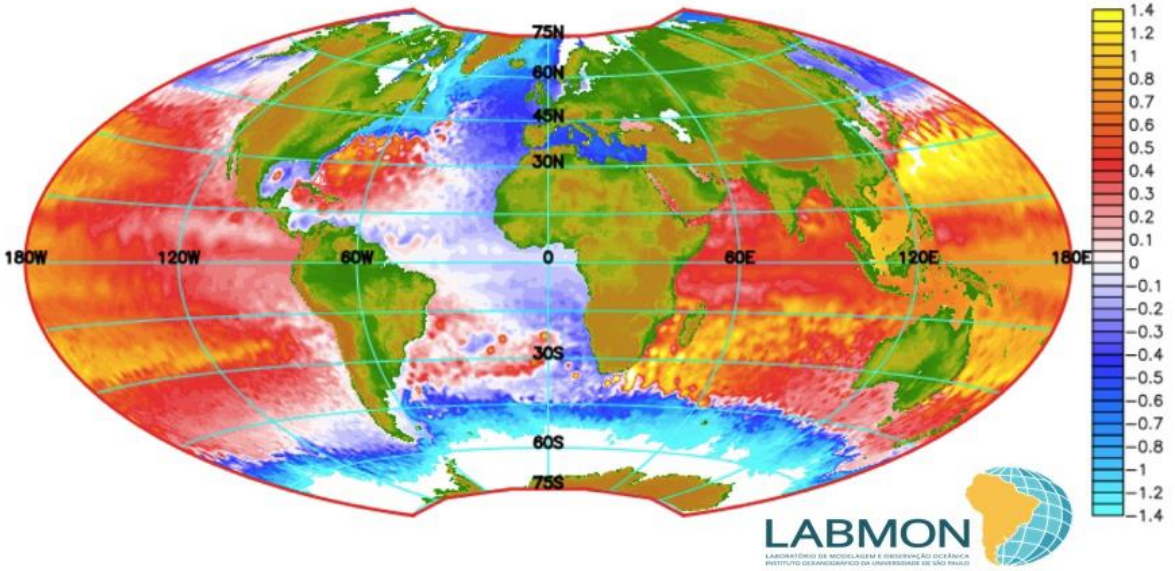
A 1/12-degree global experiment with HYCOM forced with NCEP products from 1949 to 2014



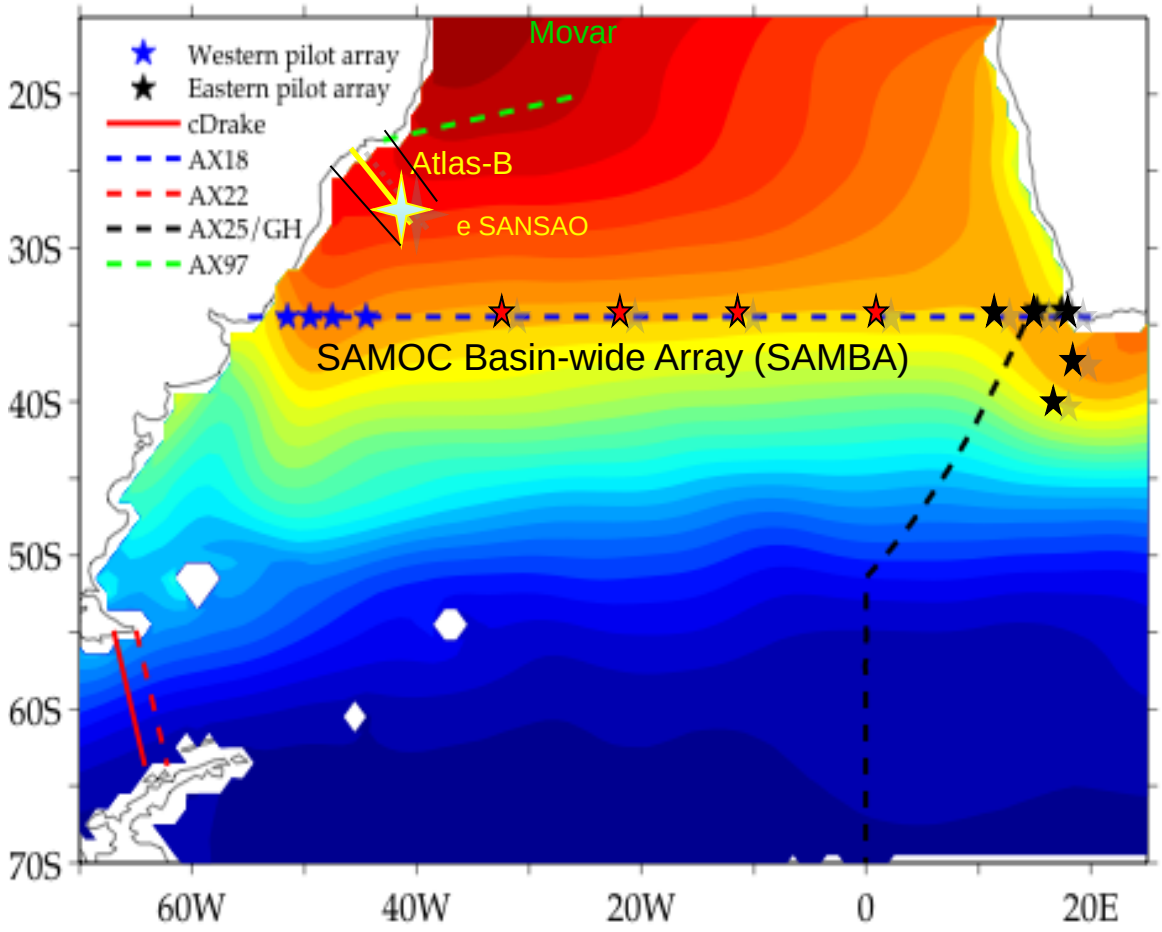
Edmo J. D. Campos

Oceanographic Institute of the University of São Paulo

Numerical Modeling Laboratory - LABMON

15th Layered Ocean Model Workshop - Copenhagen, Denmark – June 2-4/2015

South Atlantic MOC (SAMOC)



An international program to monitor the MOC in the South Atlantic. (*amol.noaa.gov/phod/SAMOC_international*)

