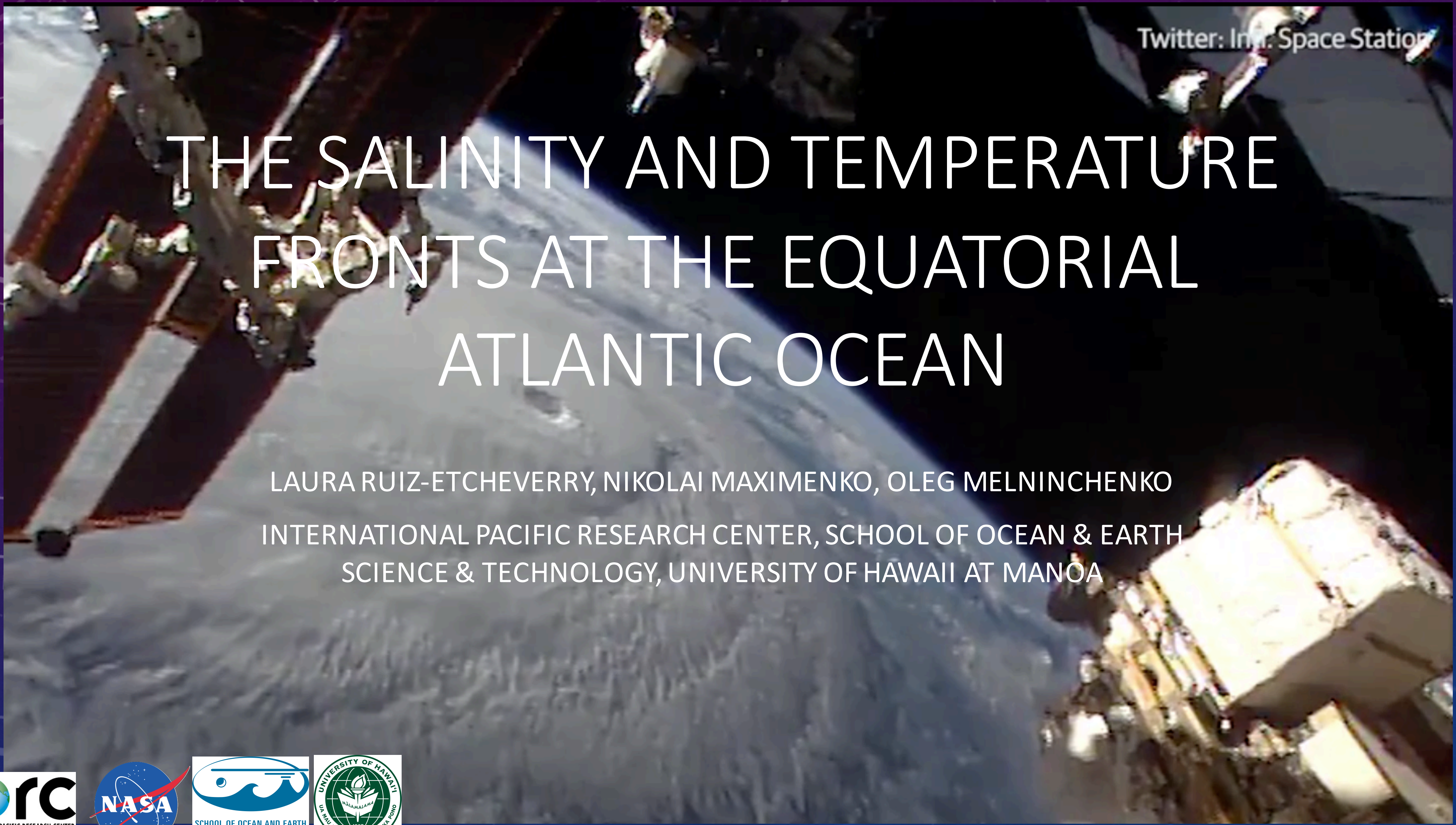


Twitter: Intl. Space Station

THE SALINITY AND TEMPERATURE FRONTS AT THE EQUATORIAL ATLANTIC OCEAN

LAURA RUIZ-ETCHEVERRY, NIKOLAI MAXIMENKO, OLEG MELNINCHENKO

INTERNATIONAL PACIFIC RESEARCH CENTER, SCHOOL OF OCEAN & EARTH SCIENCE & TECHNOLOGY, UNIVERSITY OF HAWAII AT MANOA

SST 2018, Santa Rosa

INTRODUCTION

Front

What is a marine front?

Why are important the frontal systems?

- Primary and secondary production.
- Air-sea interaction

MOTIVATION

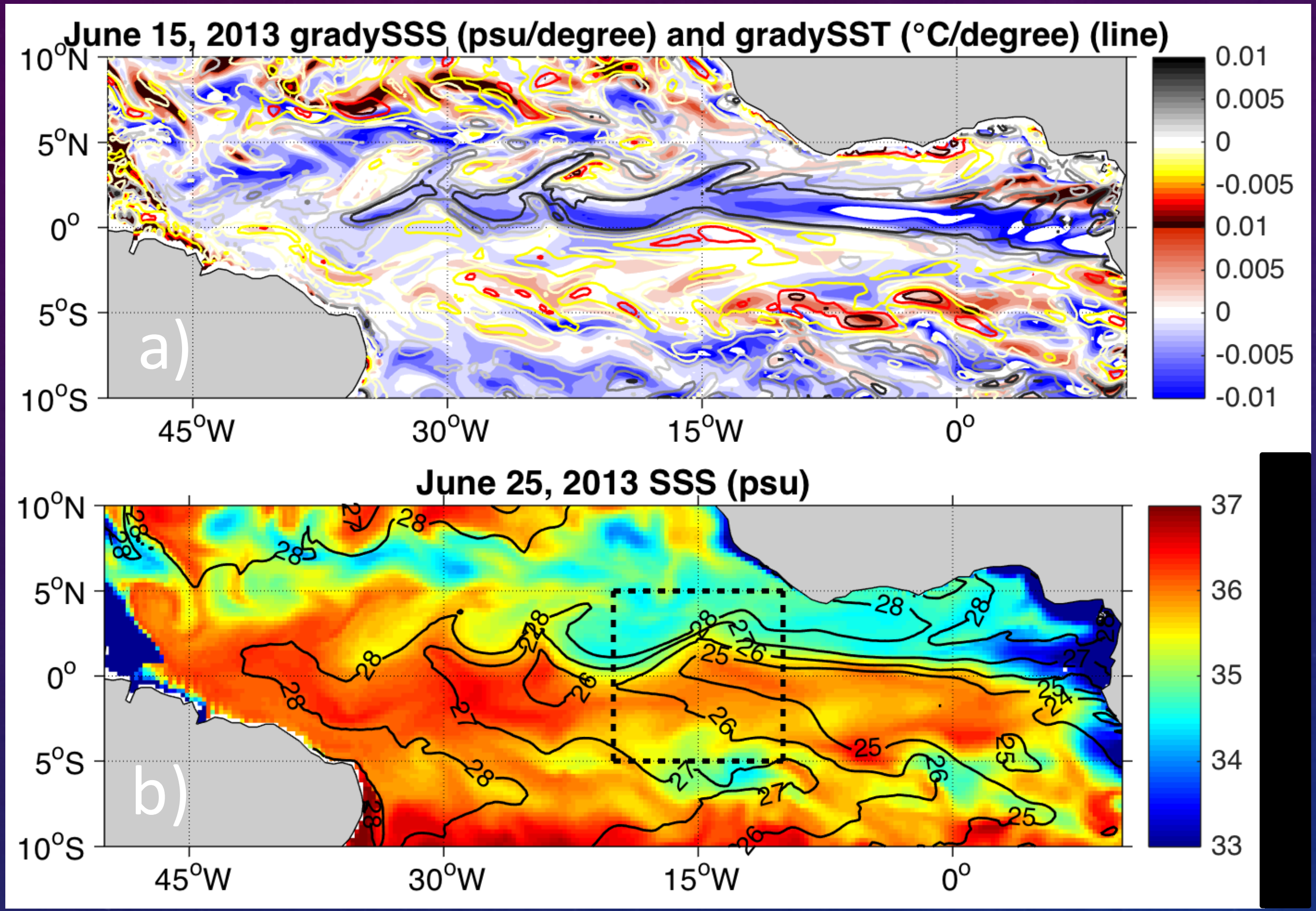


Fig. 1: a) Meridional gradient of salinity (map) and temperature (contours) for June 15, 2013. b) Salinity map and temperature contours for the same day as a).

WHY THE TROPICAL ATLANTIC?

- It plays an important role in the hydrological cycle.
- Fresh water sources: Amazon river, Congo river, precipitation ITCZ
- Satellite data allows to study salinity front

MOTIVATION

Case of study: Equatorial front


Journal of Geophysical Research: Oceans

RESEARCH ARTICLE
10.1002/2015JC010865

On the seasonal variations of salinity of the tropical Atlantic mixed layer

I. Camara[1,2], Nicolas Kolodziejczyk[2], Juliette Mignot[1,2,3], Alban Lazar[1,2], and Amadou T. Gaye[1]

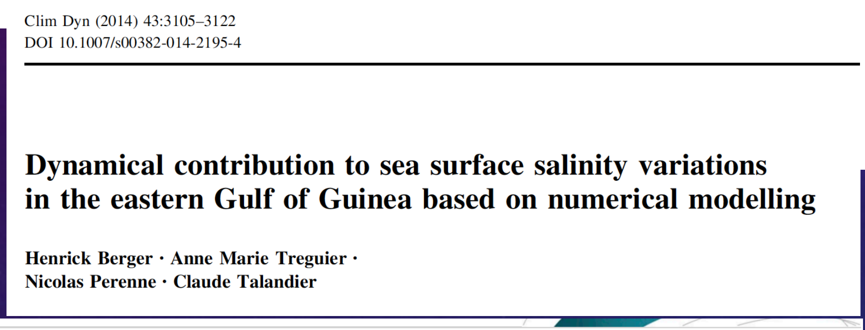
[1]LPAO-SF, ESP, UCAD, Dakar, Senegal, [2]LOCEAN Laboratory, Sorbonne Universits (UPMC Université Paris 6), CNRS, IRD, MNHN, Paris, France, [3]Climate and Environmental Physics, Physics Institute, Oeschger Centre of Climate Change Research, University of Bern, Bern, Switzerland

Key Points:
- Weak relative surface salinity seasonal variation in the tropical Atlantic
- Compensation between physical processes entering in the salt budget


Clim Dyn (2014) 43:3147–3162
DOI 10.1007/s00382-014-2293-3

Lagrangian sources of frontogenesis in the equatorial Atlantic front

Hervé Giordani · Guy Caniaux


Clim Dyn (2014) 43:3105–3122
DOI 10.1007/s00382-014-2195-4

Dynamical contribution to sea surface salinity variations in the eastern Gulf of Guinea based on numerical modelling

