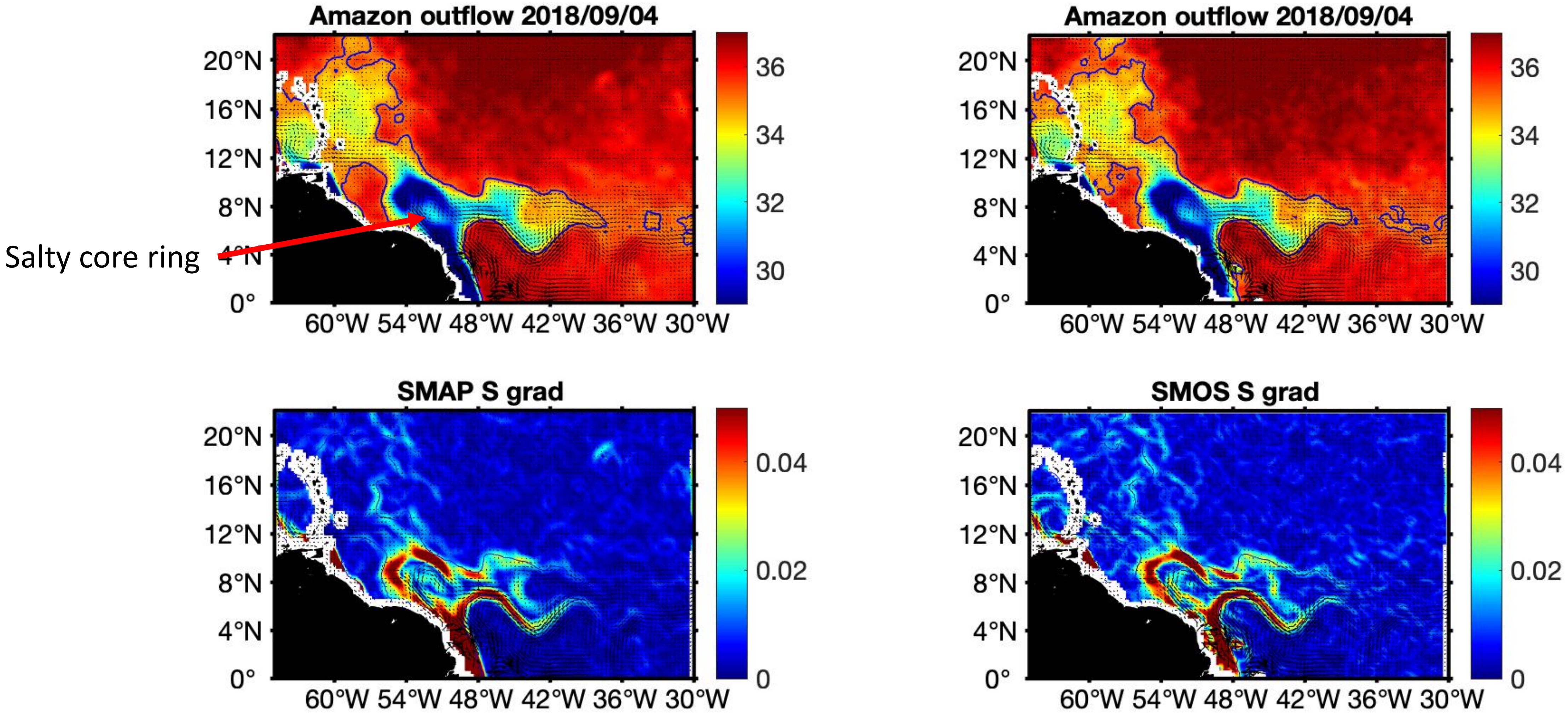


Snapshot of Amazon outflow on 2018/8/12

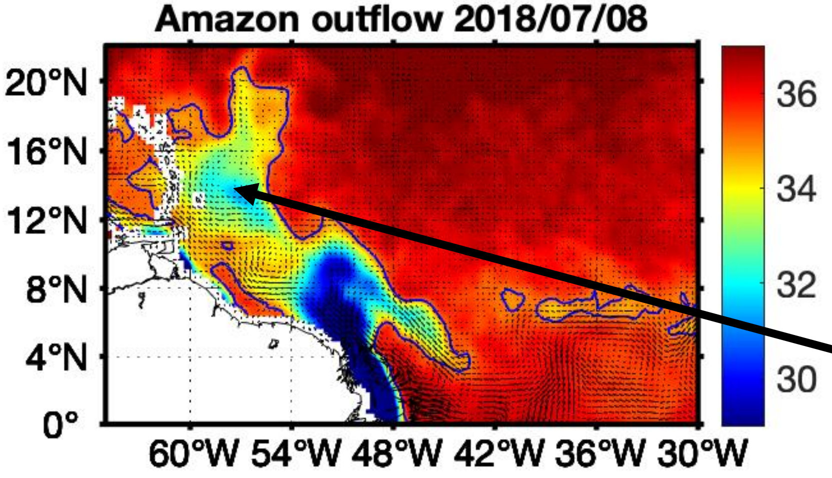
original spatial resolution