SAMBA: The SAMOC Basin-Wide Array

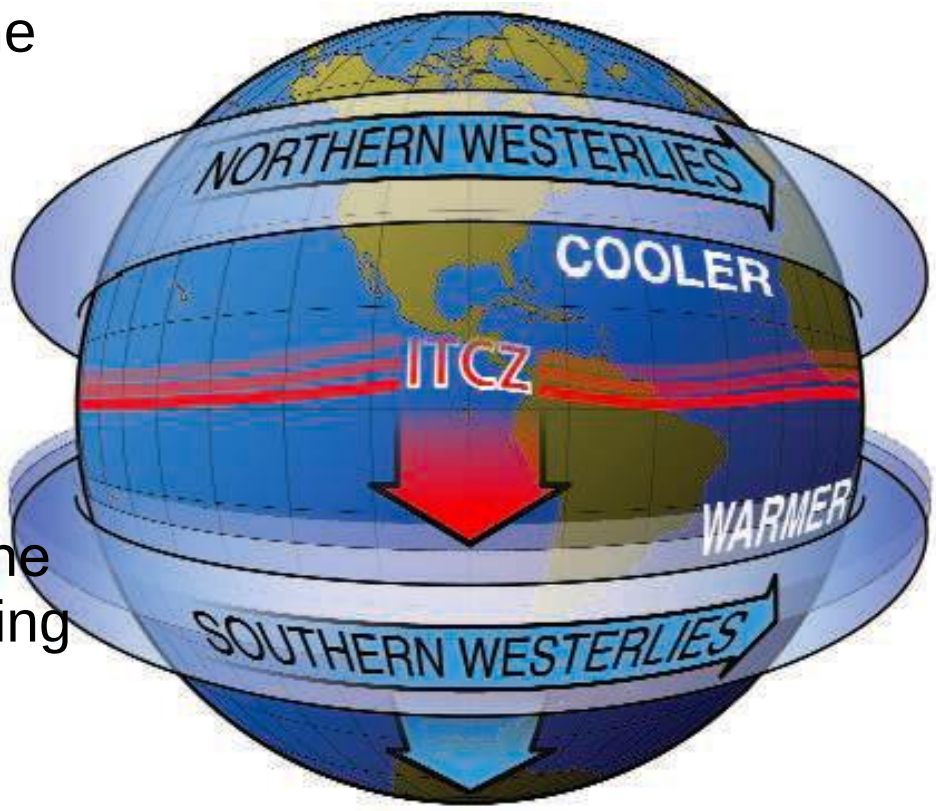
Observations and numerical modeling.

Shifting Westerlies

The southern hemisphere's westerly winds have strengthened and shifted towards the pole over the past decades.

Fact:
The ocean circulation in the in the upper layers is mainly driven by the winds.

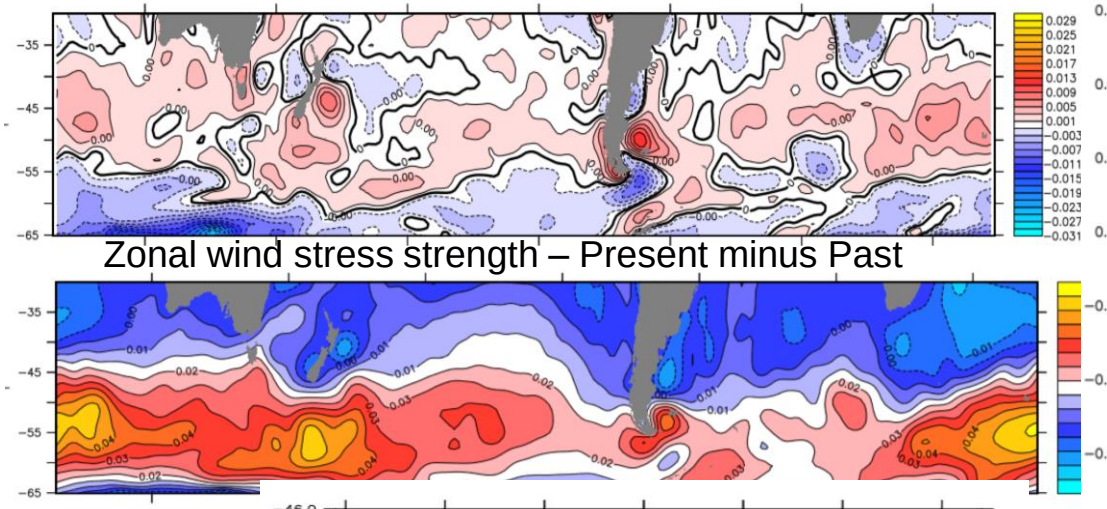
Question:
What would be the ocean's response to the shifting westerlies in a global eddy-resolving ocean general circulation model (OGCM) forced with observed wind products?