Henrick Berger · Anne Marie Treguier ·
Nicolas Perenne · Claude Talandier


Journal of Geophysical Research: Oceans

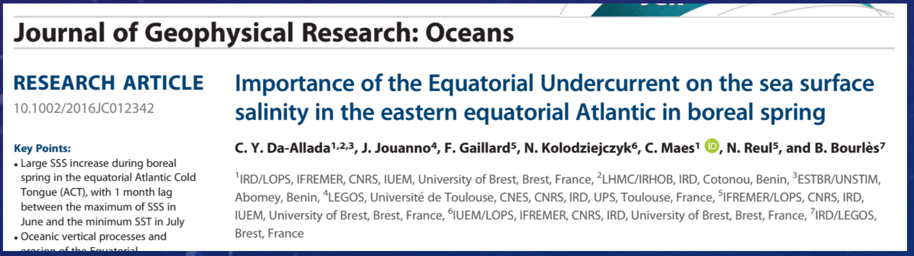
RESEARCH ARTICLE
10.1002/2014JC010021

Mixed layer heat and salinity budgets during the onset of the 2011 Atlantic cold tongue

Michael Schlundt[1], Peter Brandt[1], Marcus Dengler[1], Rebecca Hummels[1], Tim Fischer[1], Karl Bumke[1], Gerd Krahmann[1], and Johannes Karstensen[1]

[1]GEOMAR Helmholtz-Zentrum für Ozeanforschung Kiel, Kiel, Germany

Key Points:
- Atlantic cold tongue development from May to July 2011 was examined
- Diapycnal mixing is key process for cooling in western cold tongue


Journal of Geophysical Research: Oceans

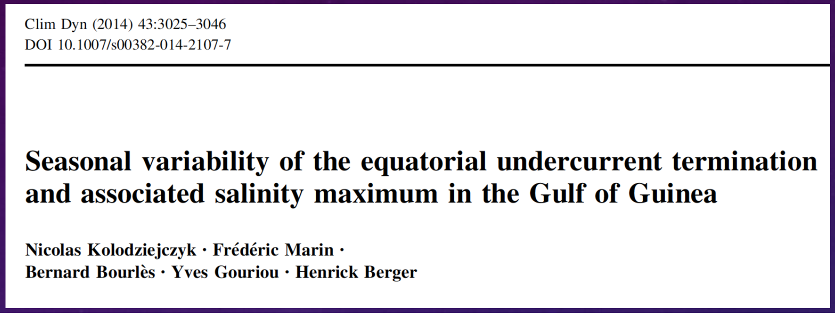
RESEARCH ARTICLE
10.1002/2016JC012342

Importance of the Equatorial Undercurrent on the sea surface salinity in the eastern equatorial Atlantic in boreal spring

C. Y. Da-Allada[1,2,3], J. Jouanno[4], F. Gaillard[5], N. Kolodziejczyk[6], C. Maes[1], N. Reul[5], and B. Bourlès[7]

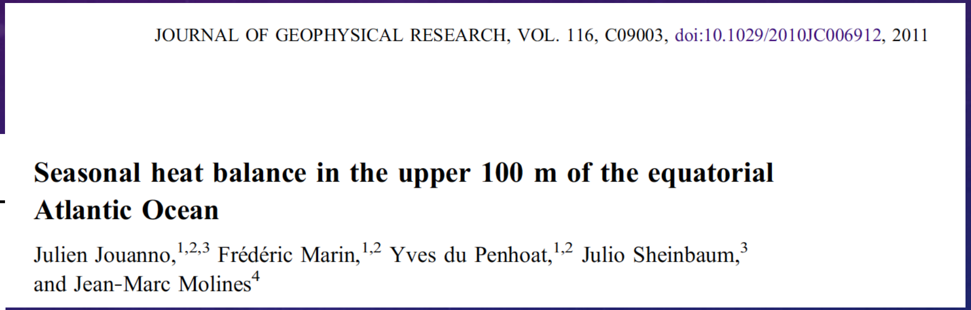
[1]IRD/LOPS, IFREMER, CNRS, IUEM, University of Brest, Brest, France, [2]LHMC/IRHOB, IRD, Cotonou, Benin, [3]ESTBR/UNSTIM, Abomey, Benin, [4]LEGOS, Université de Toulouse, CNES, CNRS, IRD, UPS, Toulouse, France, [5]IFREMER/LOPS, CNRS, IRD, IUEM, University of Brest, Brest, France, [6]IUEM/LOPS, IFREMER, CNRS, IRD, University of Brest, Brest, France, [7]IRD/LEGOS, Brest, France

Key Points:
- Large SSS increase during boreal spring in the equatorial Atlantic Cold Tongue (ACT), with 1 month lag between the maximum of SSS in June and the minimum SST in July
- Oceanic vertical processes and


Clim Dyn (2014) 43:3025–3046
DOI 10.1007/s00382-014-2107-7

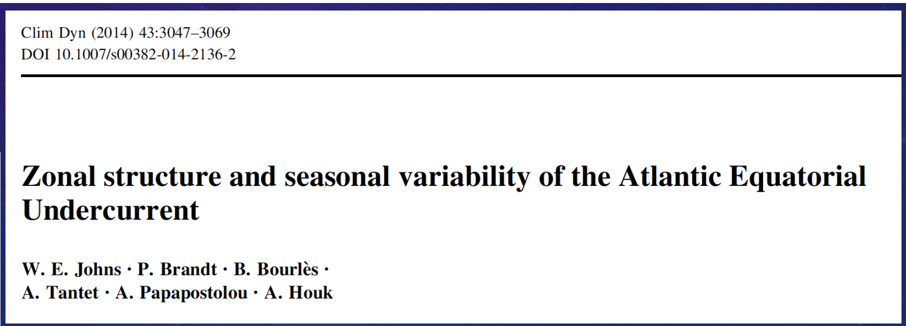
Seasonal variability of the equatorial undercurrent termination and associated salinity maximum in the Gulf of Guinea

Nicolas Kolodziejczyk · Frédéric Marin ·
Bernard Bourlès · Yves Gouriou · Henrick Berger


JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 116, C09003, doi:10.1029/2010JC006912, 2011

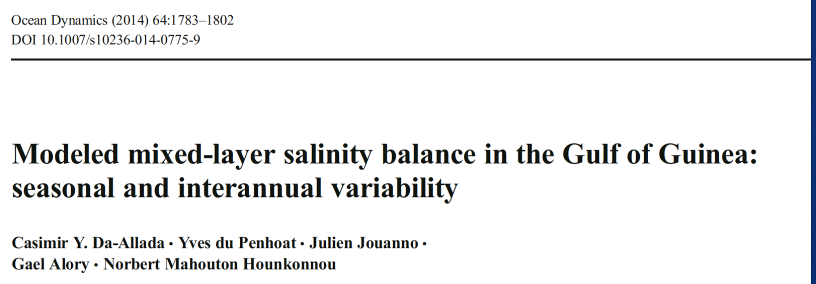
Seasonal heat balance in the upper 100 m of the equatorial Atlantic Ocean

Julien Jouanno,[1,2,3] Frédéric Marin,[1,2] Yves du Penhoat,[1,2] Julio Sheinbaum,[3] and Jean-Marc Molines[4]


Clim Dyn (2014) 43:3047–3069
DOI 10.1007/s00382-014-2136-2

Zonal structure and seasonal variability of the Atlantic Equatorial Undercurrent

W. E. Johns · P. Brandt · B. Bourlès ·
A. Tantet · A. Papapostolou · A. Houk


Ocean Dynamics (2014) 64:1783–1802
DOI 10.1007/s10236-014-0775-9

Modeled mixed-layer salinity balance in the Gulf of Guinea: seasonal and interannual variability

Casimir Y. Da-Allada · Yves du Penhoat · Julien Jouanno ·
Gael Alory · Norbert Mahouton Hounkonnou

- Several studies are focused in the SST front.
- From the salinity point of view, the studies are focused in MLS, specially in the Cold tongue area.

❖ Why is there a salinity front?
❖ Same dynamic as temperature front?
❖ What are the causes of the generation and attenuation of the salinity front?

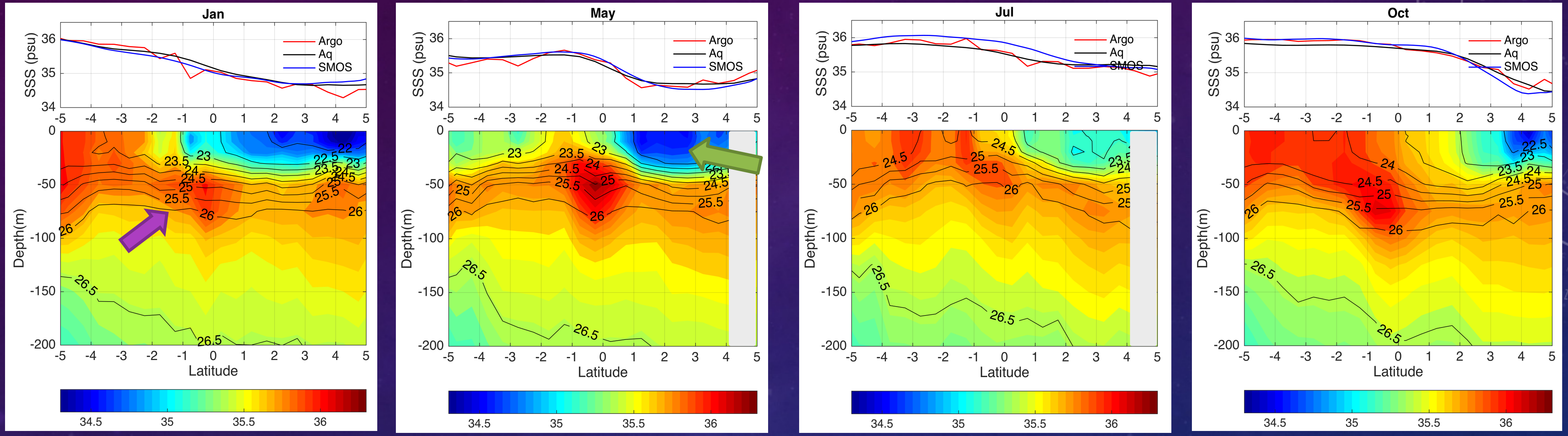
DATA

- Sea Surface Salinity (SSS) from Aquarius, 3 years (1/Jan/2012-31/Dec/2014), 0.5x0.5 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), 0.25x0.25 spatial resolution, daily.
- Reanalysis global model Glorys from CMEMS (http://marine.copernicus.eu/), 3 years (1/Jan/2011-31/Dec/2015), 0.25X0.25 horizontal resolution, 77 depth levels, daily and monthly temporal resolution. Output: salinity, temperature, zonal and meridional velocities.
- Precipitation, evaporation, river run-off and net heat fluxes from ERA-Interim.
- Argo: profiles from IPRC (http://apdrc.soest.hawaii.edu/projects/argo/).