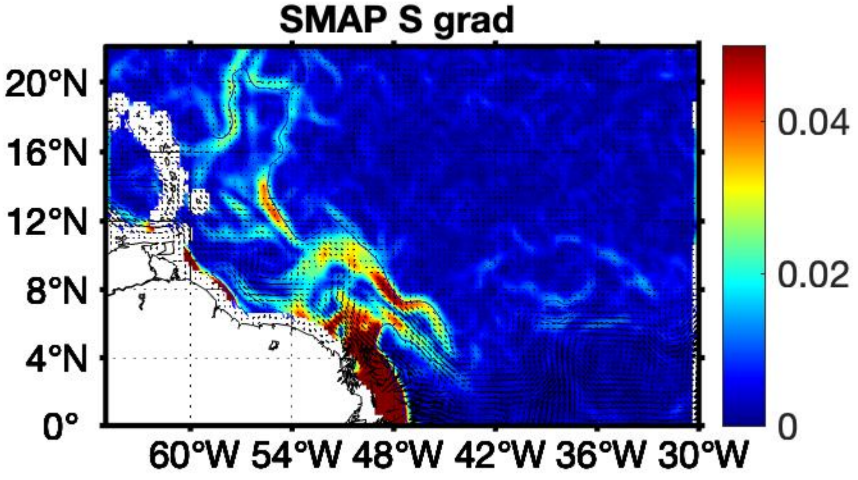


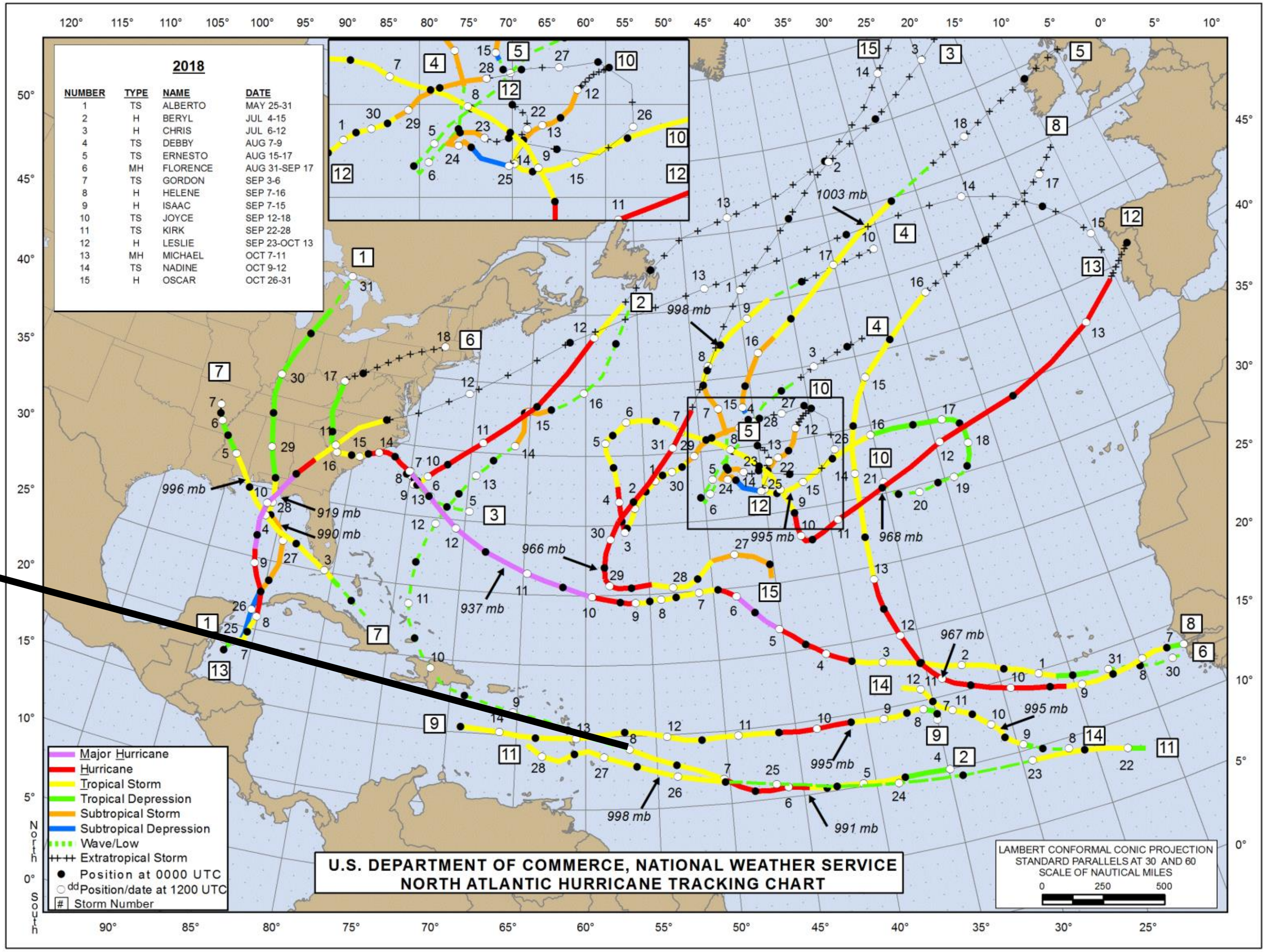
Snapshot of Amazon outflow on 2018/9/4



Variations related to hurricane activities