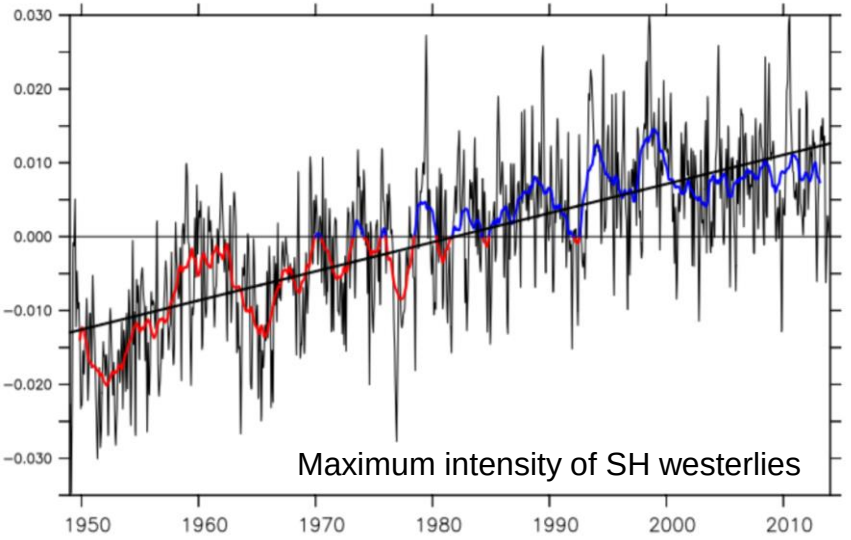
Toggweiler, J.R. (2009), *Science*

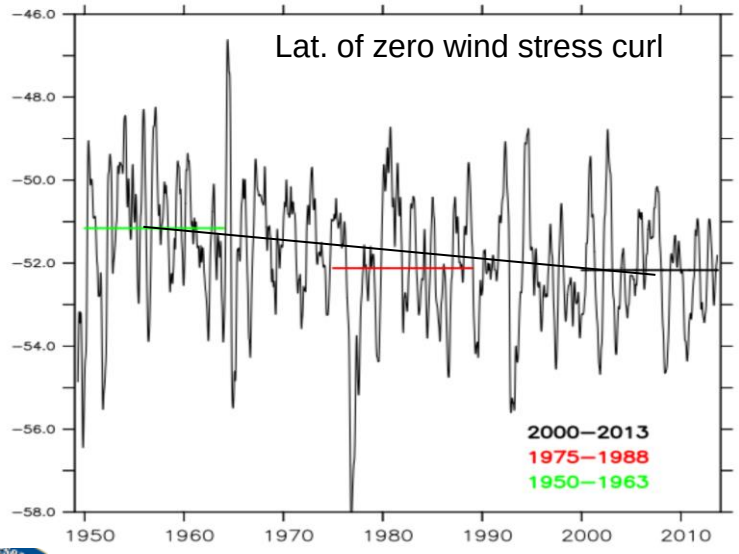
Forcing Fields (NCEP)

Wind stress curl – Present minus Past



Zonal wind stress strength – Present minus Past





NCEP's westerlies in the SH have intensified and shifted poleward

LABMON's Computer Resources

TUPÃ Supercomputer

Center for Weather Prediction and Climate Research
Brazilian Space Research Institute (CPTEC/INPE)

CRAY XT6 with 1280 nodes with 24 processors;
Maximum performance 258 Tflops
4.5 Petabytes of disc storage

Tupã: The supreme god, the creator of everything in the Tupi-Guarani mythology in Brazil.

Cluster CAIPORA

LABMON/IOUSP

SGI ALTIX-ICE with a total of 980 computer cores and ~120TB of disc

Caipora is an entity of the Tupi-Guarani mythology in Brazil. It is mischievous dark-skinned, small Indian, naked with a very long black mane

Experiments

ATIa0.25: Atlantic-Indian Ocean Basin (98W – 114E, 65S:65N); 0.25-deg; 22 sigma0 layers. Forced with NCEP-1 monthly means, 1949-2010

ATIb0.08: South Atlantic (70W-40E; 55S-10N); 1/12-deg nested in **ATIa0.25**.

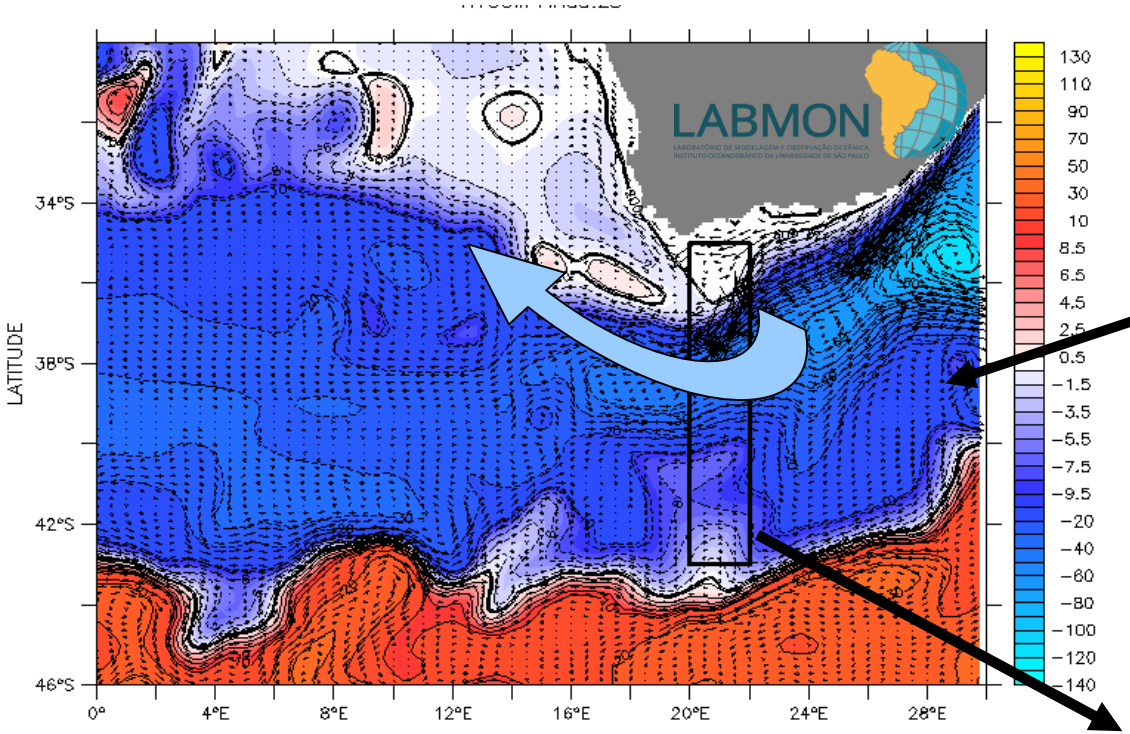
- expt_17.4 – Forced with NCEP-1 monthly means
- expt_17.5 – Forced with NCEP-2 6-hourly products (from 2000 to 2010)