RESULTS: Comparison Model-Argo: Salinity

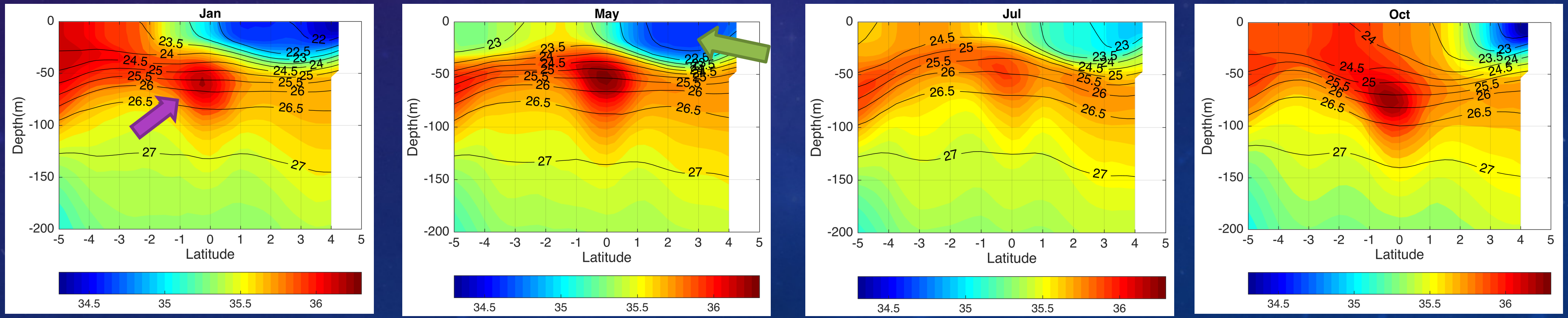
Argo 50km binned (climatology)

January May July October



EUC: variation on the salinity (Johns et al., 2014)

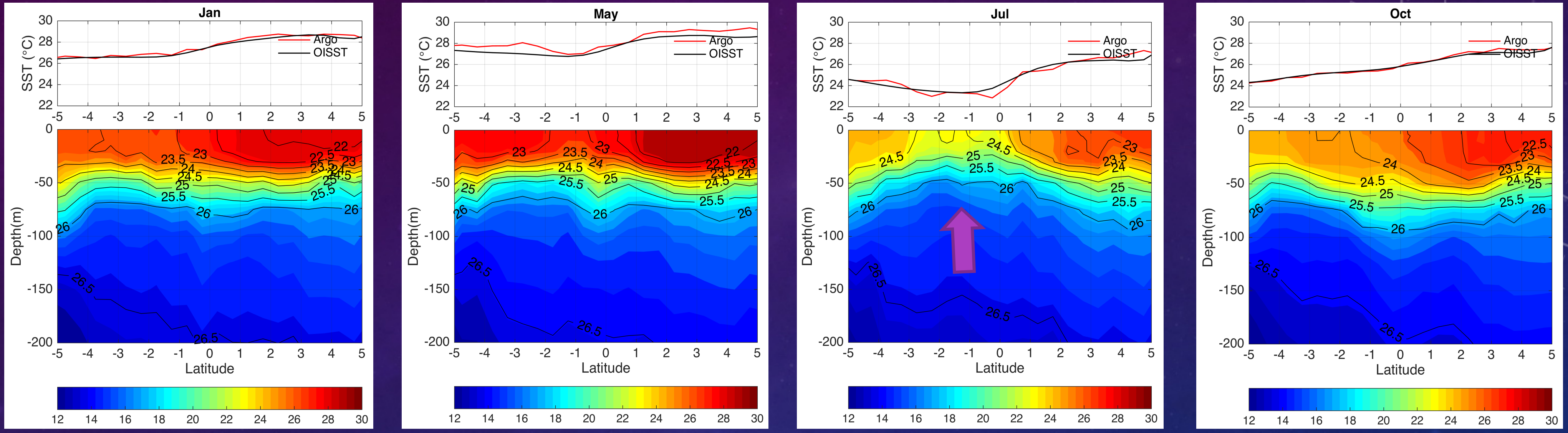
Glorys



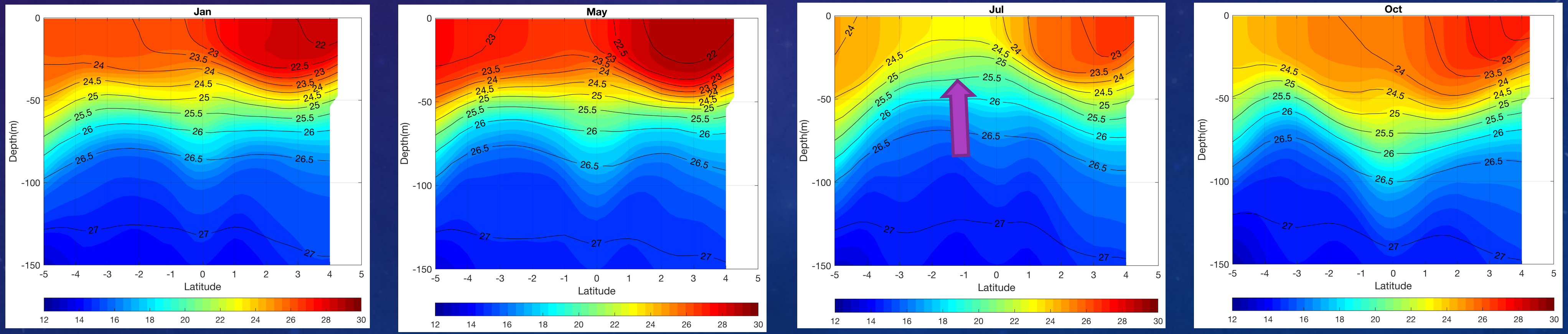
RESULTS: Comparison Model-Argo: Temperature

Argo 50km binned (climatology)

January May July October

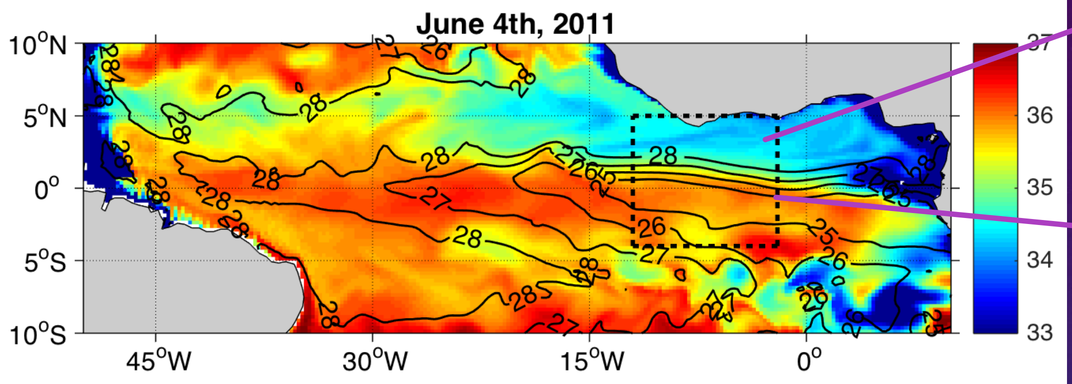


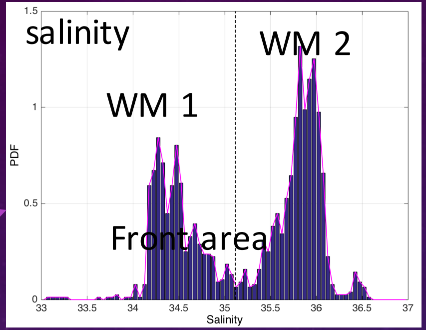
Glorys

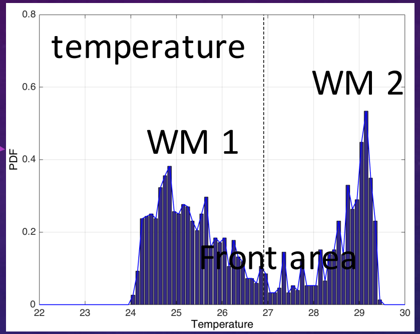


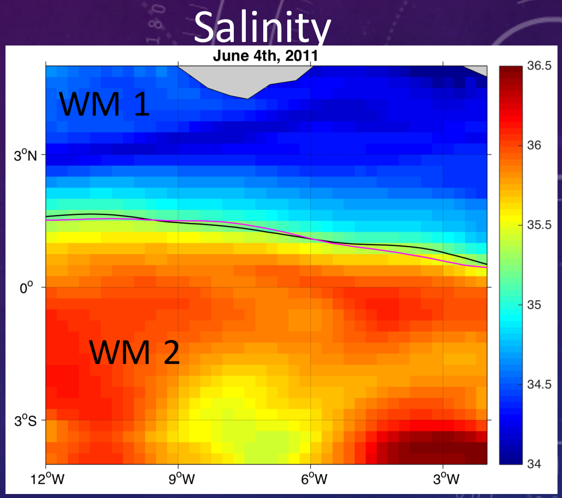
RESULTS: Method Probability Density Function

Salinity map superimposed with temperature contours (black line)

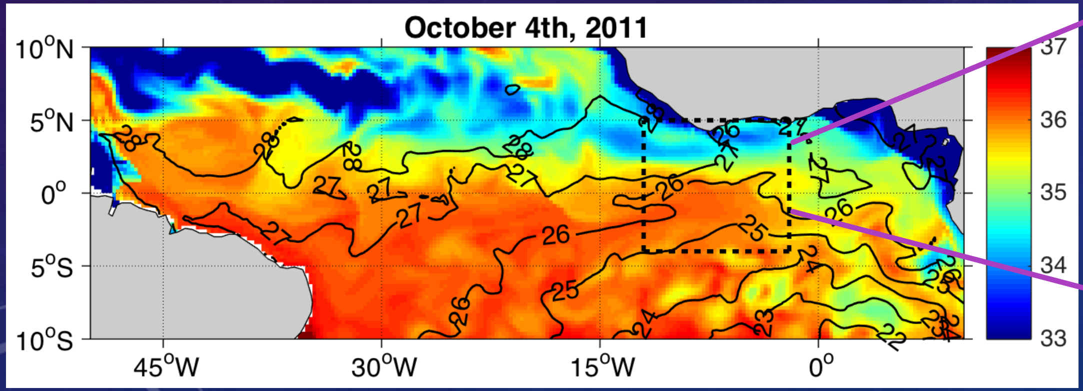


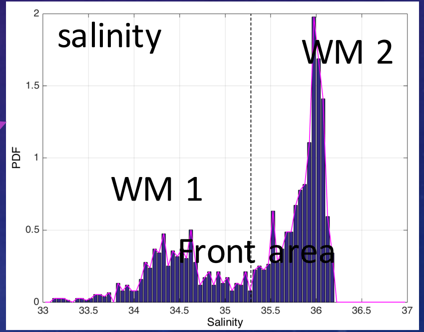


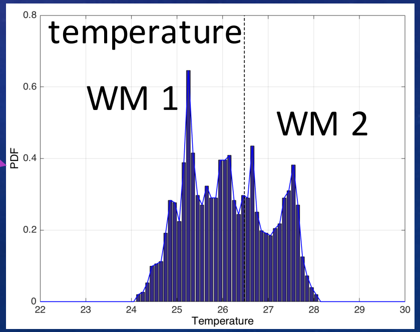


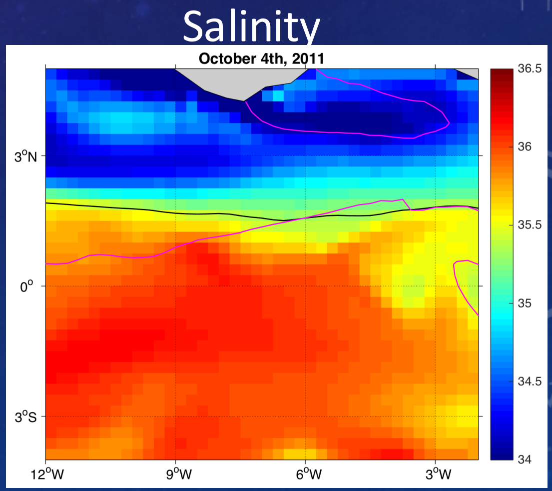


Salinity map superimposed with temperature contours (black line)