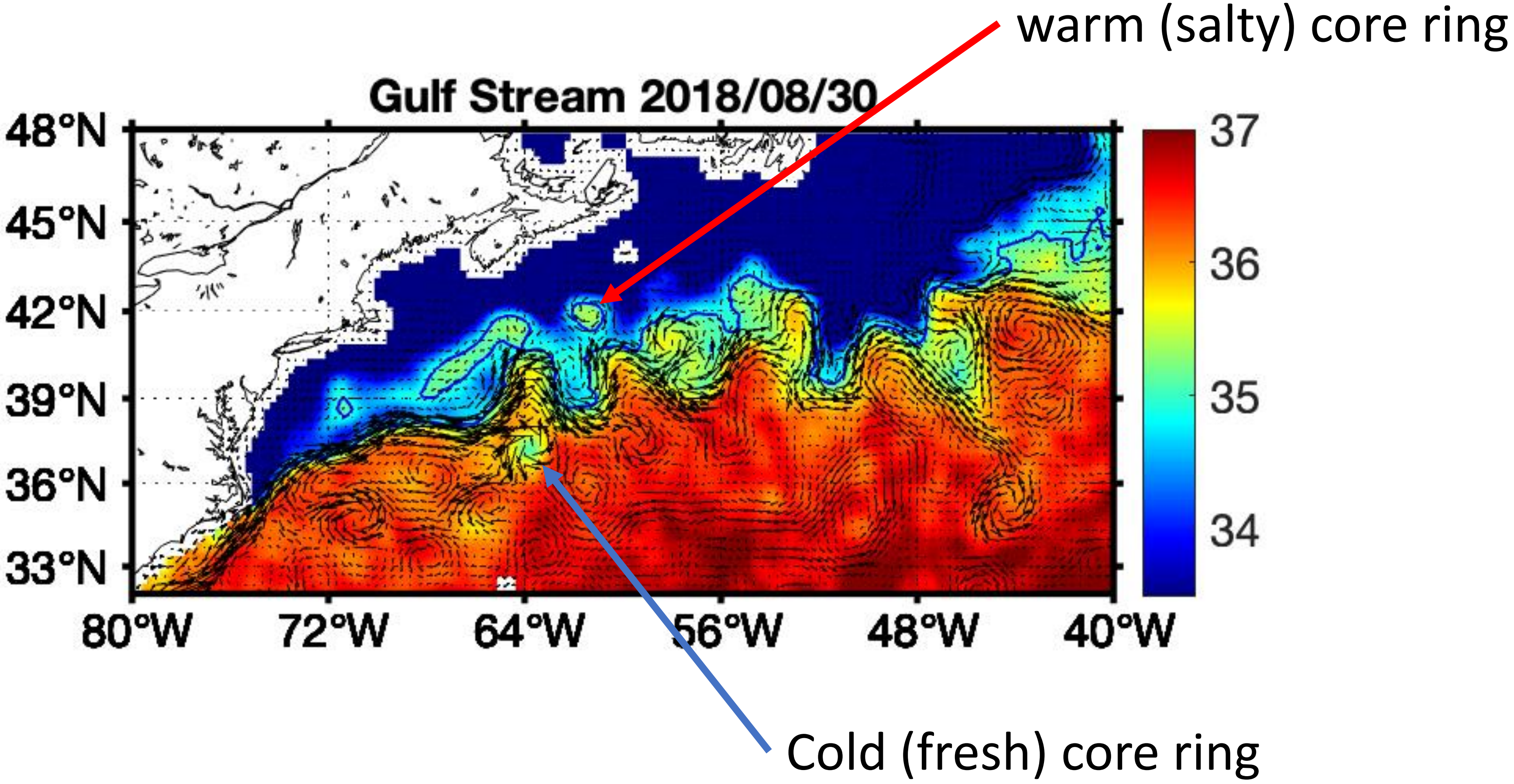




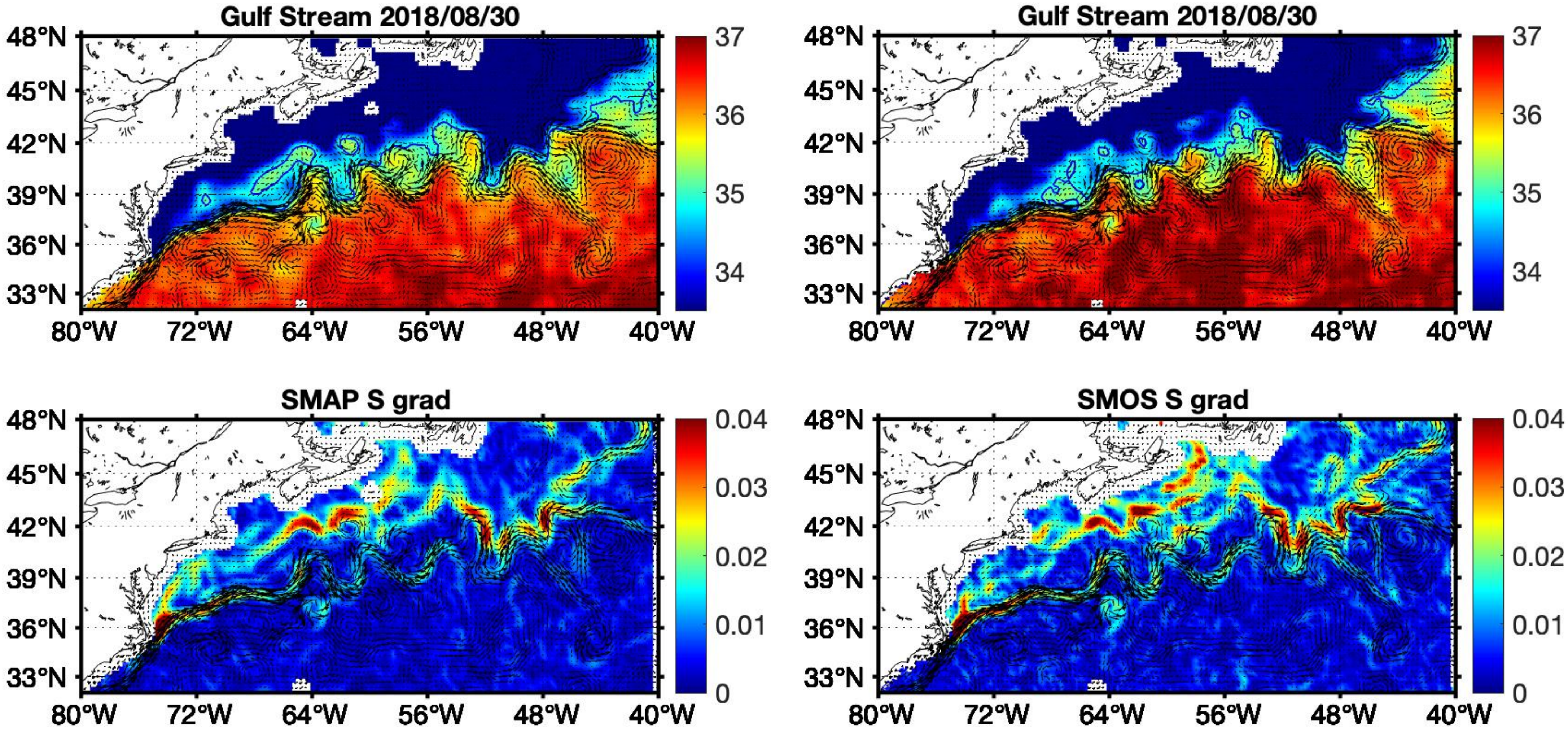
Future work: Investigate the hurricane induced salinity variations in Amazon plume