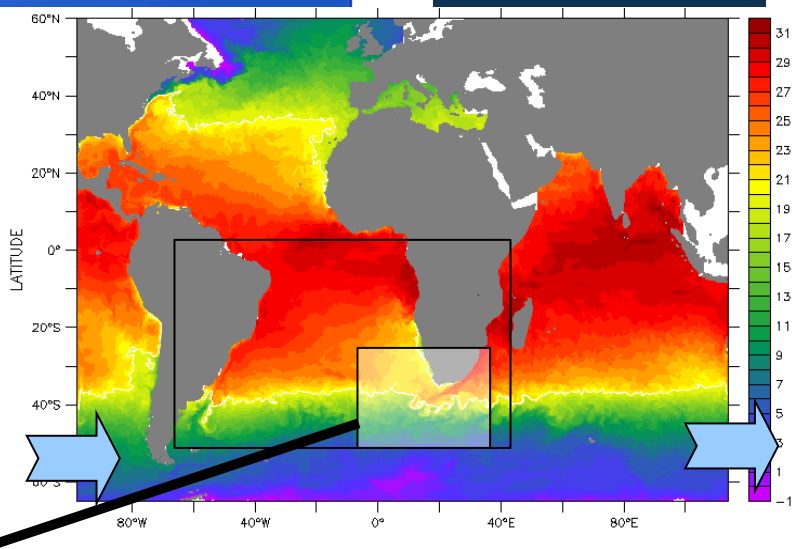
GLBa0.08: Global; 1/12-deg; 32 sigma2 layers. Forced with NCEP-1 monthly means.

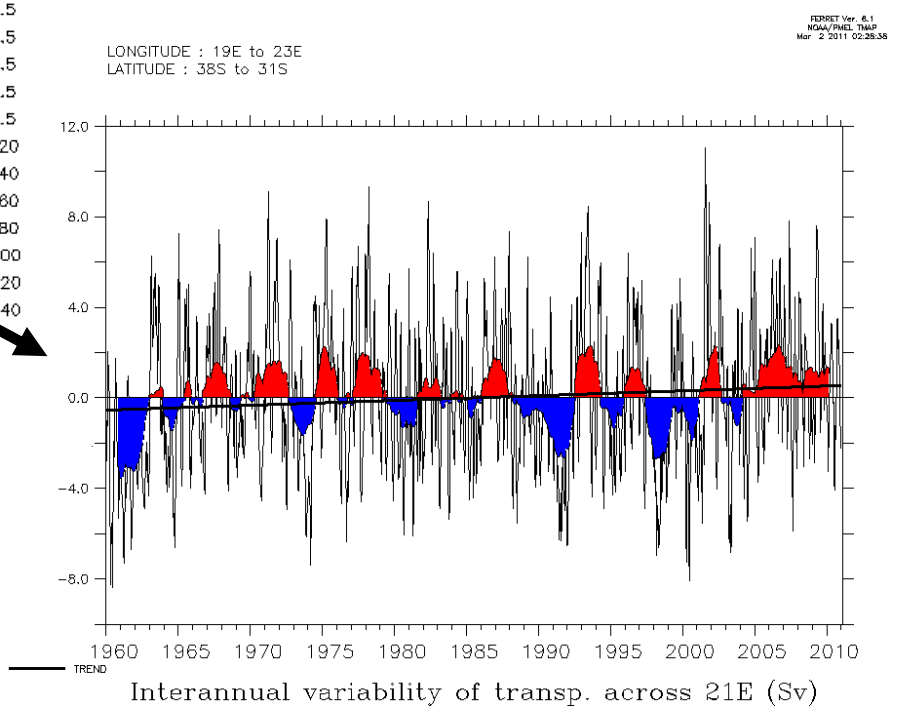
- expt_18.2: kapref = 2; vsigma = 0; ticegr = 2; iceflg = 0; flxoff = 0; priver = 1
- expt_18.3: kapref = -1; vsigma = 1; ticegr = 0; iceflg = 1; flxoff = 1; priver = 1

* Setting-up of GLBa0.08, particularly expt_18.3, was made with the most valuable help from Alex Bozec.