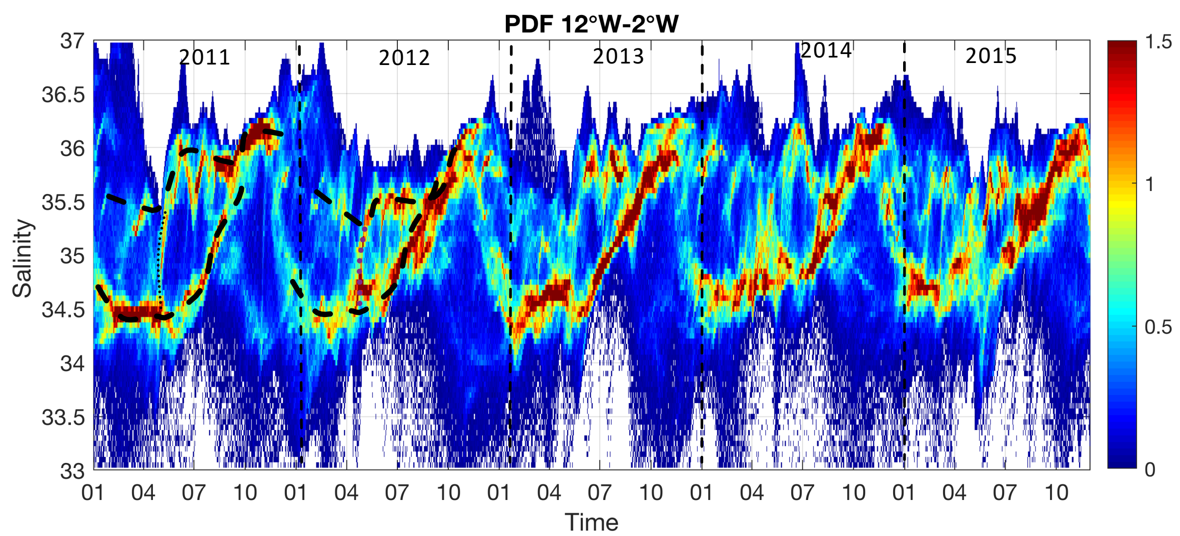


Magenta solid line: temperature threshold.
Black solid line: salinity threshold

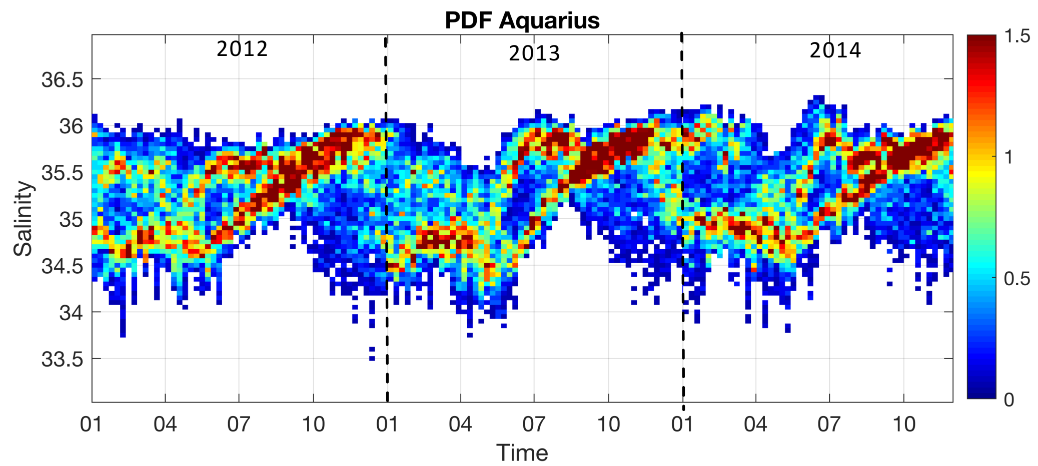
RESULTS: Temporal variability of salinity and temperature PDF