Daily Variations of Salinity Fronts along Gulf Stream

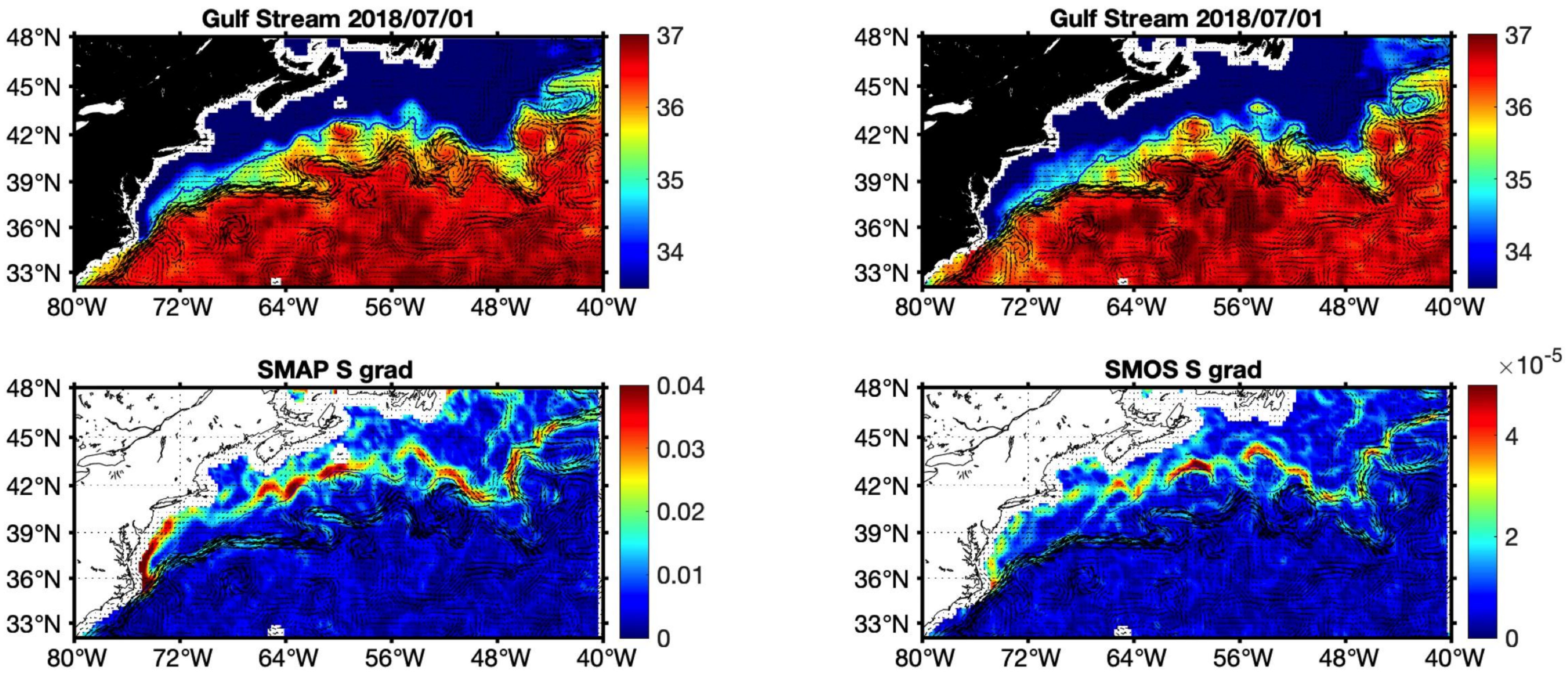
SMOS and SMAP



Snapshot of Gulf Stream on 2018/8/30

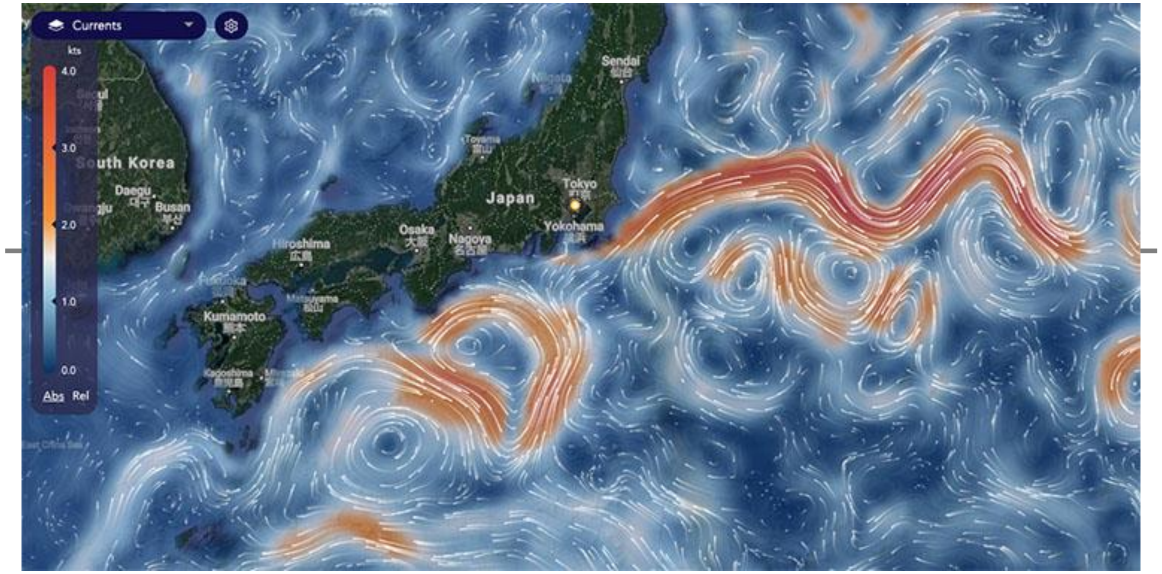


Animation of salinity maps along Gulf Stream



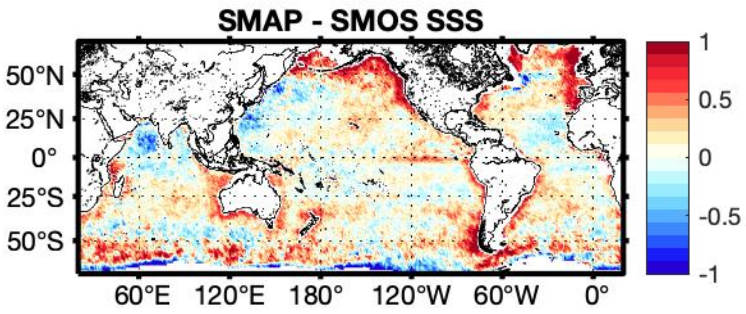
Daily Variations of Salinity Fronts at Kuroshio currents

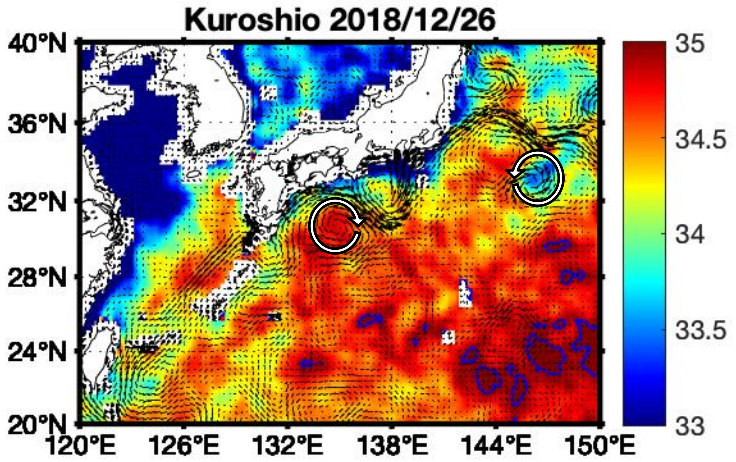
SMAP and SMOS

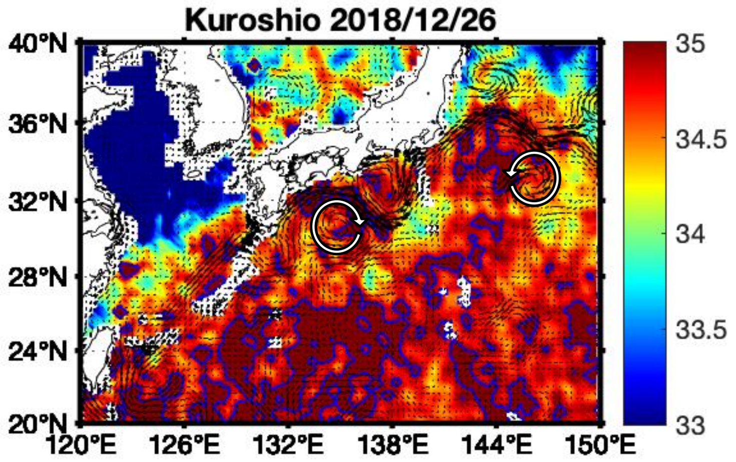


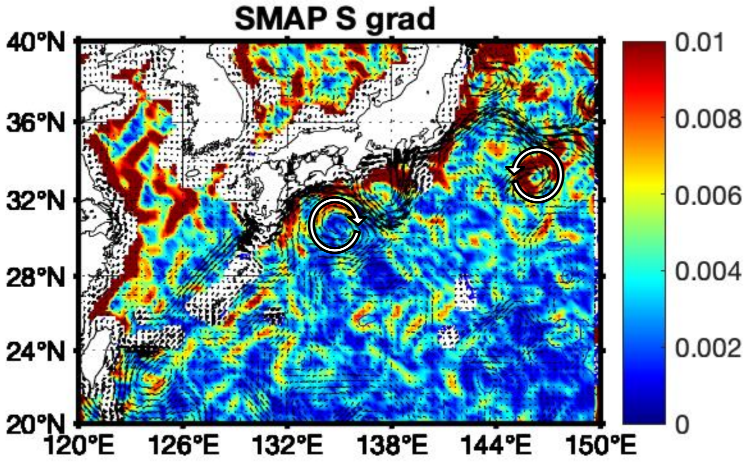
The Kuroshio Current off the coast of Japan, as visualized by Saildrone Forecast.

