Interannual tropical Atlantic variability modes : classification and Sea Surface Salinity signature

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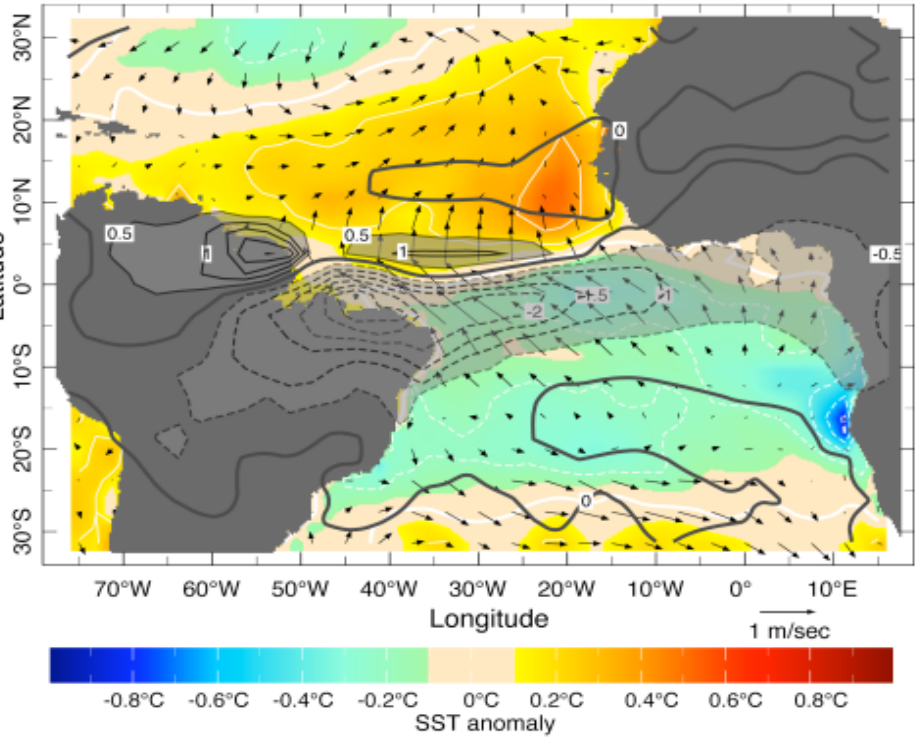
Interannual tropical Atlantic climate Modes

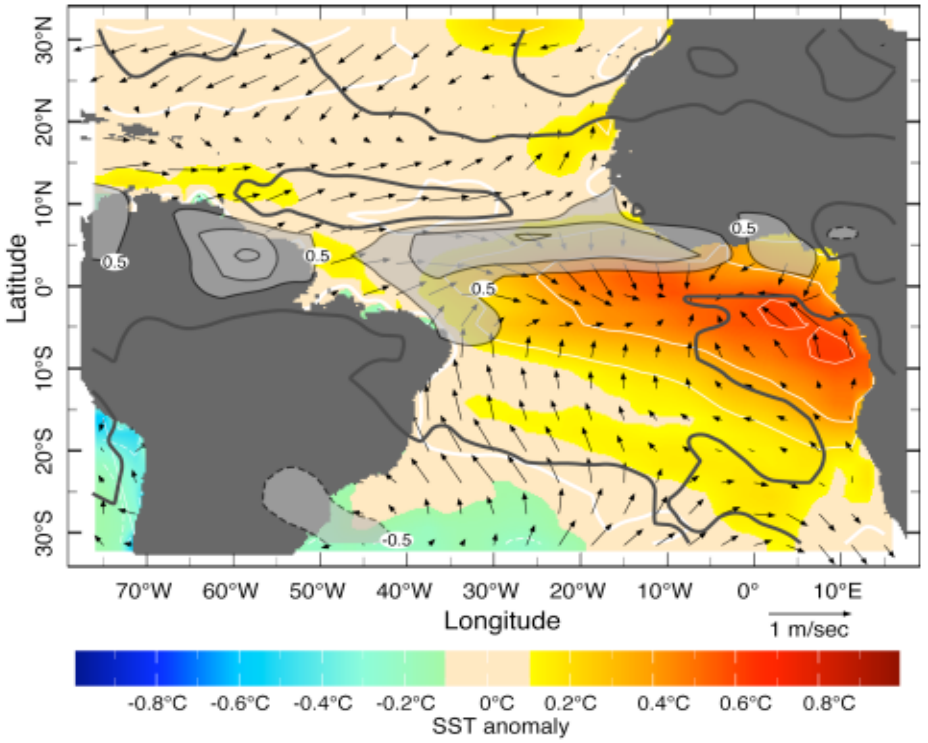
Meridional mode

- Inter hemisphéric SST gradient
- Affects precipitation in Northeast Brazil and tropical cyclone development in the North Atlantic.
- Peacks in boreal spring



Equatorial mode

- Atlantic "El Nino", lower than in the Pacific
- Interannual SST anomalies in Gulf of Guinea that affect Atlantic Cold tongue
- Peacks in boreal summer



Scientific questions :

- How can we classify annual activity of interannual modes ?
- What is the signature of meridional and equatorial modes in Sea Surface Salinity (SSS)?
- What are the processes (oceanic and/or atmospheric) responsible for this signature?

Data and Methodology

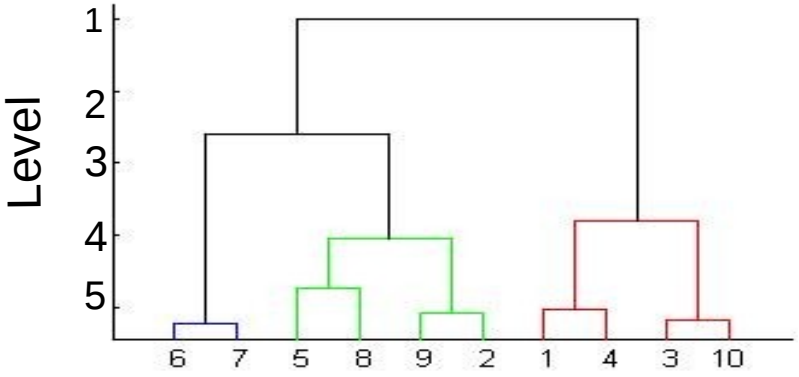
DATA (1980-2012)

- **Observation**: SST, Wind, precipitation (Era interim) and SSS (LEGOS)
- **Model :** NEMO simulation (resolution: 1/4°, 1day, 75 vertical levels)

METHODOLOGY

For classification of the modes:

- Empirical Orthogonal Function (EOF)
- Agglomerative Hierarchical Clustering (AHC):



AHC dendrogram tree

The cluster analysis is a nonlinear composite procedure that merges similar SST maps into clusters.