Salinity

Model

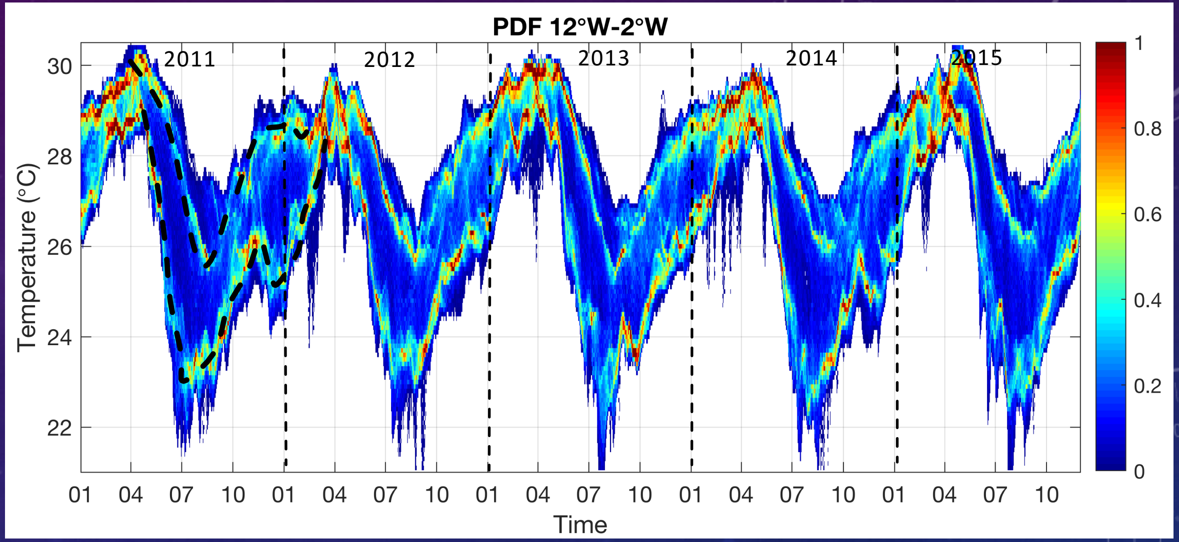


OISSS

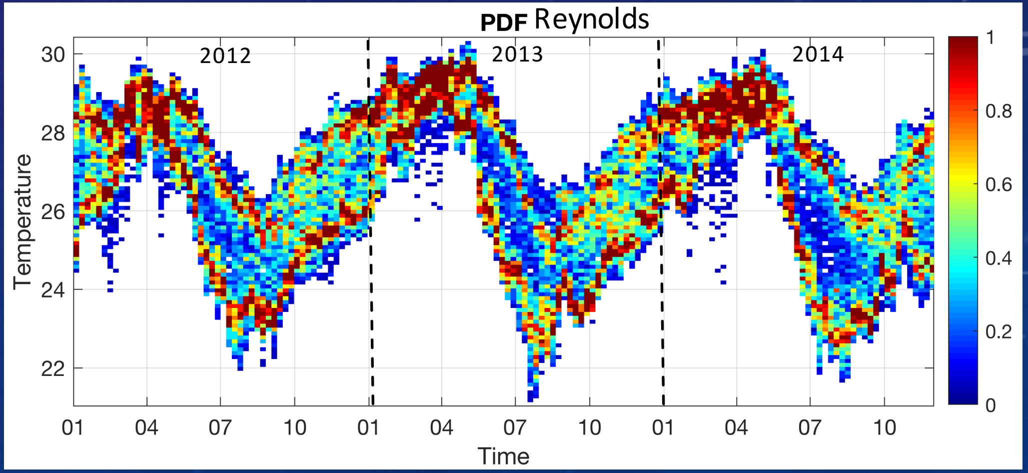


Temperature

Model

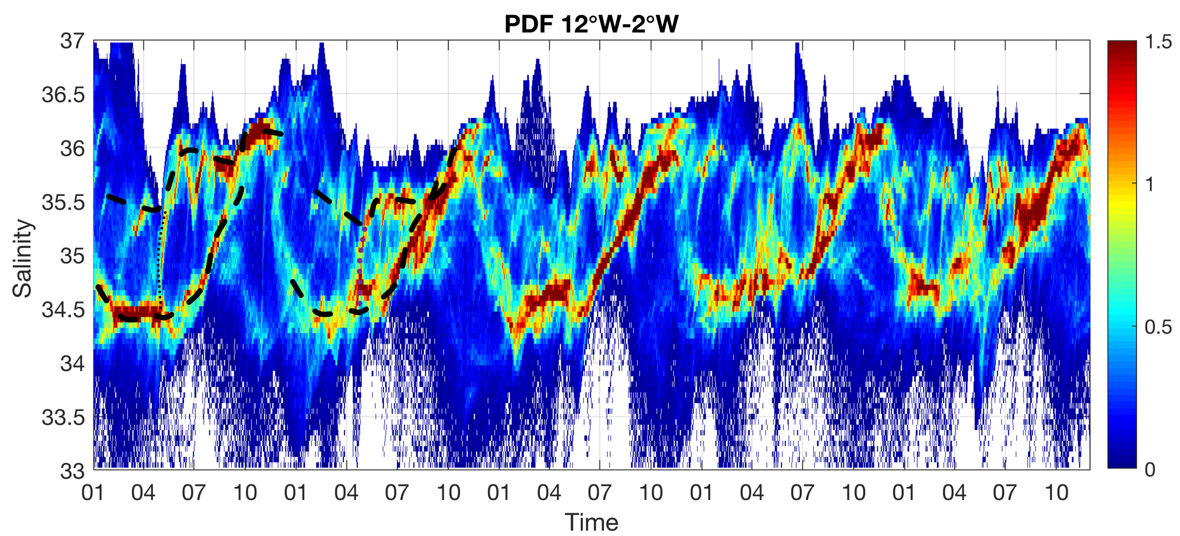


OISST

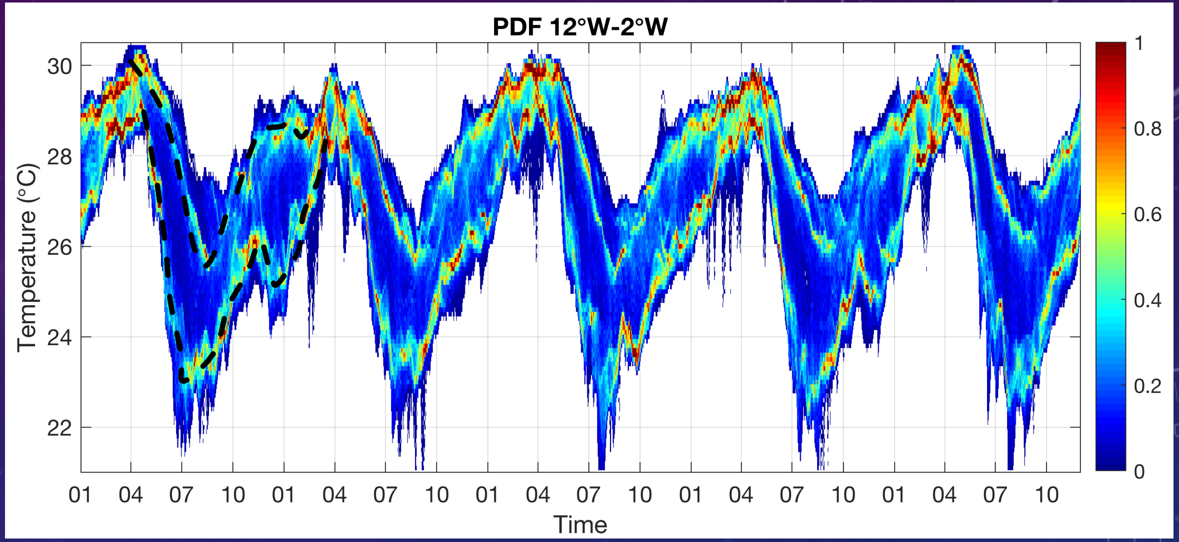


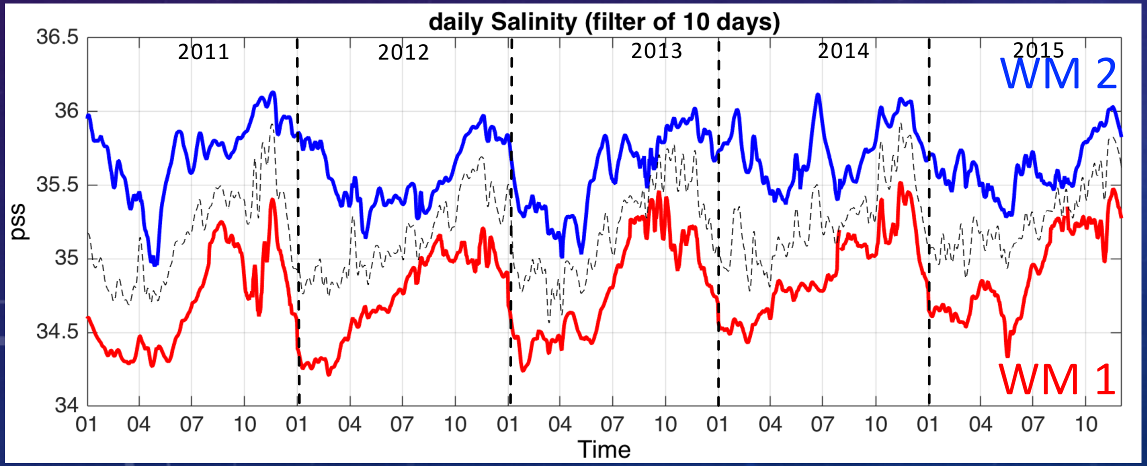
RESULTS: Temporal variability of spatial mean of each water mass

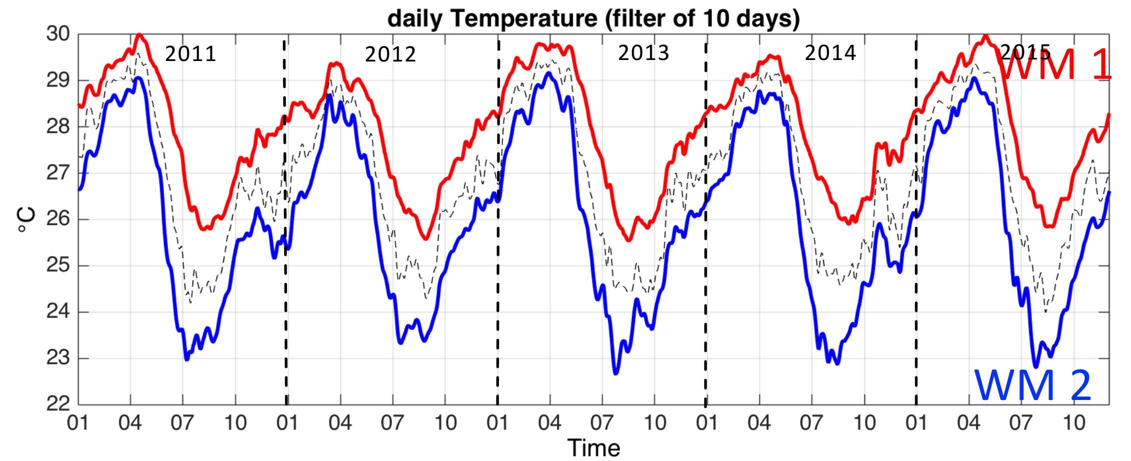
Salinity



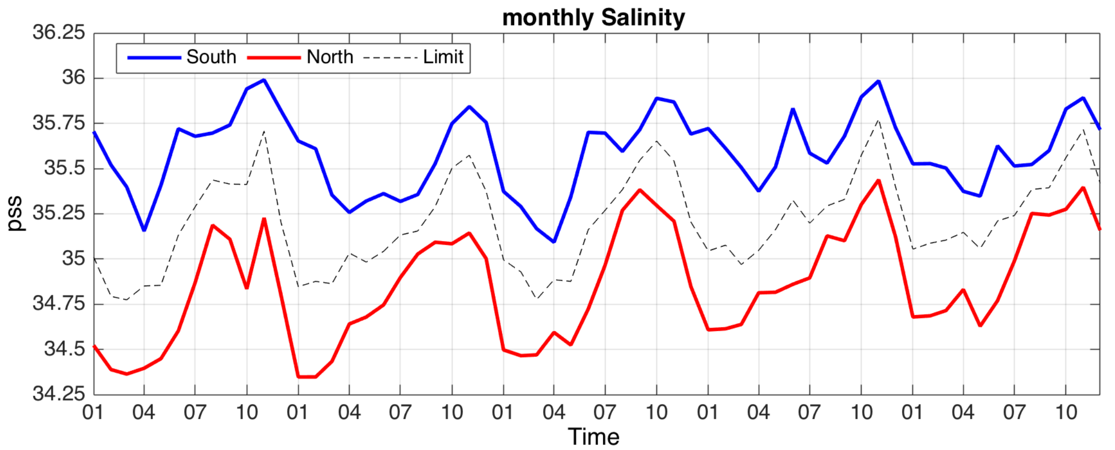
Temperature

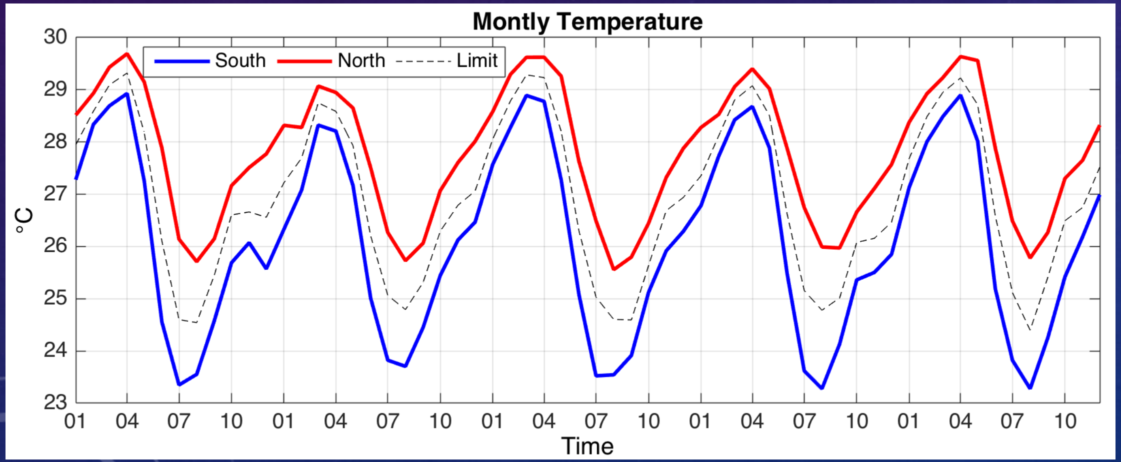






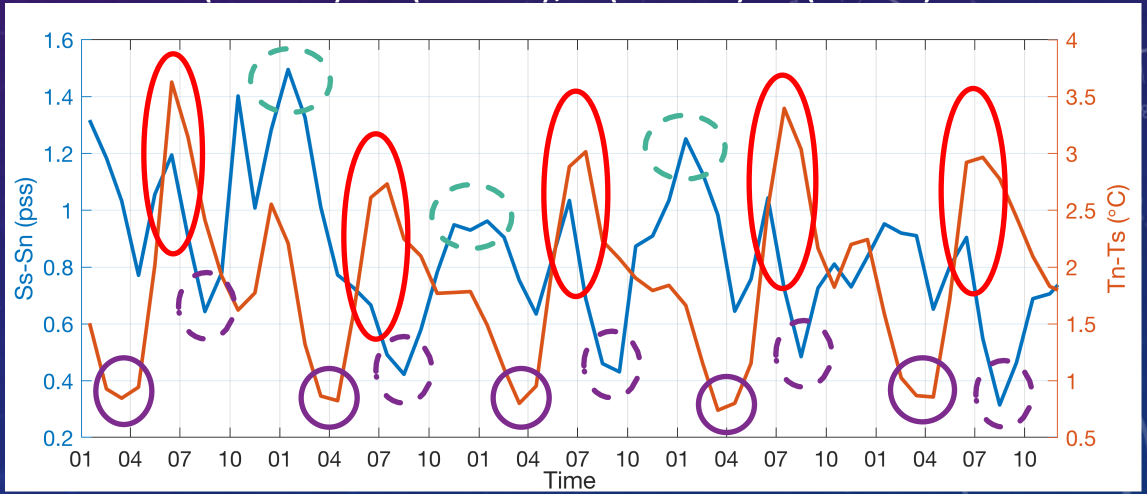
RESULTS: Temporal variability of spatial mean of each water mass





- Possible S front due to the dynamics of both WM
- Possible T front due to the dynamics of WM 2

S(WM 2) - S(WM 1); T(WM 1) -T(WM2)



Maximum difference= Front

Minimum difference=No front

RESULTS: Significant salinity and temperature budget terms

Following Lee et al. (2004):

$$\begin{cases} \dfrac{\partial}{\partial t}\left(\dfrac{\oiiint S dV}{V}\right) = \dfrac{1}{V}\oiint S(E-P-R)dx\,dy - \dfrac{1}{V}\oiiint \vec{\nabla}(S\vec{v})dV + VDIFFs + RES \\ \dfrac{\partial}{\partial t}\left(\dfrac{\oiiint T dV}{V}\right) = \dfrac{1}{V}\oiint \dfrac{Q}{\rho Cp}dx\,dy - \dfrac{1}{V}\oiiint \vec{\nabla}(T\vec{v})dV + VDIFFt + RES \end{cases}$$