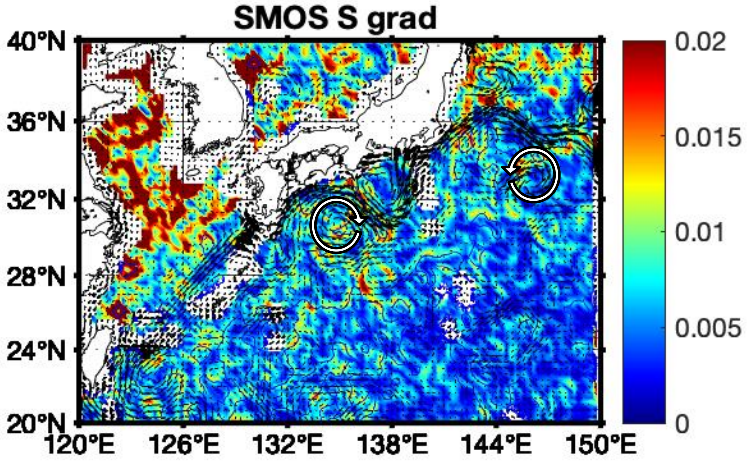
Snapshot of Kuroshio currents on 2018/12/26





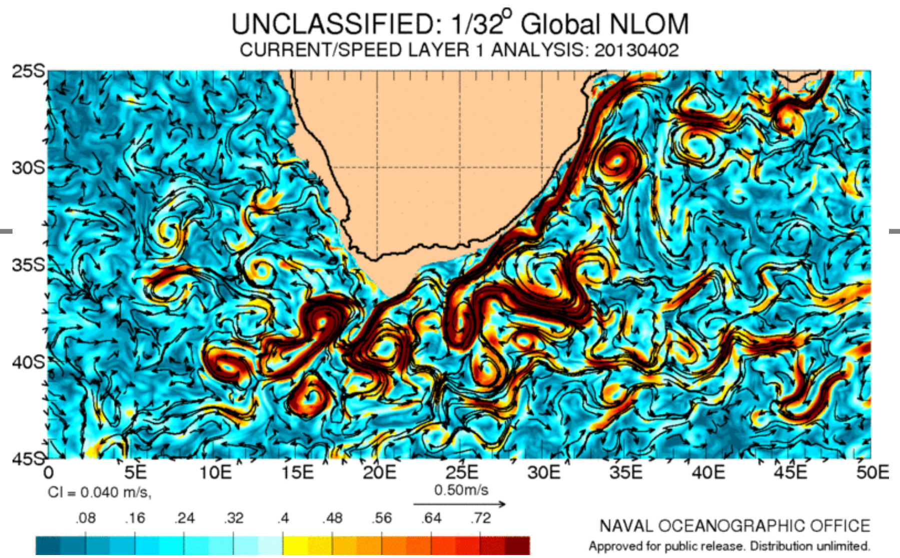




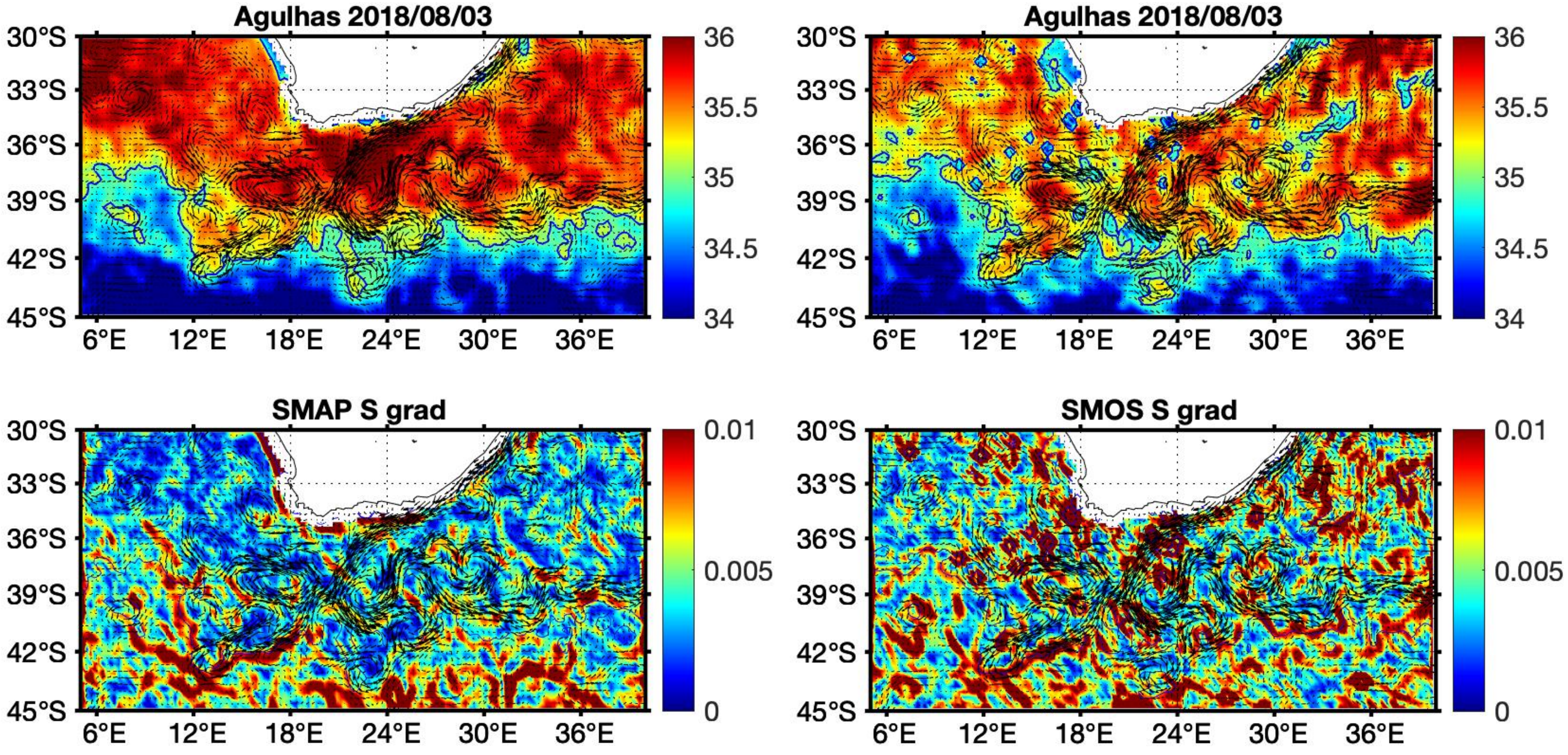


Daily Variations of Salinity Fronts at Agulhas currents

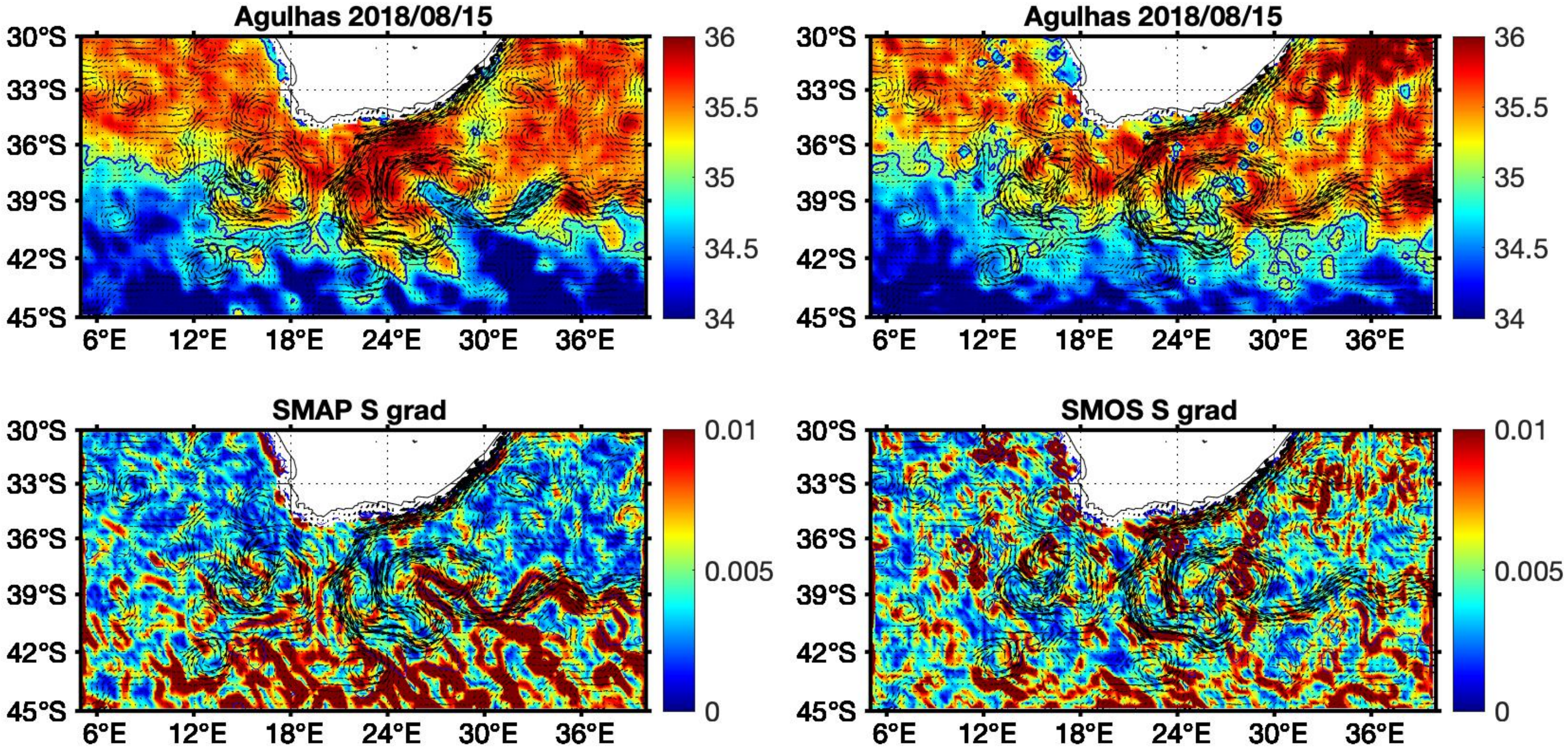
SMAP and SMOS



Snapshot of Agulhas currents on 2018/8/3



Snapshot of Agulhas currents on 2018/8/15

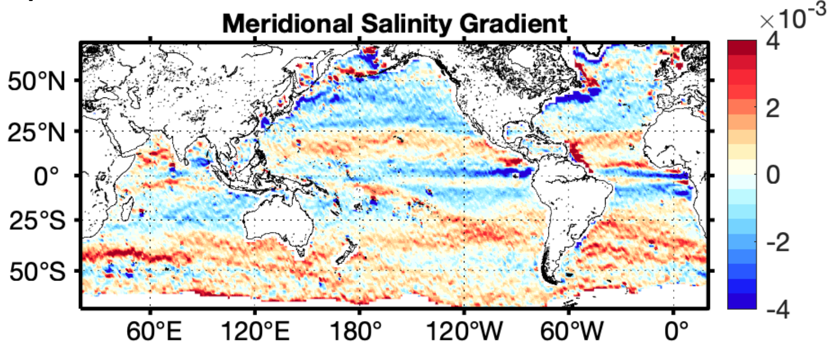