Same AHC procedure as Singh et al. 2011

Data and Methodology

METHODOLOGY (end)

For identification and explanation of SSS signature:

- Linear regression

- Mixed-layer salinity evolution equation

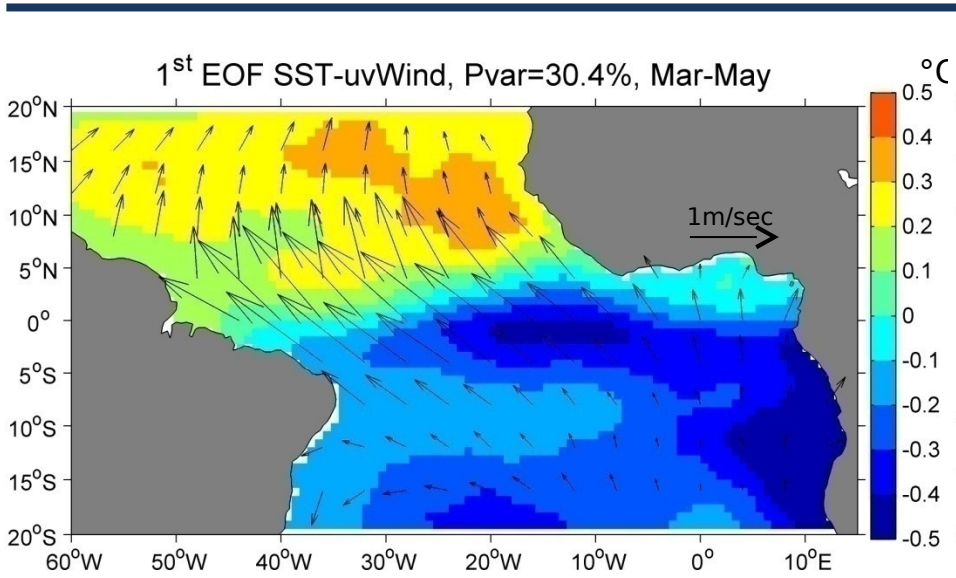
$$\partial_t \mathrm{SSS} = \underbrace{-\langle u\partial_x S\rangle}_{\mathrm{ADU}} \underbrace{-\langle v\partial_y S\rangle}_{\mathrm{ADV}} \underbrace{-\langle w\partial_z S\rangle}_{\mathrm{ADW}} \underbrace{+\langle D_l(S)}_{\mathrm{DIFL}} \underbrace{-\frac{(k\,\partial_z S)_{z=-h}}{h}}_{\mathrm{DIFV}} \underbrace{-\frac{1}{h}\frac{\partial h}{\partial t}(\mathrm{SSS}-S_{z=-h})}_{\mathrm{ENT}} \underbrace{+\frac{(E-P-R)\ \mathrm{SSS}}{h}}_{\mathrm{FWF}}$$

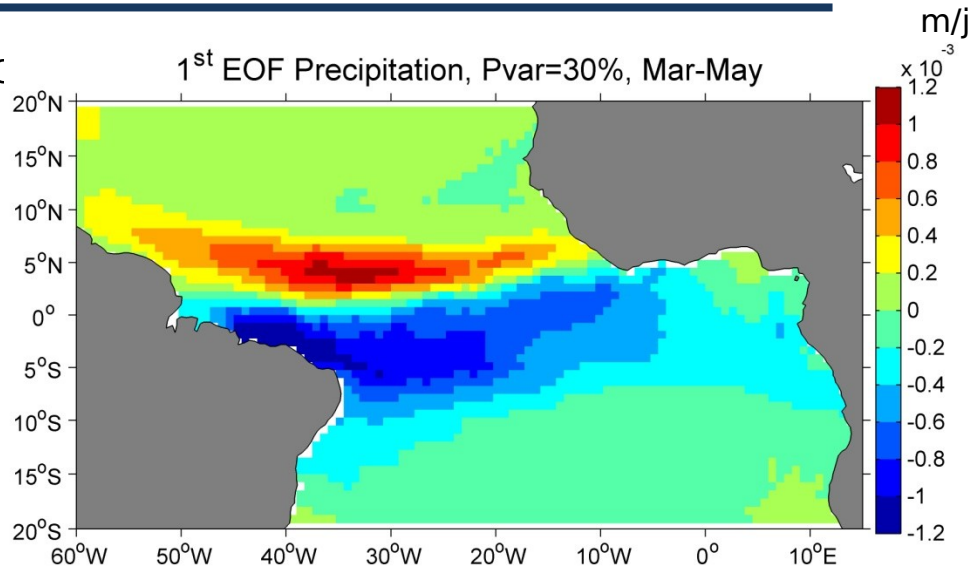
tendency | advection | diffusion | entrainment | Fresh water flux