ATIa0.25 and ATIb0.08



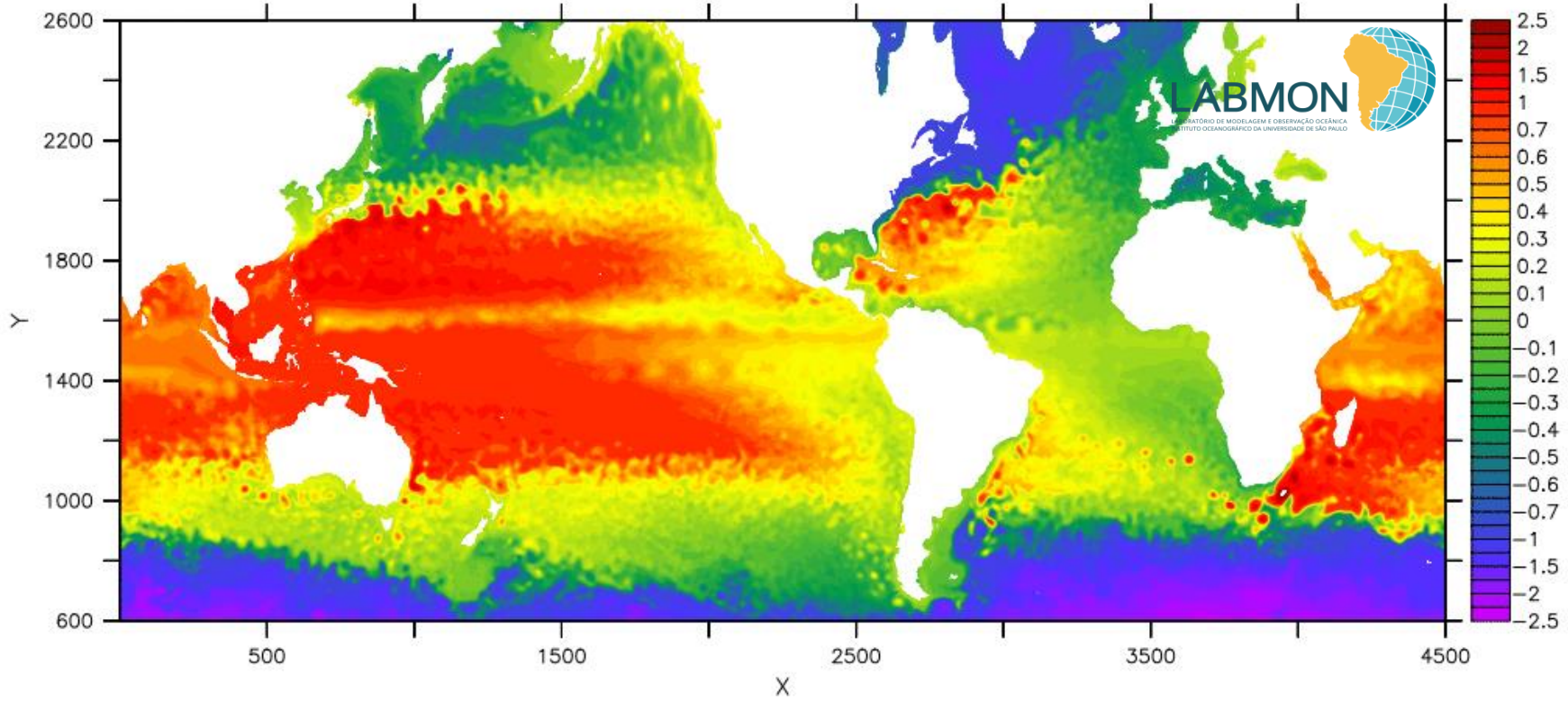




ATIa0.25 and ATIb0.08 were able to reproduce variability in the Agulhas region. Results are being published (Castellanos et al., Progr. In Oceanogr., 2015; Castellanos et al., JGR in review,; Giddy et al., JGR in review, etc...)

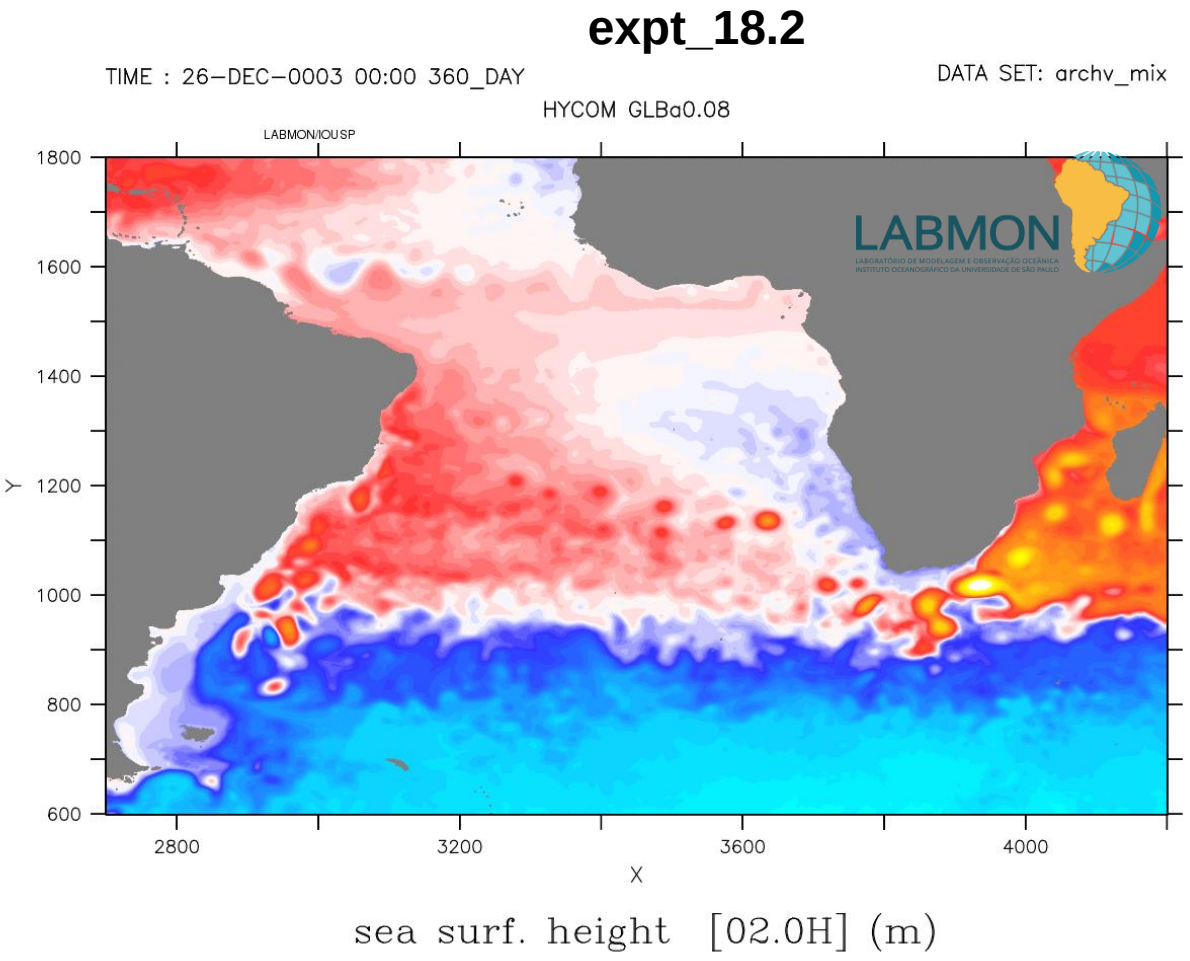
GLBa0.08

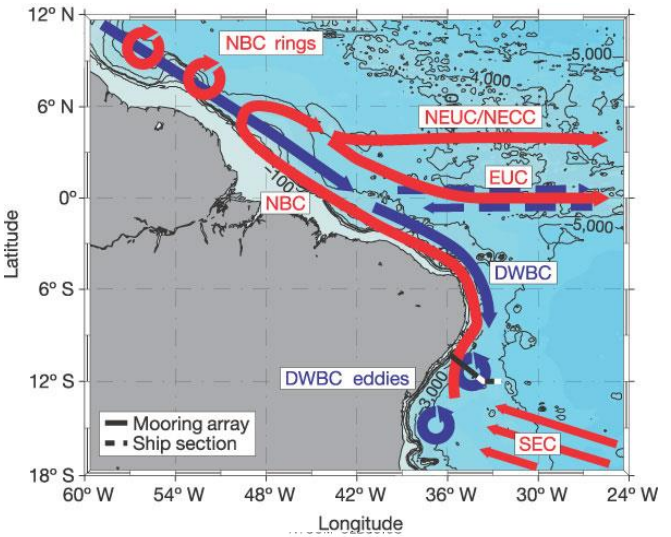
expt_18.2: kapref = 2; vsigma = 0; ticegr = 2; iceflg = 0; flxoff = 0; priver = 1