Regional analysis of some interest areas

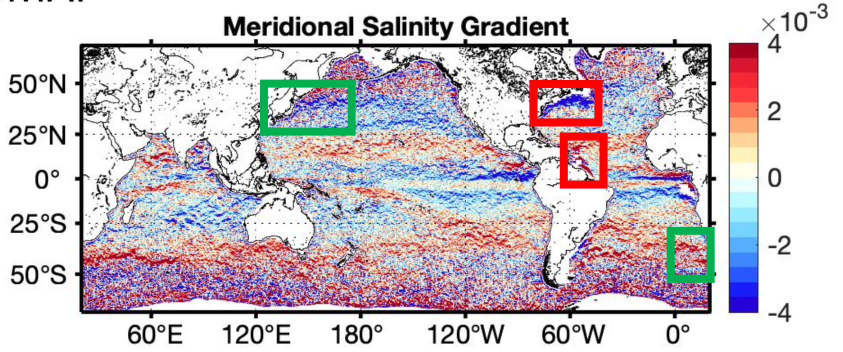
- Tropical Pacific (monthly analysis)
  1. ITCZ - good consistency
  2. Eastern Pacific - good consistency
  3. Western Pacific - good consistency
- Amazon-Orinoco Plume – good between SMAP and SMOS
- Western boundary currents
  1. Gulf Stream – good between SMAP and SMOS
  2. Kuroshio – large discrepancy
  3. Agulhas Currents – large discrepancy