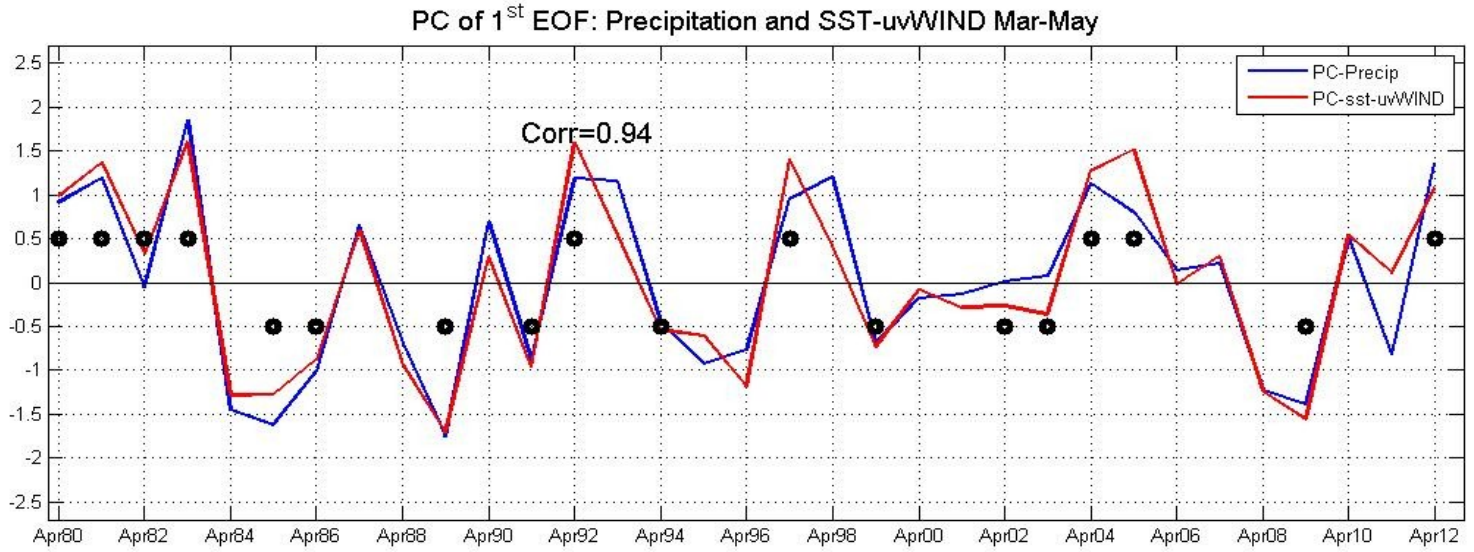
Da-Allada et al. 2014

Annual classification of interannual modes

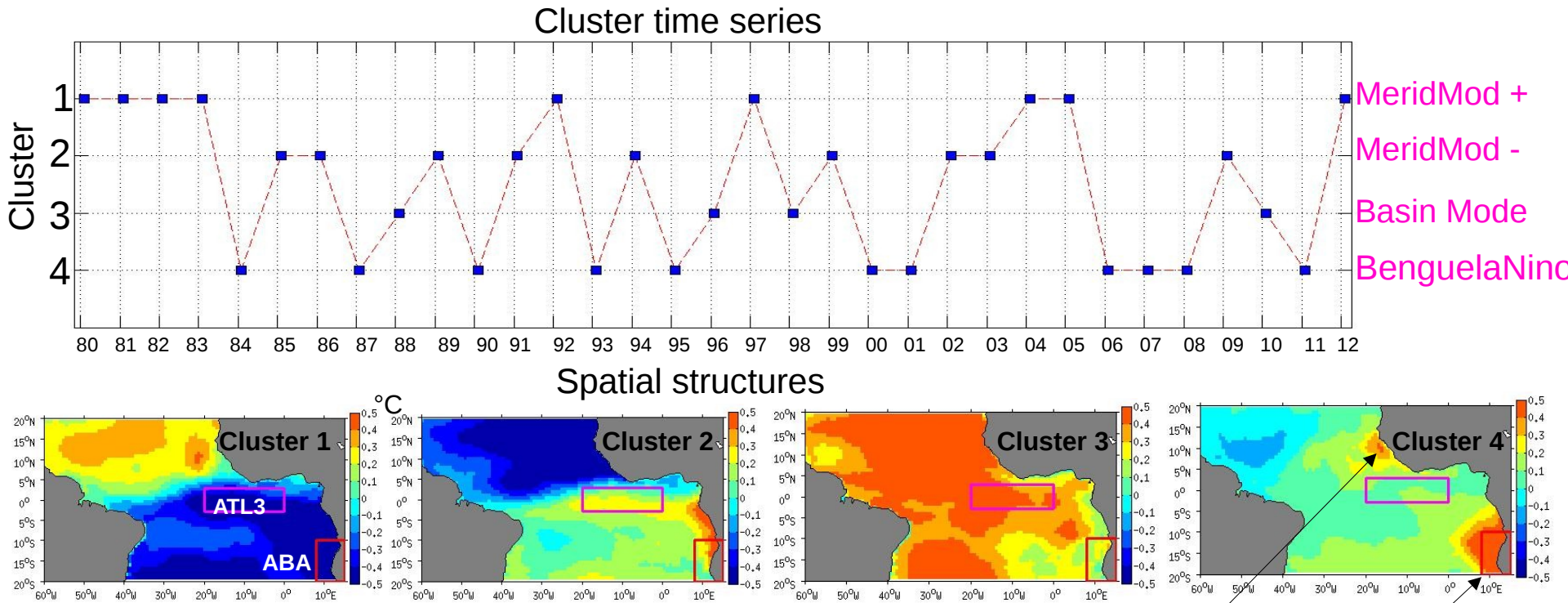
Meridional mode from Eof analysis







Spring(MAM) Modes using AHC procedure

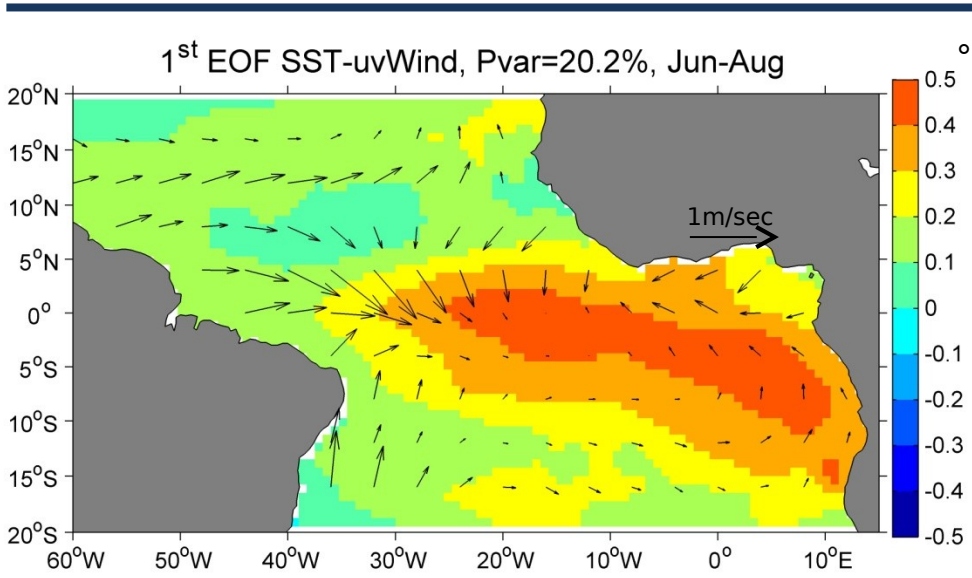


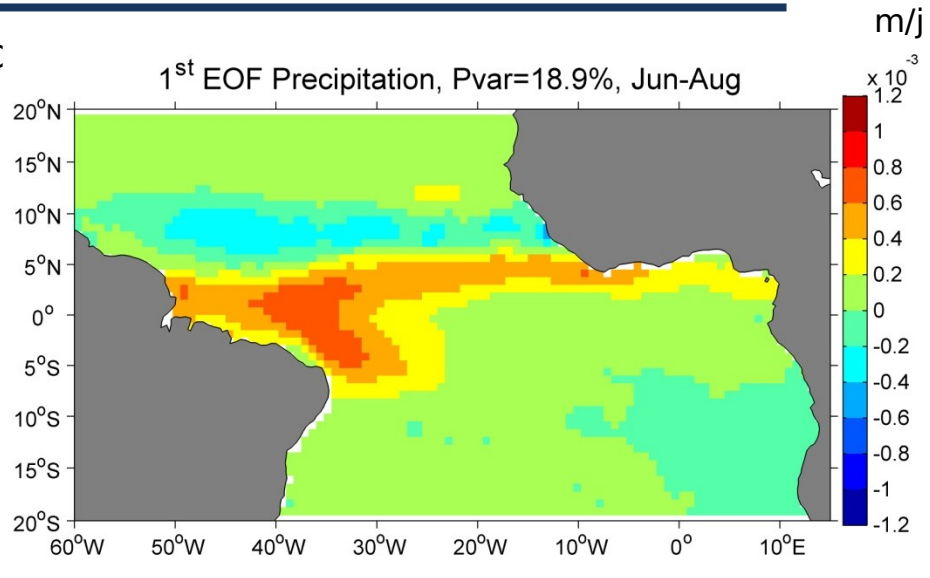
Meridional mode years:

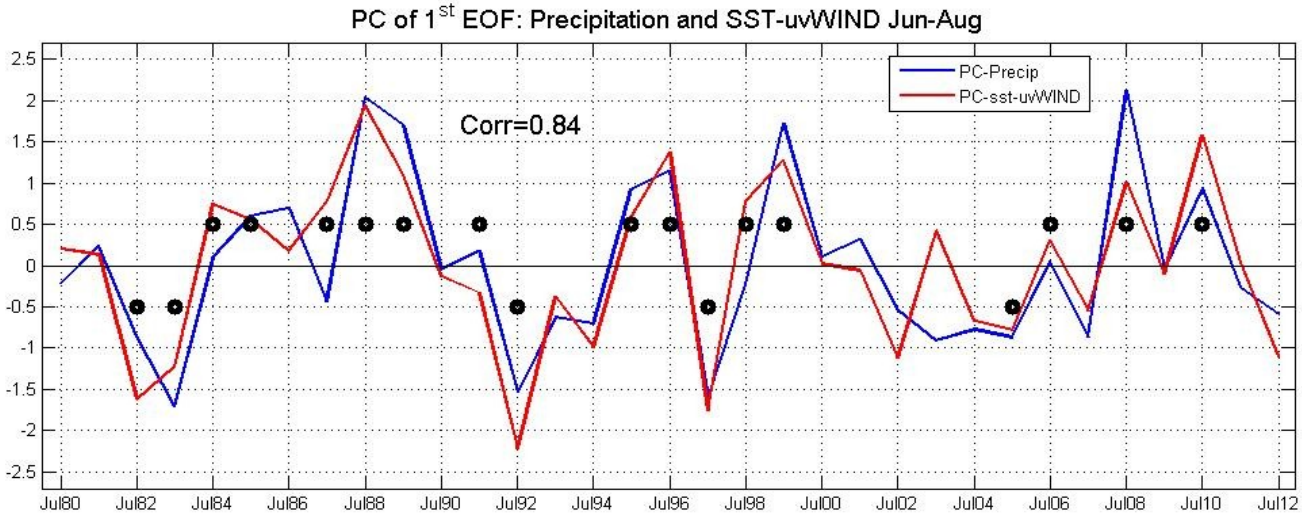
- **Positive Phase : Cluster 1 + PCeof1>+0.5:** 1980, 1981, 1983, 1992, 1997, 2004, 2005, 2012
- **Negative Phase: Cluster 2+ PCeof1<-0.5:** 1985, 1986, 1989, 1991, 1994, 1999, 2003, **2009**

- Benguela Nino appears with another coastal warming in the north tropical Atlantic
- Benguela Nina occurs more often with positive meridional mode
- Difference in spatial pattern between Benguela Nino and Benguela Nina (Benguela Nino could be an asymetric mode)