Surface forcing

Advection

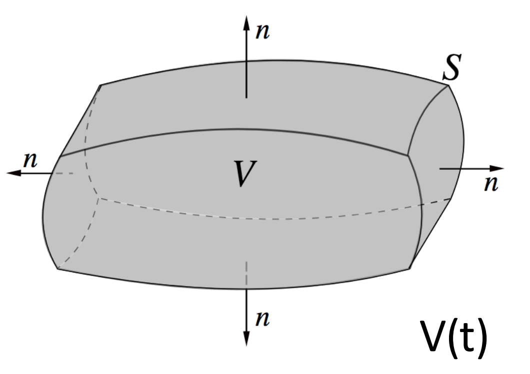
Vertical diffusion

$$Advection\ S = \frac{1}{V}\oiiint -\vec{\nabla}(S\vec{v})dV = -\frac{1}{V}\oiint_{sw}^{se}\frac{\partial(Su)dydz}{\partial x} - \frac{1}{V}\oiint_{ss}^{sn}\frac{\partial(Sv)dxdz}{\partial y} - \frac{1}{V}\oiint_{sMLD}^{ssur}\frac{\partial(Sw)dydx}{\partial z}$$

$$Advection\ T = \frac{1}{V}\oiiint -\vec{\nabla}(T\vec{v})dV = -\frac{1}{V}\oiint_{sw}^{se}\frac{\partial(Tu)dydz}{\partial x} - \frac{1}{V}\oiint_{ss}^{sn}\frac{\partial(Tv)dxdz}{\partial y} - \frac{1}{V}\oiint_{sMLD}^{ssur}\frac{\partial(Tw)dydx}{\partial z}$$

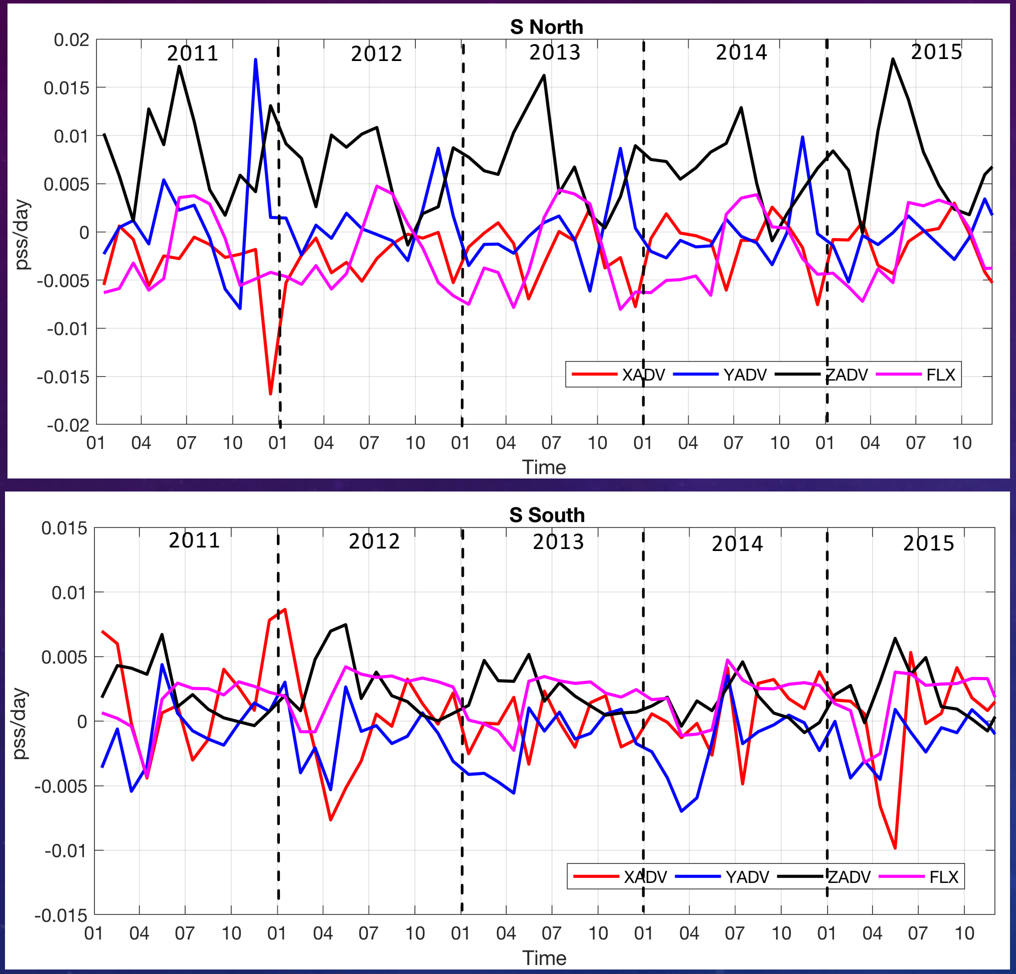
Assume mass conservation, divergence theorem