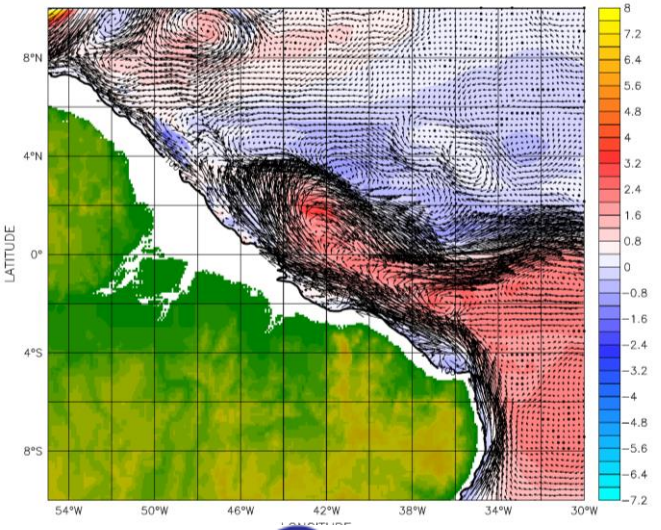


sea surf. height [02.0H] (m)

Evaluation

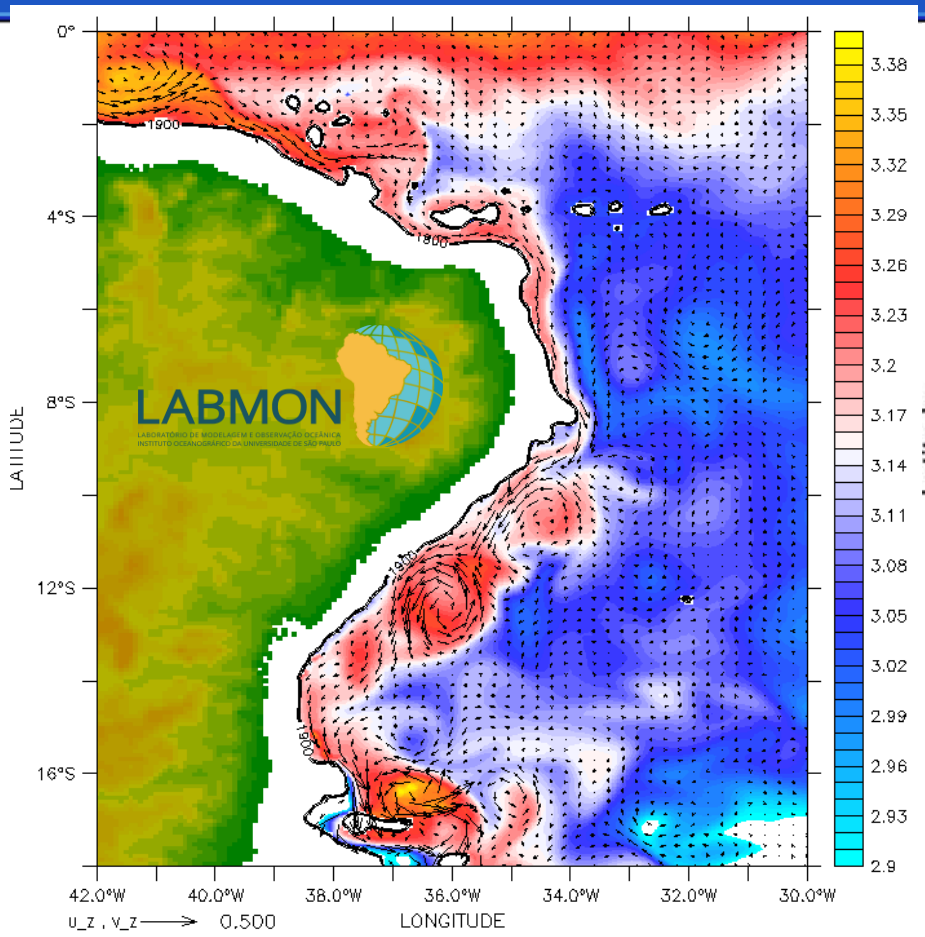

expt_18.2
TIME : 26–DEC–0003 00:00 360_DAY
DATA SET: archv_mix
HYCOM GLBa0.08
LABMON/IOUSP
LABMON
1800
1600
1400
1200
1000
800
600
Y
2800
3200
3600
4000
X
sea surf. height [02.0H] (m)