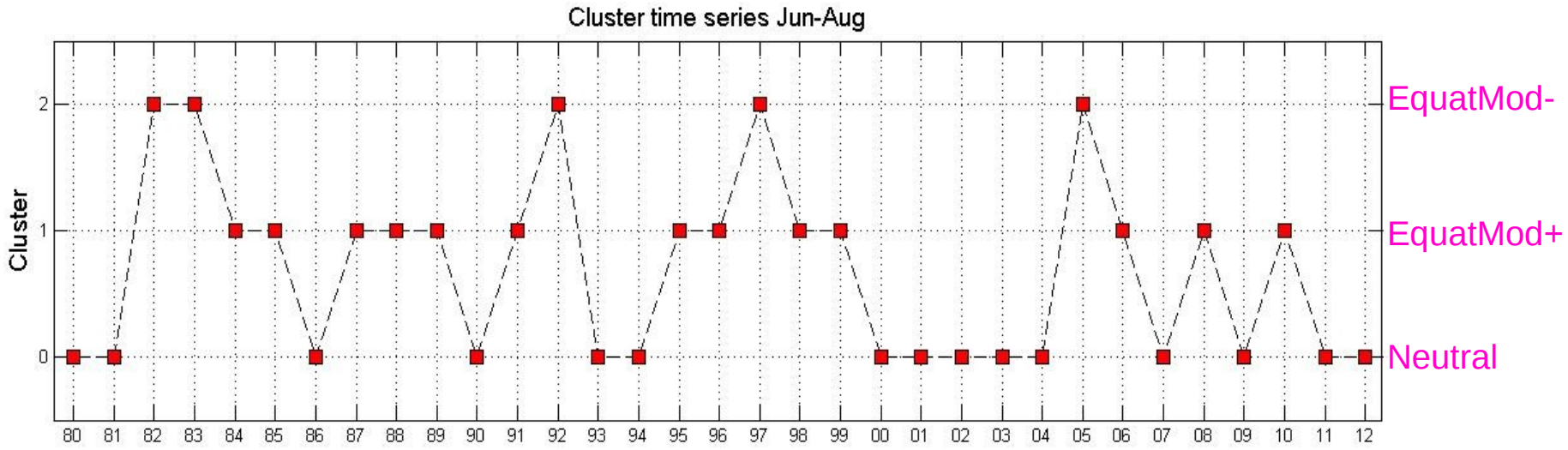
Equatorial mode From Eof analysis

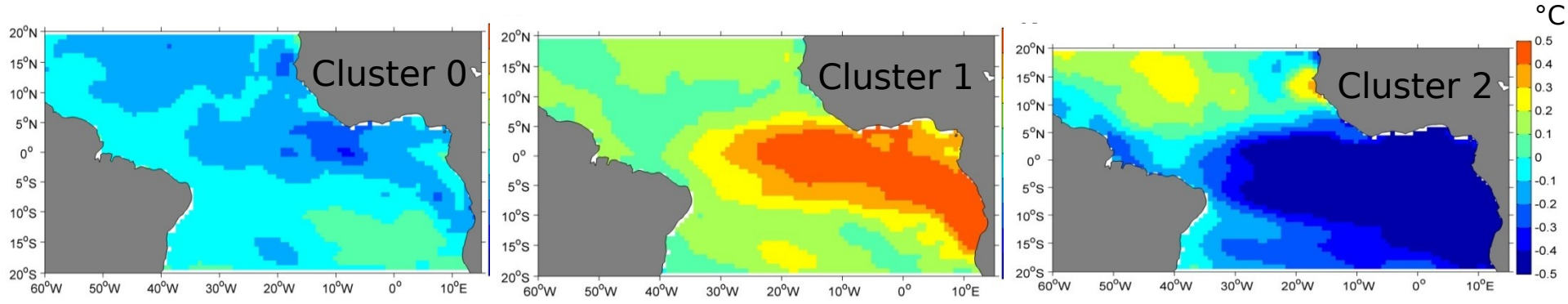






Summer(JJA) Modes using AHC procedure



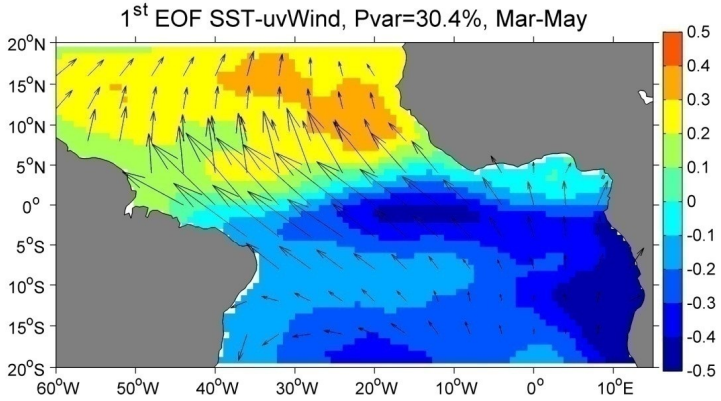


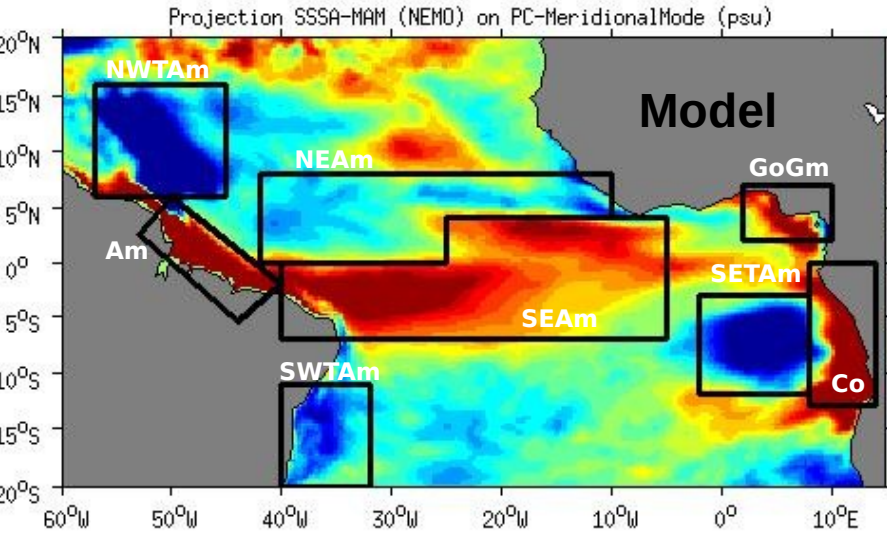
Equatorial mode years:

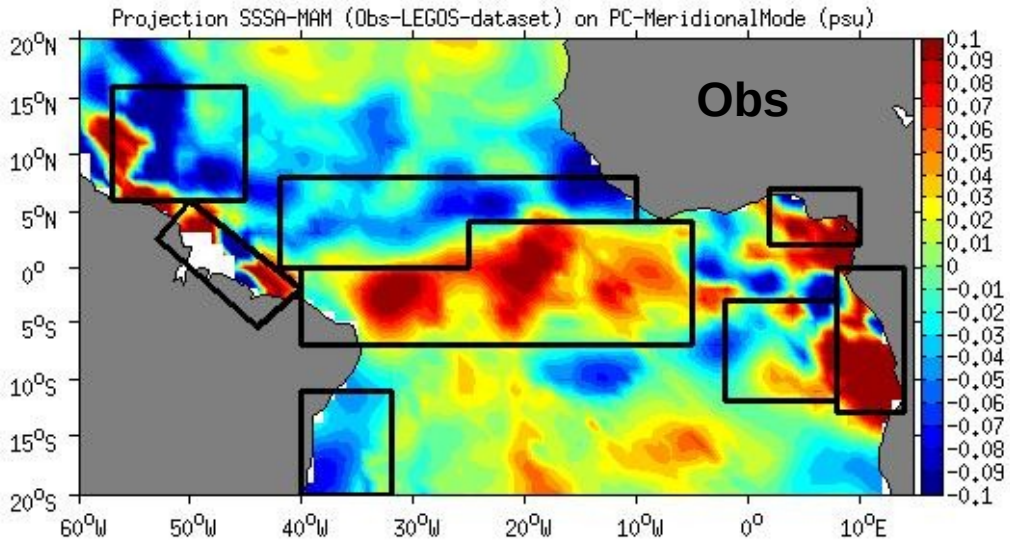
- **Positive phase: Cluster 1 + PCeof1>+0.5:** 1984, 1985, 1988, 1989, 1995, 1996, 1998, 1999, **2008**, 2010
- **Negative phase: Cluster 2+ PCeof1<-0.5:** 1982, 1983, 1992, 1997, 2005