Budget for each water mass

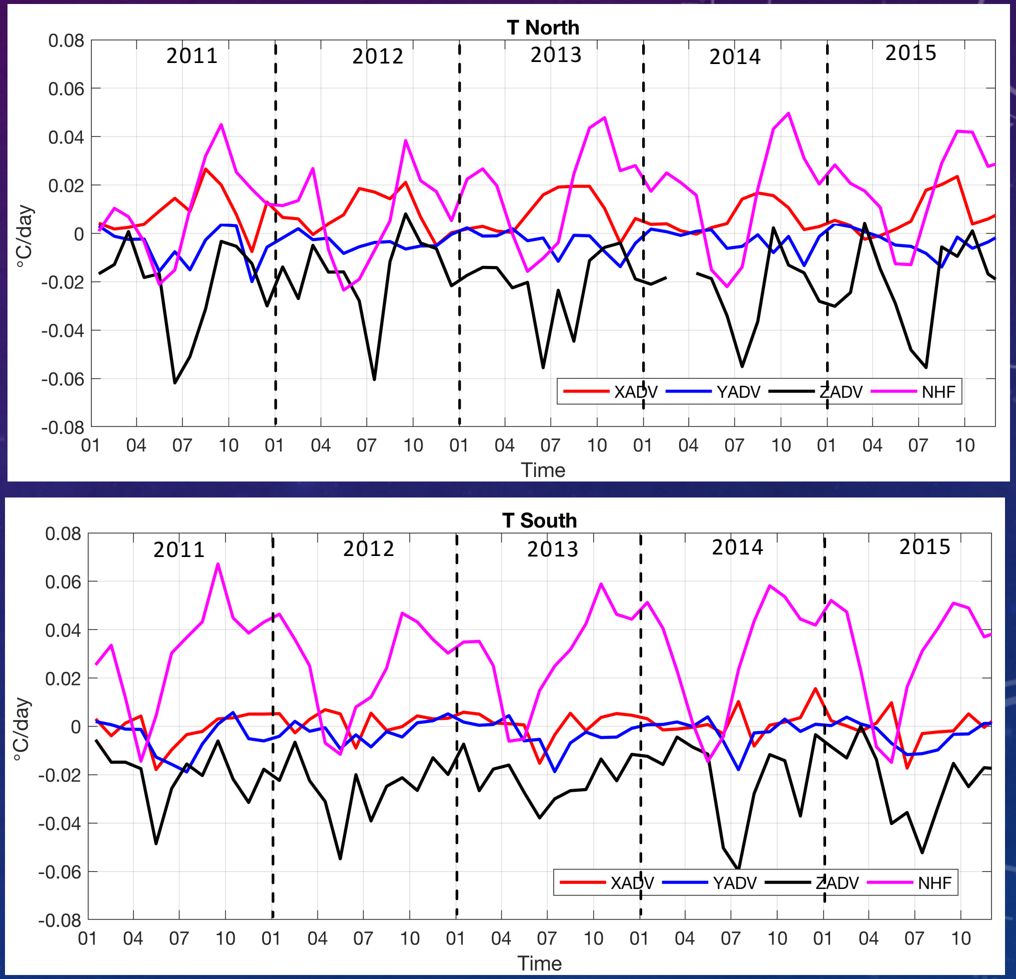


RESULTS: Significant salinity and temperature budget terms

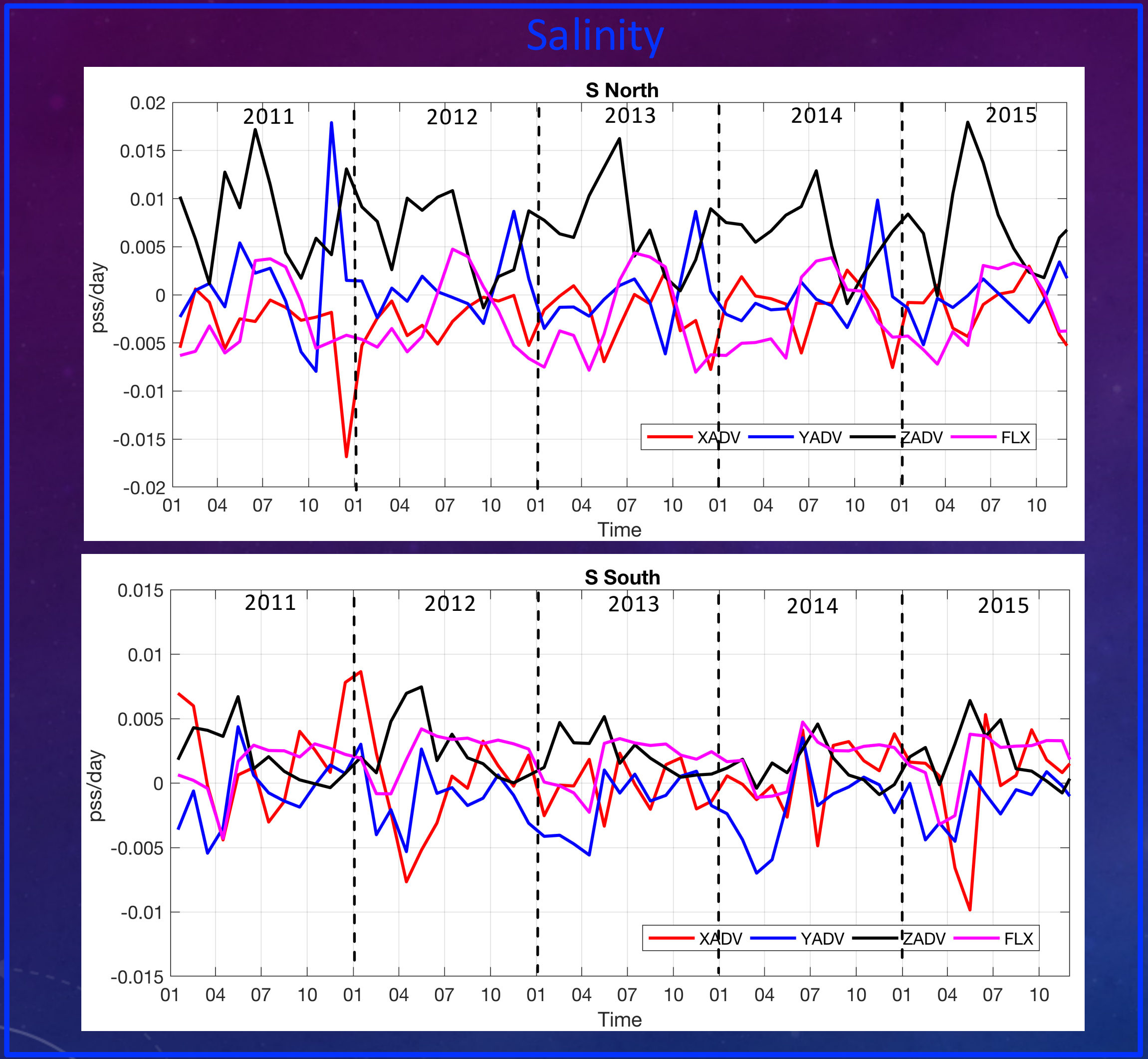
Salinity



Temperature



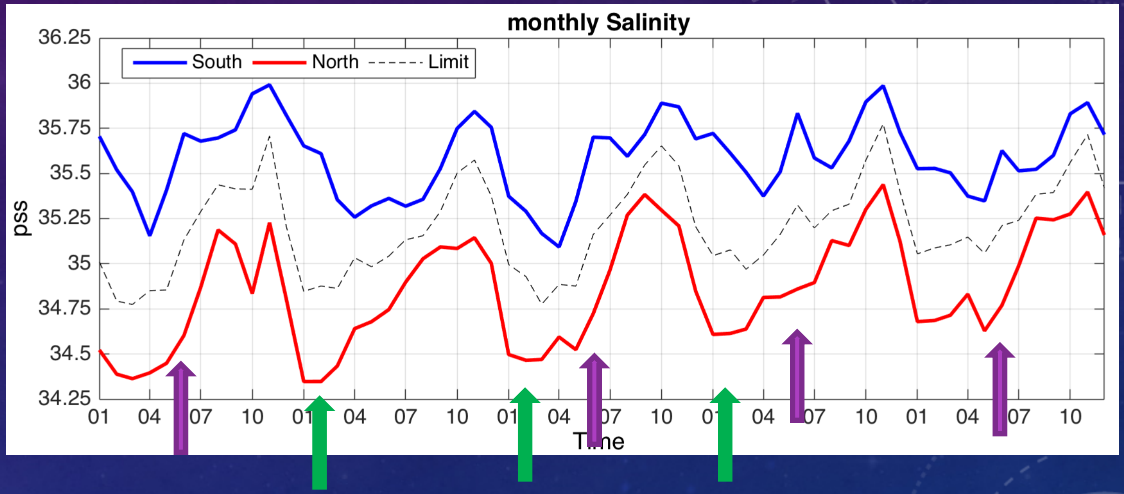
RESULTS: Significant salinity and temperature budget terms

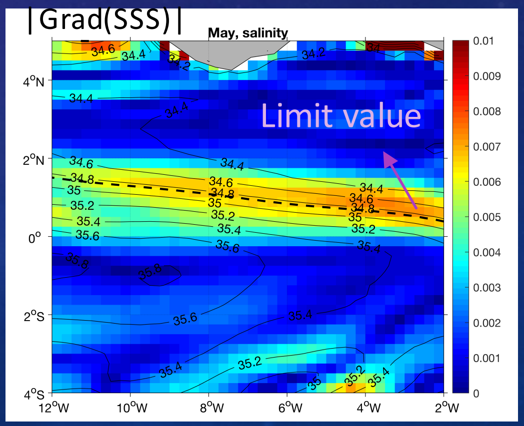


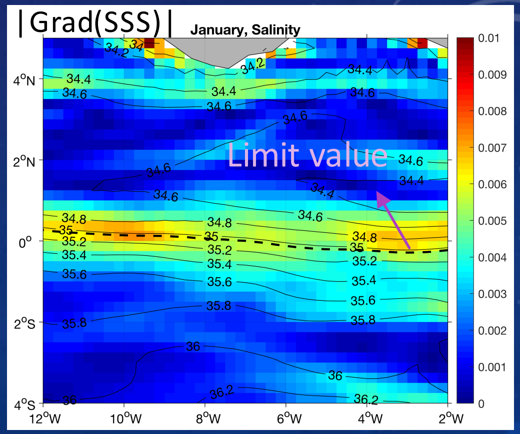
ZADV at north similar variability as ZADV at south but larger values

Boreal Summer front: ZADV (WM 1), FLX and YADV(WM 2)

Boreal winter/spring front: FLX and XADV(WM 2)



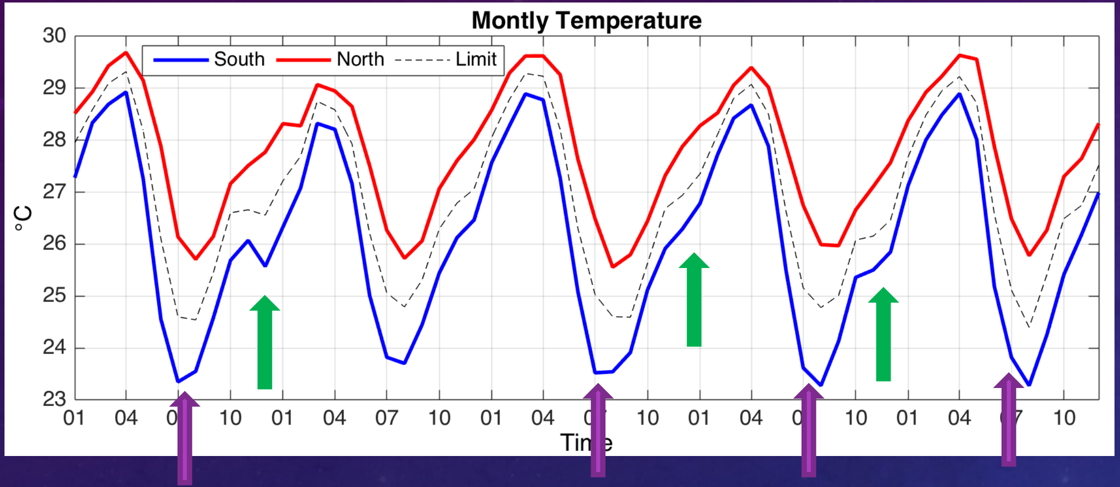


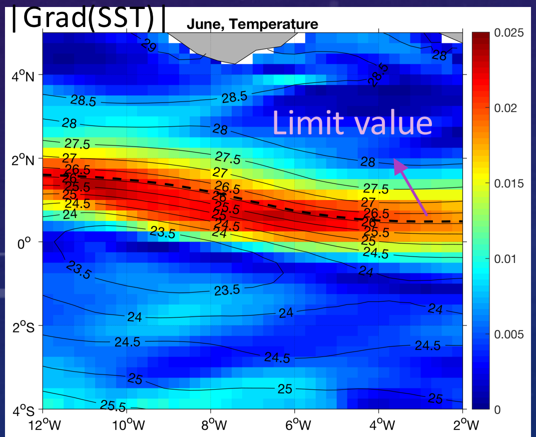


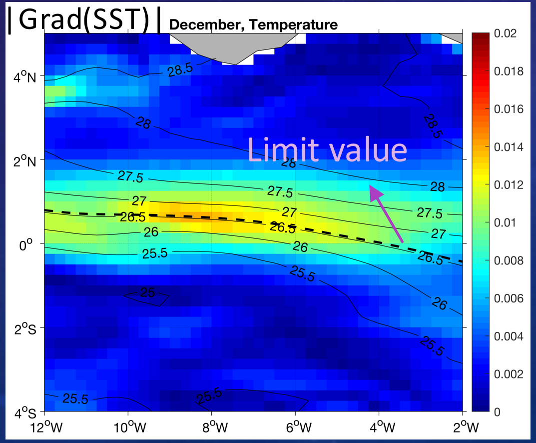
RESULTS: Significant salinity and temperature budget terms

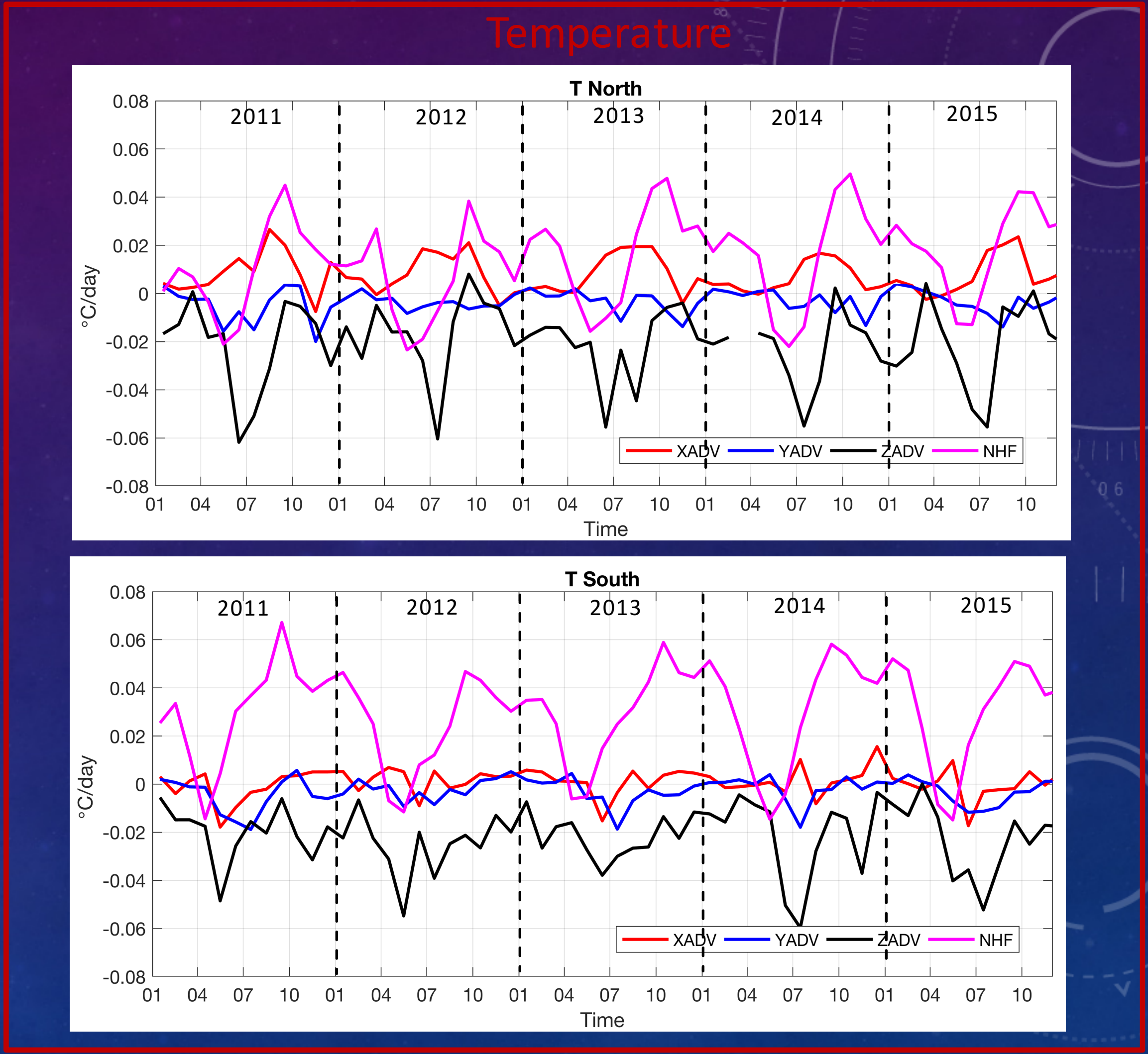
Boreal Winter front: ZADV (WM 1) and NHF (Jouanno et al. 2011)