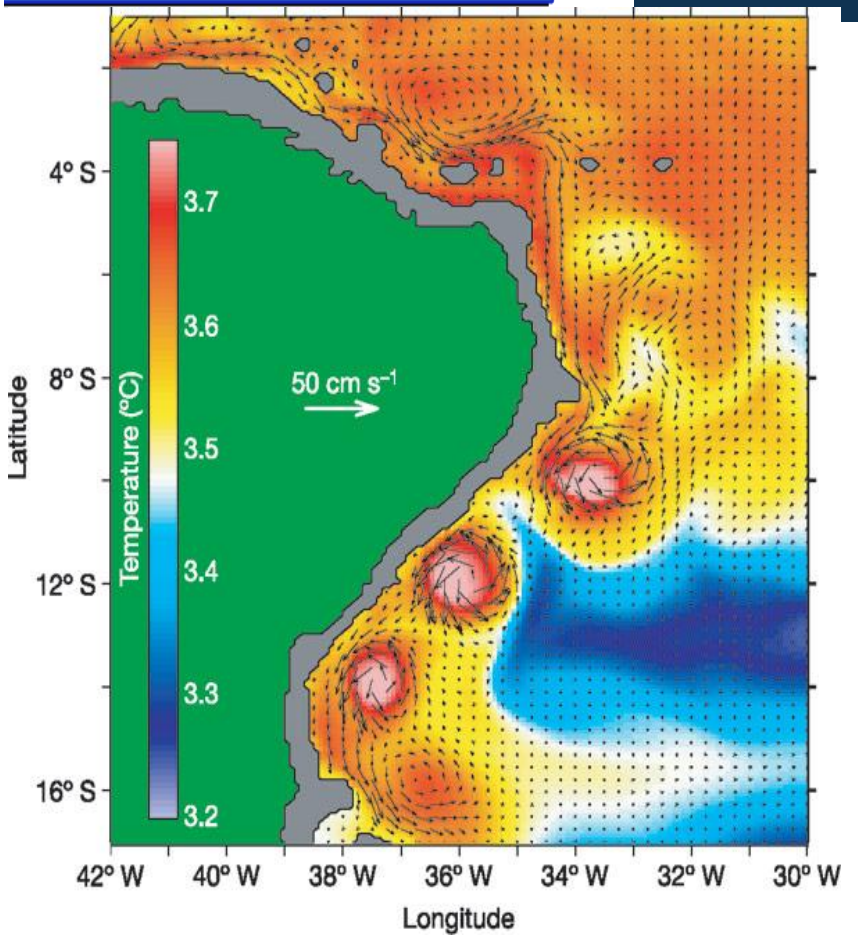

12° N
6° N
0°
6° S
12° S
18° S
Latitude
60° W
54° W
48° W
42° W
36° W
30° W
24° W
Longitude
NBC rings
NEUC/NECC
EUC
NBC
DWBC
DWBC eddies
SEC
Mooring array
Ship section
5,000
4,000
100
3,000


8°N
4°N
0°
4°S
8°S
LATITUDE
54°W
50°W
46°W
42°W
38°W
34°W
30°W
8
7.2
6.4
5.6
4.8
4
3.2
2.4
1.6
0.8
0
-0.8
-1.6
-2.4
-3.2
-4
-4.8
-5.6
-6.4
-7.2