May 2015

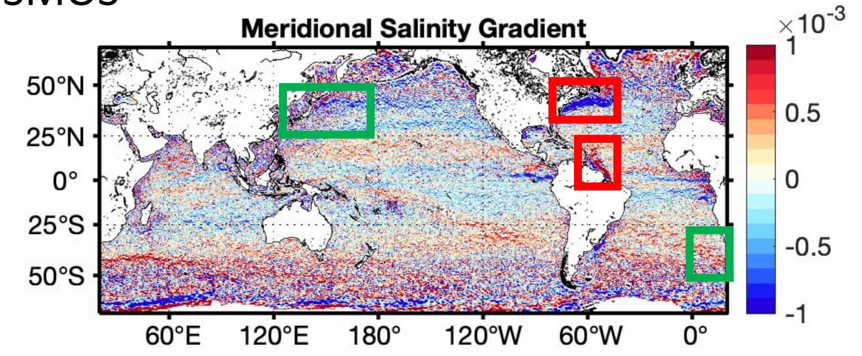
Aquarius

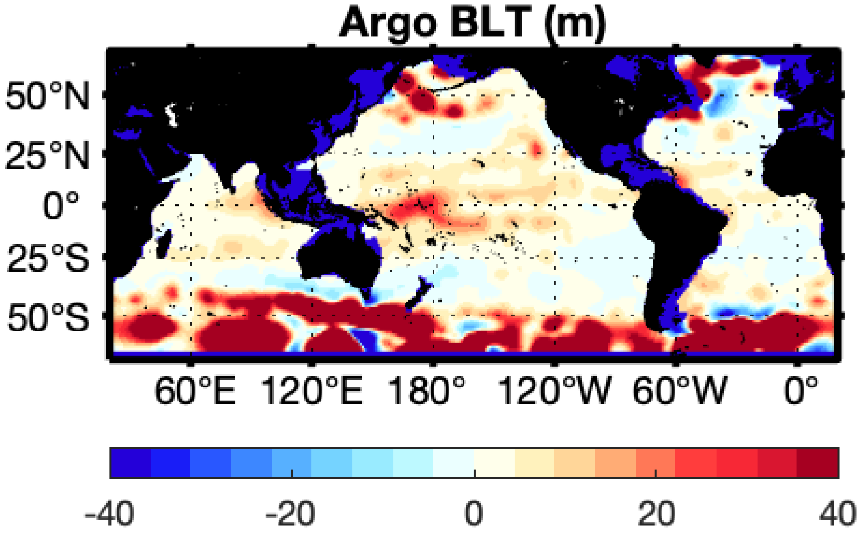


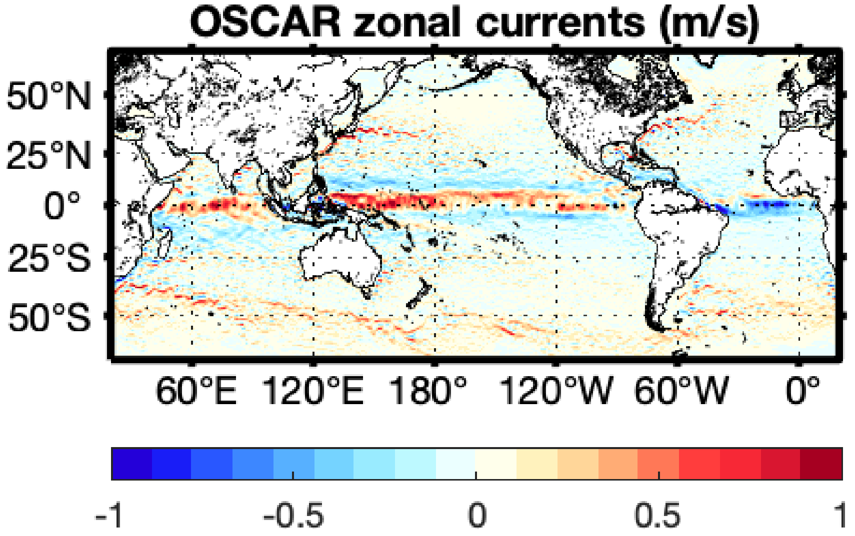
SMAP

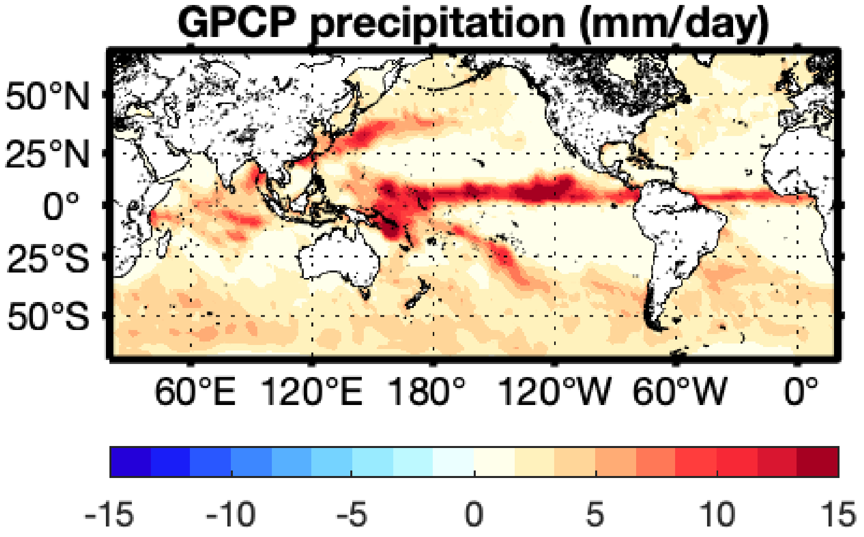


SMOS









Future work:

Other variables related to salinity gradient variations

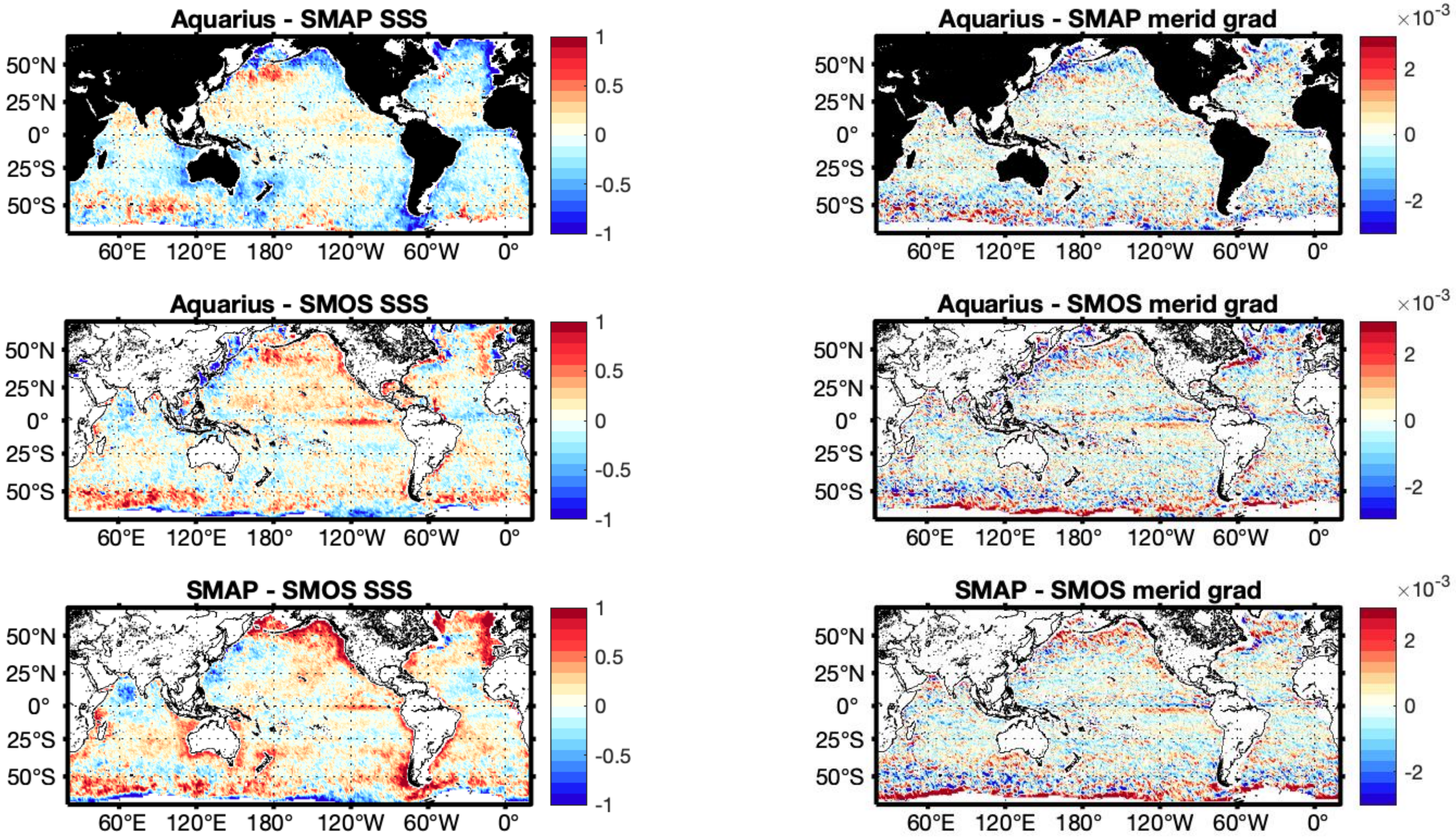
Thank you!