Signature of meridional and equatorial modes in SSS

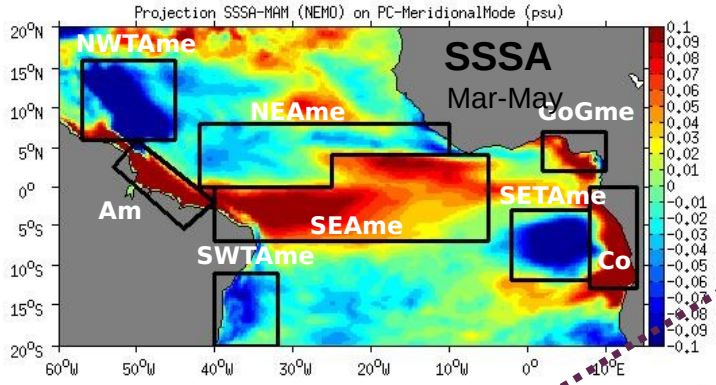
Signature of meridional mode in SSS

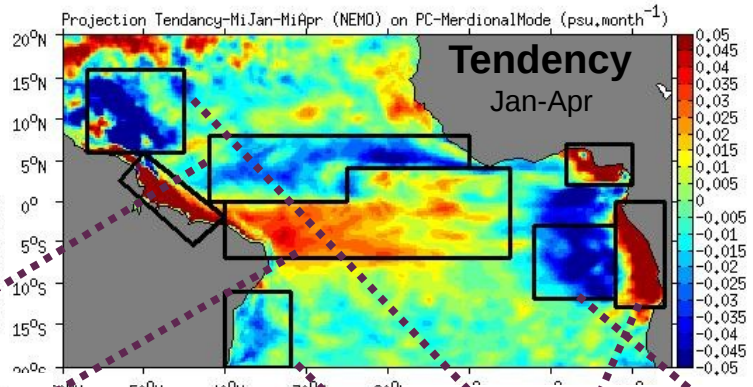


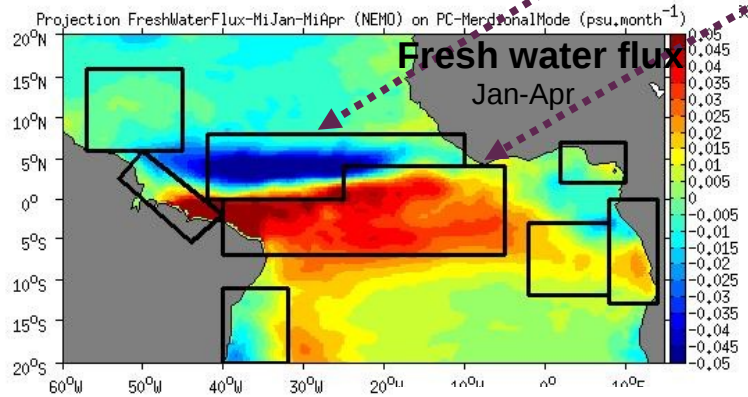


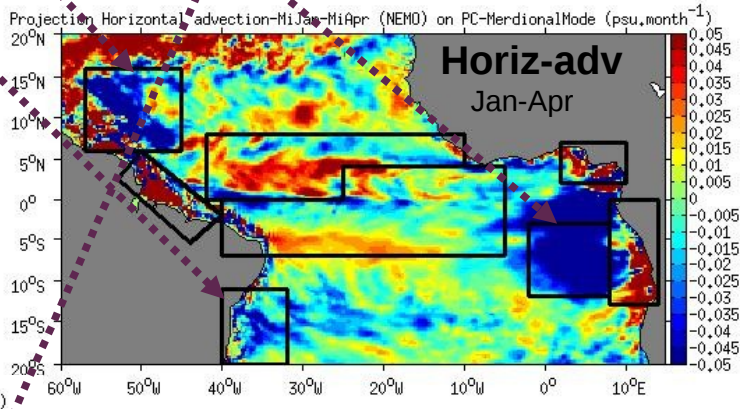


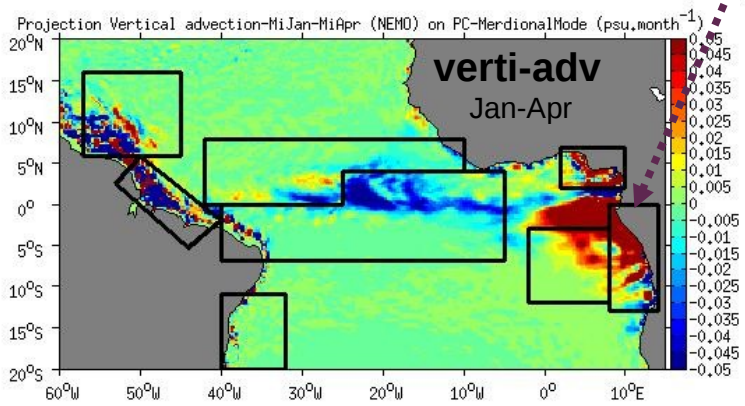
SSS-Meridional Mode : **mixed-layer salinity budget**









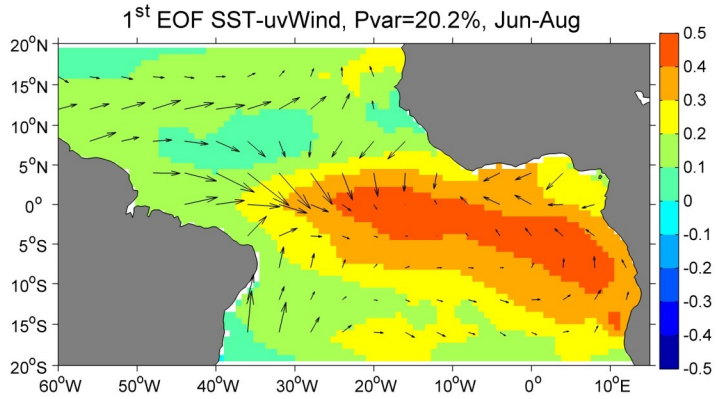


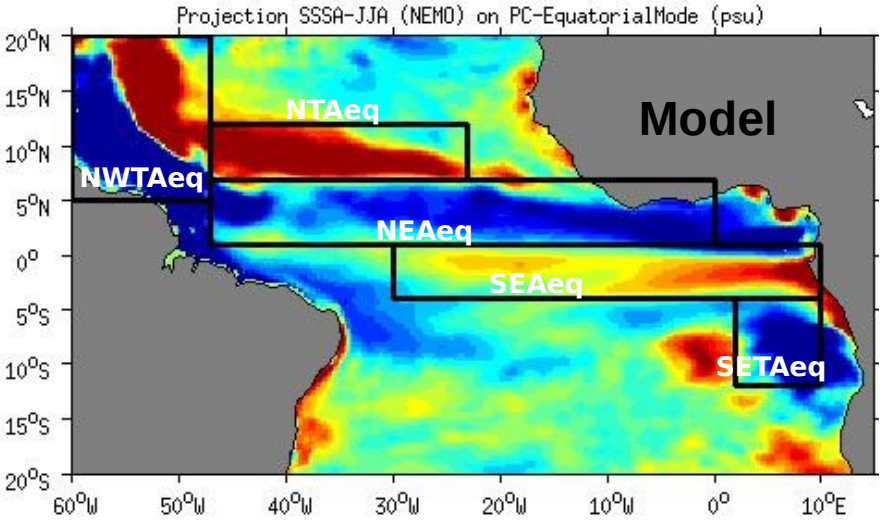
NEAme & **SEAme**= Fresh Water Flux

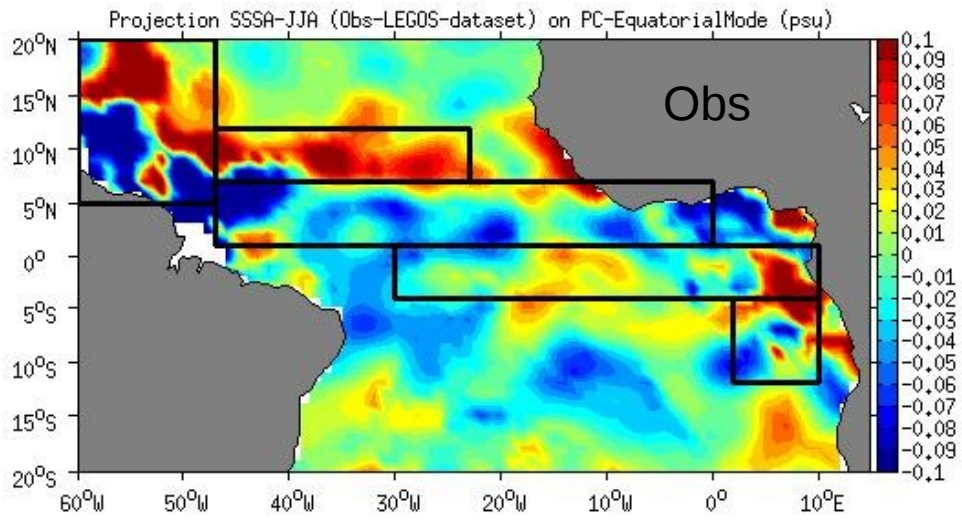
NWTAme & **SETAme** & **SWTAme** = horiz adv