Boreal Summer front: ZADV (WM 1) (Giordani et al. 2014)


Montly Temperature


|Grad(SST)|
June, Temperature


|Grad(SST)|
December, Temperature


Temperature

T North

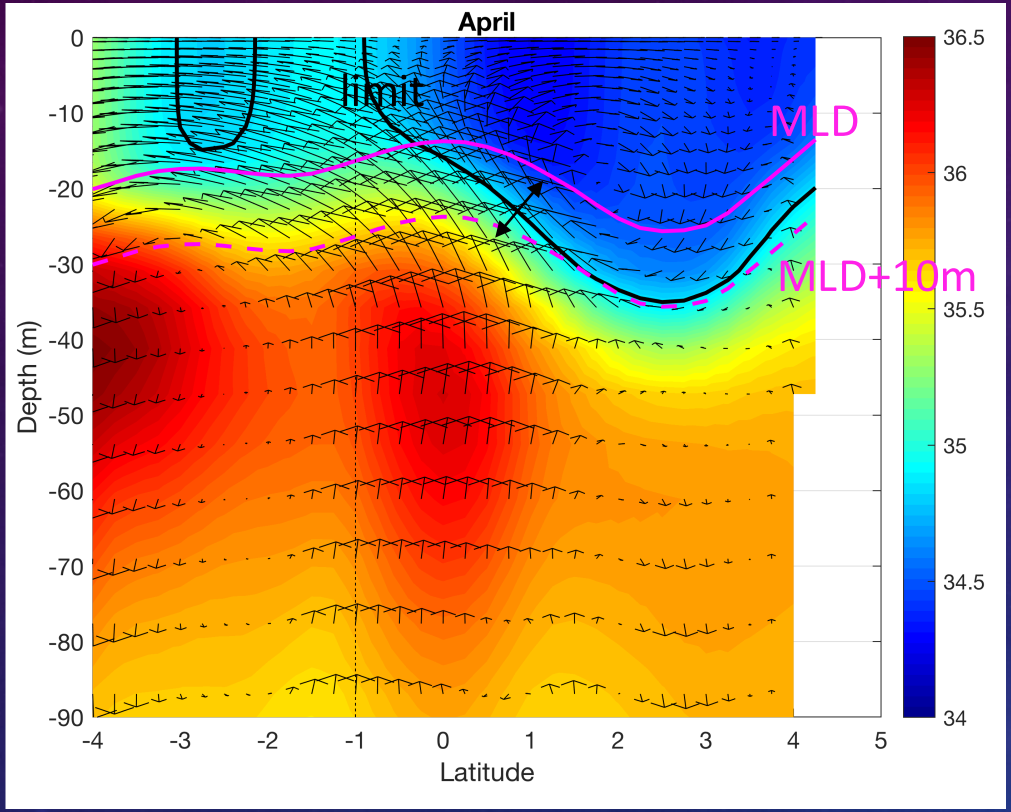
T South

ZADV at north similar variability as ZADV at south but larger values

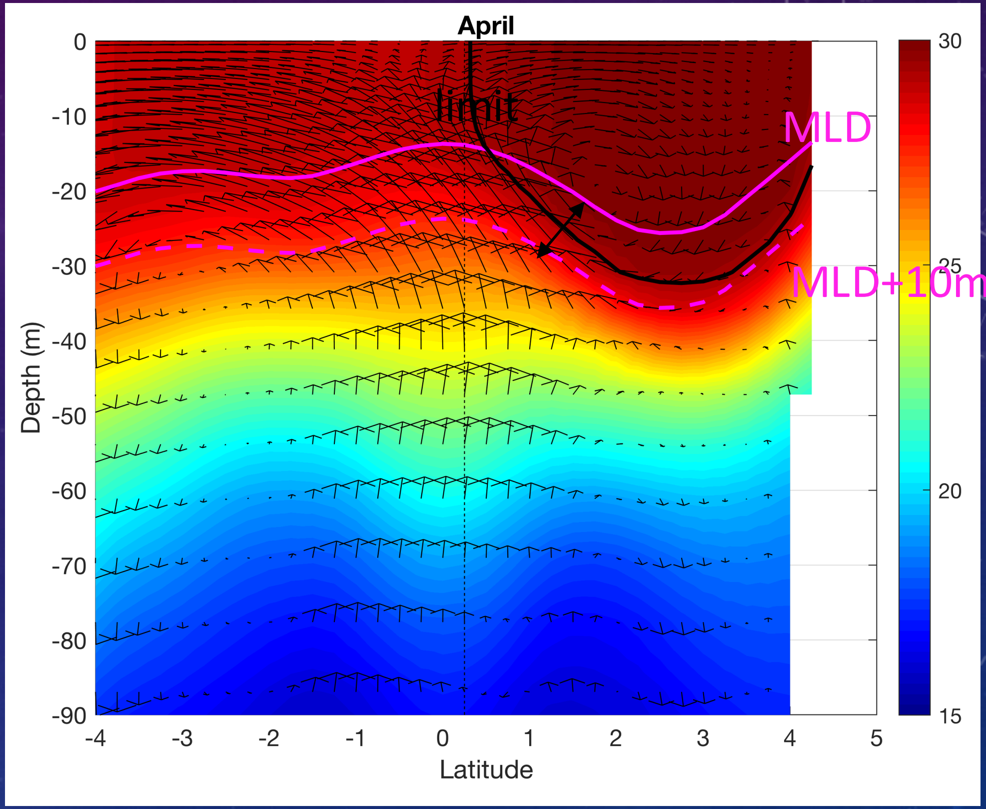
RESULTS: Significant salinity and temperature budget terms

Why the vertical advection is larger in the north than in the south?

Salinity

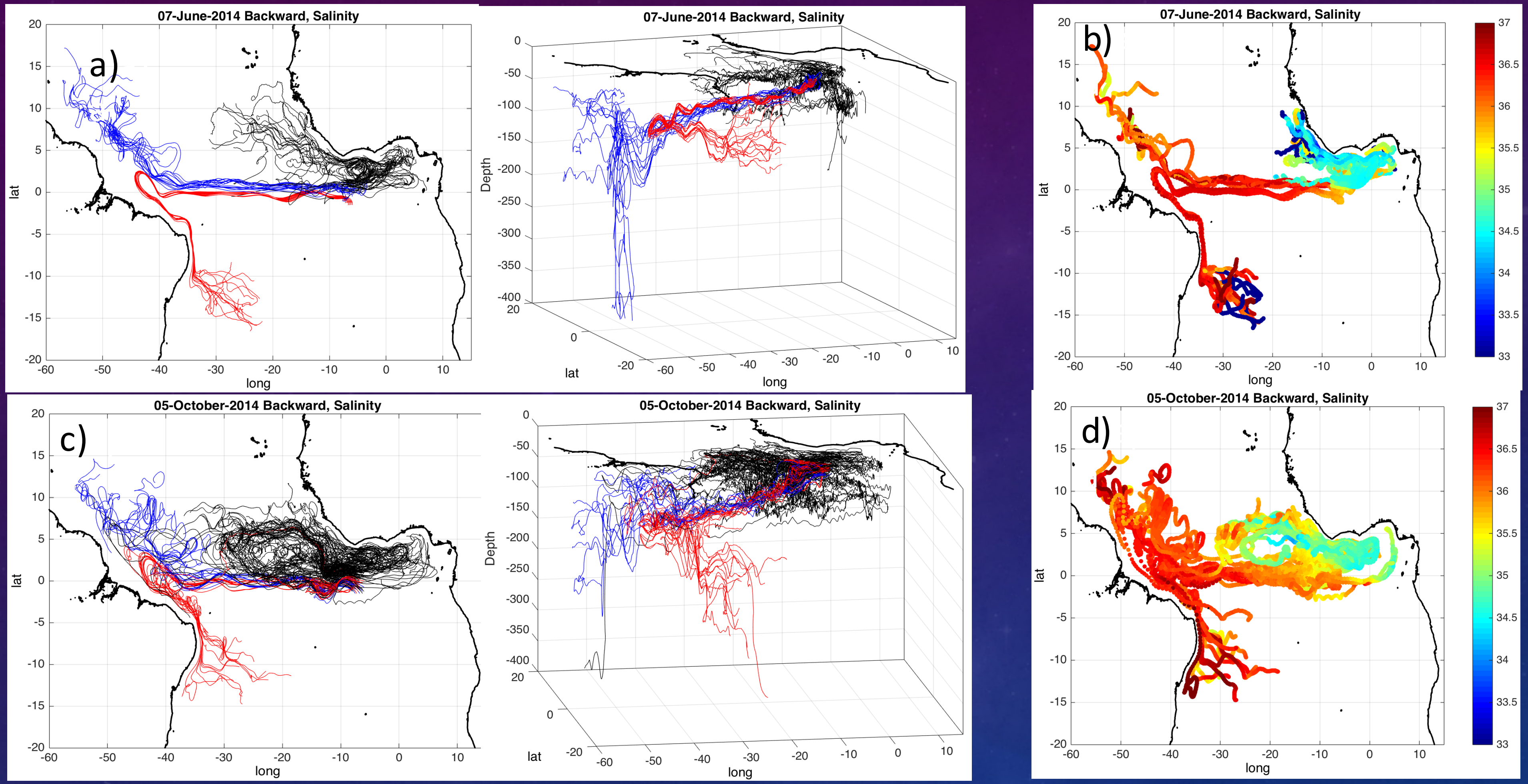


Temperature



Computation of ZADV in a volume?
Role vertical diffusion?

RESULTS: Trajectories derived from daily model data



Daily trajectories derived from model velocities. The particles are launched backward between 8ºW-6ºW, 1.5ºS-1.5ºN and 20-40 meters depth. a) and c) show the path of the particles for one year for two different start date, 07-June-2014 and 05-October 2014. b) and d) show the salinity (pss) along the trajectories.

Start date: 07-June-2014 when there is a salinity front.
Salty signal is coming from the EUC, coherent with Da Allada et al. (2017), Johns et al. (2014)

Start date: 05-Oct-2014, when there is no salinity front.
Salinity at the North of Equator increases and the gradient south-north is weak.

CONCLUSIONS AND DISCUSSION

- The model data represents adequately salinity variability of the equatorial region.
- The temporal variability of the PDF for salinity and temperature shows the presence of frontal system.
- During boreal summer, both fronts are generated due to vertical processes with one month of difference. However, the salinity front weakens due to the salinification of the fresh water pool on the north of the Equator caused by positive FLX and horizontal advection.
- The salinity front at the beginning of the year and the temperature front at the end of the year are associated with the variability of the surfaces fluxes, FLX and NHF respectively.
- The daily trajectories allowed to corroborate the origin of the water masses at both side of the equator.

THE END…….

Thank you!!

laurare@hawaii.edu