Questions? Comments?

backup

Comparisons among three satellite SSS data on *May 2015*

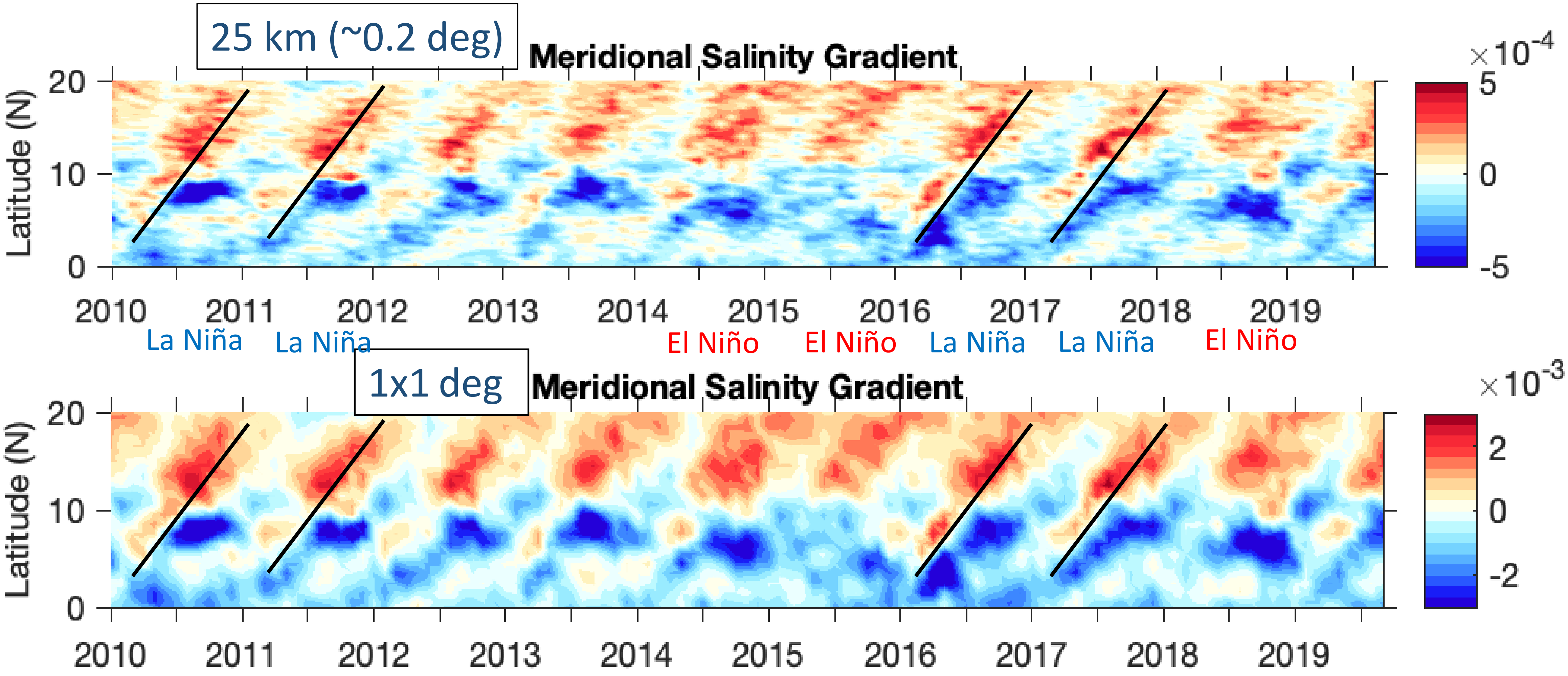
SSS differences | **Meridional salinity gradient differences**



-Most differences show up along the coasts and high latitude.

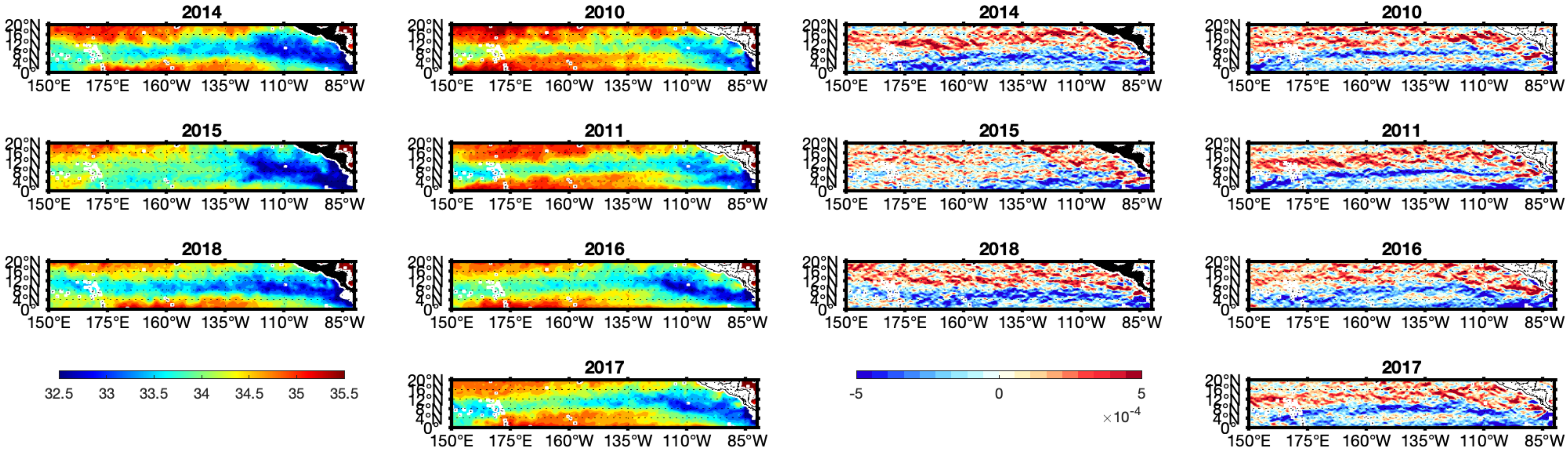
-SMOS SSS in the equatorial eastern Pacific is fresher than the other two

SMOS salinity gradient with different spatial resolution



SMOS salinity in September in ENSO years

SMOS SSS El Niño | SMOS SSS La Niña | SMOS Salinity gradient El Niño | SMOS Salinity gradient La Niña



Freshwater bands are more confined in a narrow band during La Niña years, leading to sharper salinity gradients around it. During El Niño years, the precipitation is stronger and widen the freshwater bands, resulting in blurred salinity fronts.

Agulhas currents

- The western boundary current of the southwest Indian Ocean. It’s the largest western boundary current in the world ocean, with and estimated net transport of 70 Sverdrups. Gulf Stream (34 Sv), Kuroshio (42Sv).
- The flow of the Agulhas Current is directed by the topography. At the tip of the Agulhas Bank, the momentum of the current overcomes the vorticity balance holding the currents to the topography and the current leaves the shelf.
- The core of the current is defined as where the surface velocities reaches 100 cm/s, which gives the core an average width of 34km.
- Agulhas leakage and rings

Hovmöller diagrams of SSS
averaged between 80˚W and 100˚W