GoGme & **Co**= (horiz+ verti) adv

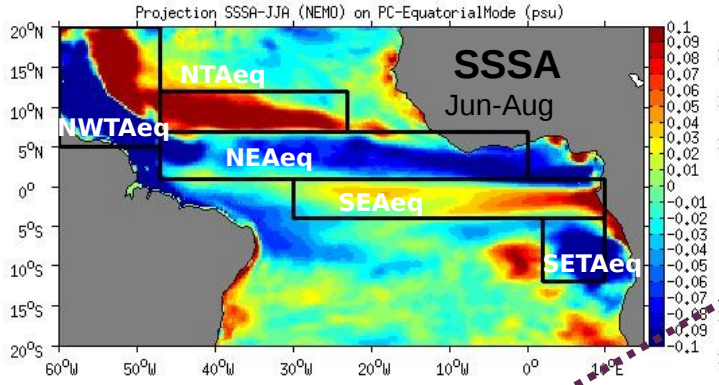
Signature of equatorial mode in SSS

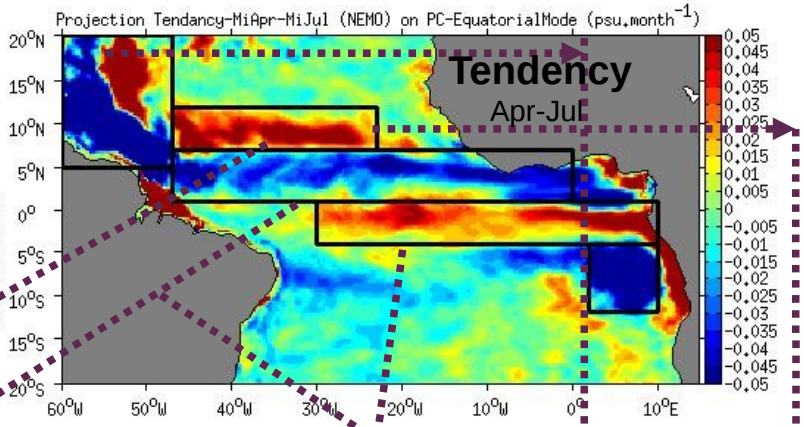


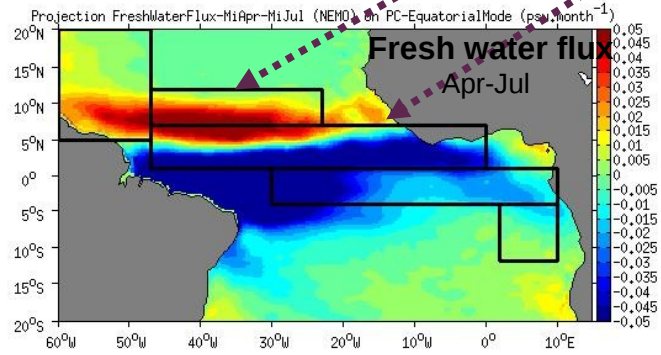


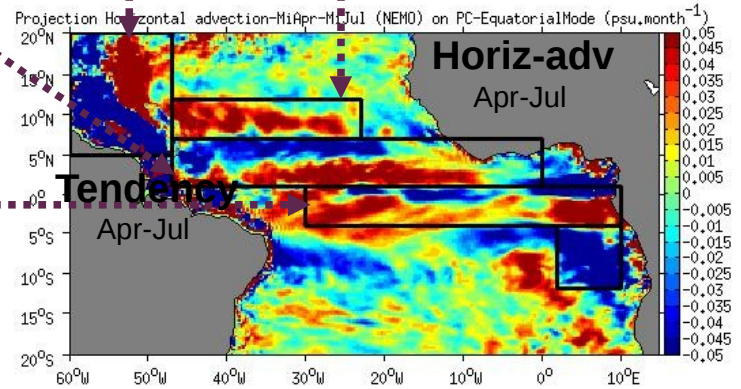


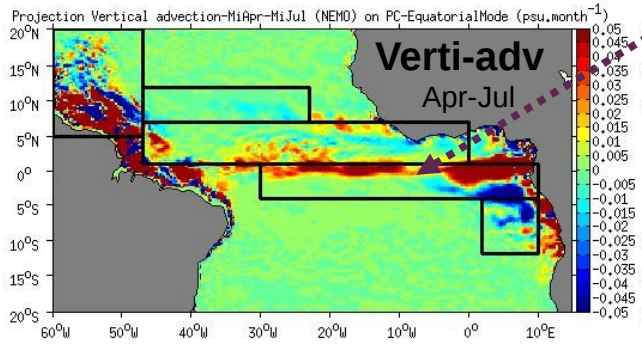
SSS-Equatorial Mode : **mixed-layer salinity budget**

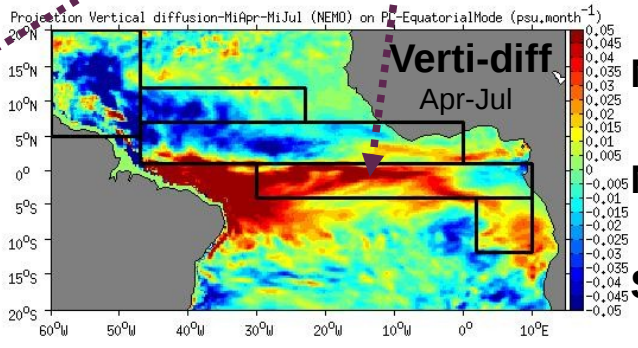












NTAeq & **NEAeq**= FWF + horiz adv

NWTAeq & **SETAeq**= horiz adv

SEAeq= (horiz+ vert) adv + vert diff

Conclusion

1. AHC is a useful tool to classify tropical Atlantic modes :

- 4 dominant modes are identified : meridional mode, benguela Nino, equatorial mode and basin mode
- Benguela Nino could be an asymetric mode and appears with another coastal warming in North tropical Atlantic

2. Processes responsible for the signature of meridional and equatorial modes :

- For meridional mode :
  - + equatorial region: changes in fresh water flux: ITCZ northern migration
  - + East and West regions: changes in horizontal advection: SSS gradient vs currents ?
  - + Runoff regions (GoG & CO): changes in horizontal + vertical advection : strong horizontal/vertical gradients

- For equatorial mode :
  - + North equatorial region: combined contribution of fresh water flux and horizontal advection : ITCZ southern migration + ?
  - + East and West regions: changes in horizontal advection
  - + South equatorial region: changes in horizontal + vertical advection and vertical diffusion

Next step: roles of current anomalies ?

Thank you !