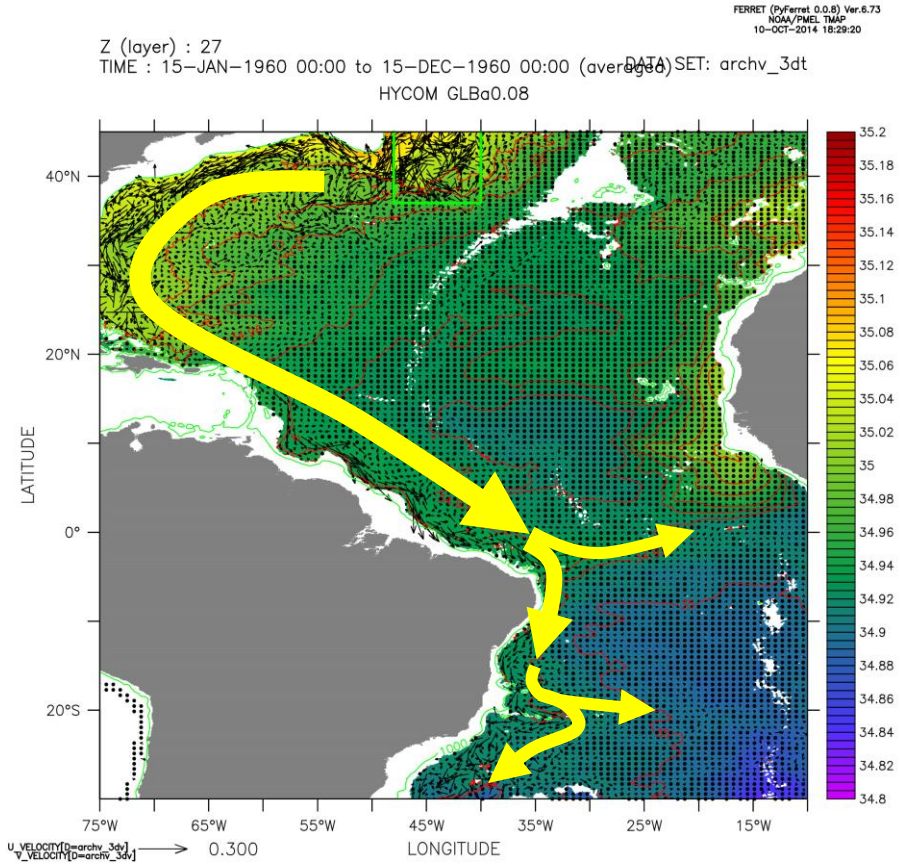
Evaluation

expt_18.2

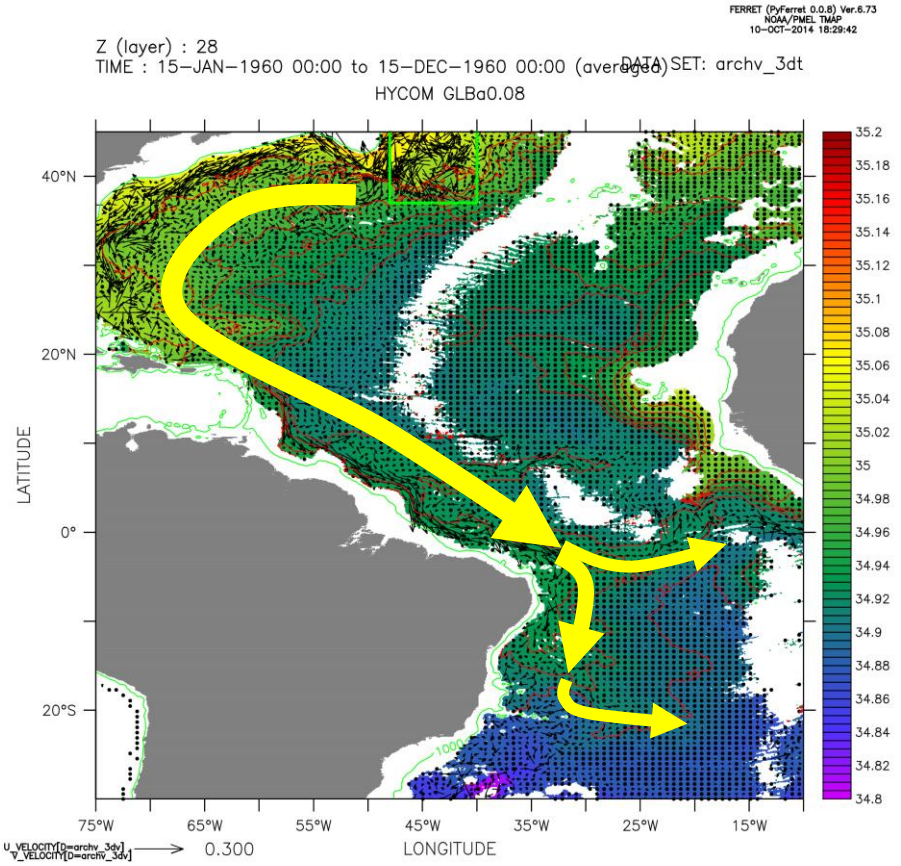




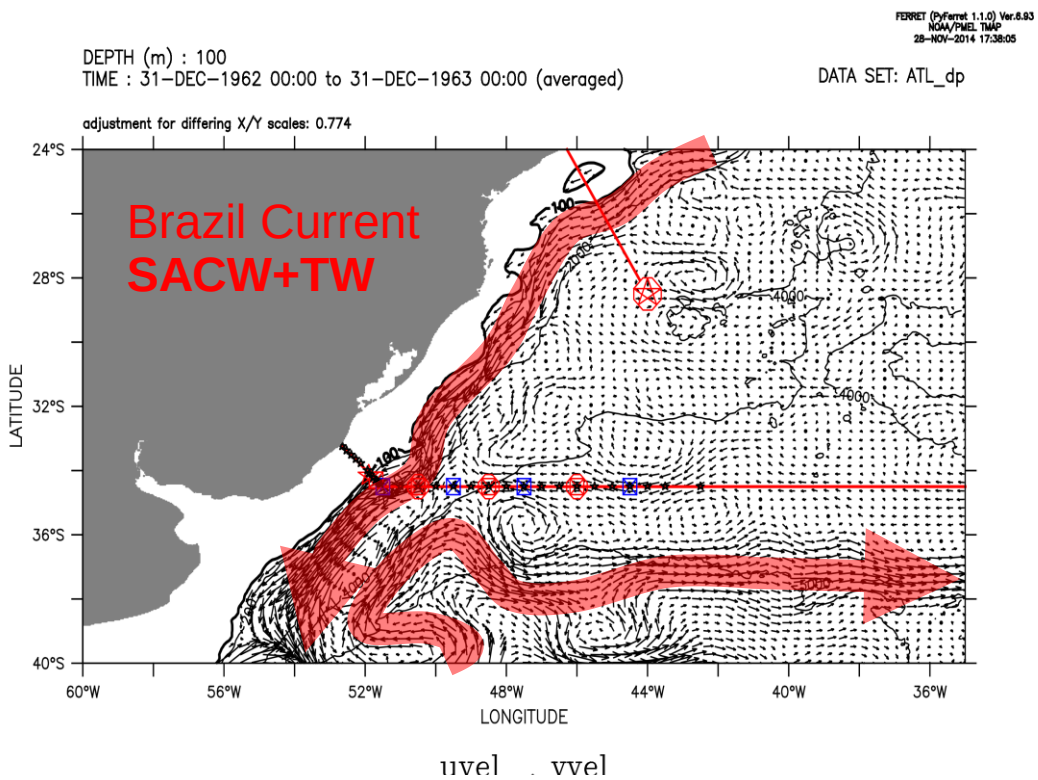
Snapshot of velocity vectors and temperature distribution at a depth of 1,900 m during Southern Hemisphere winter from the FLAME model, using climatological forcing. (Dengler et al., Nature 432, 2004)

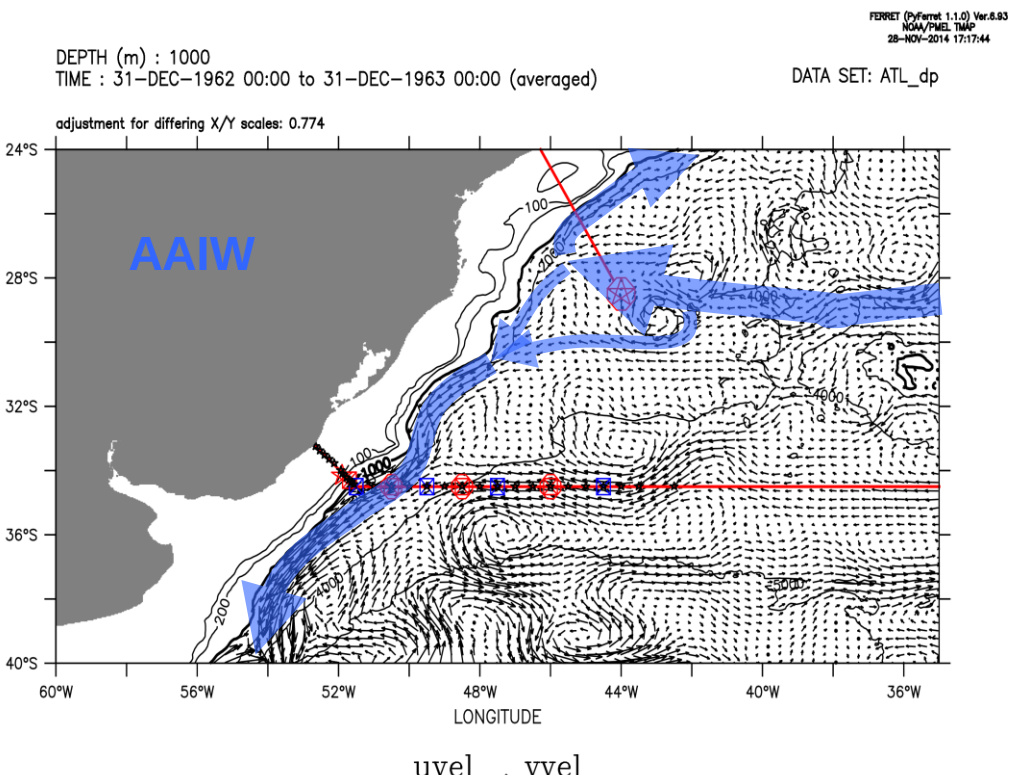


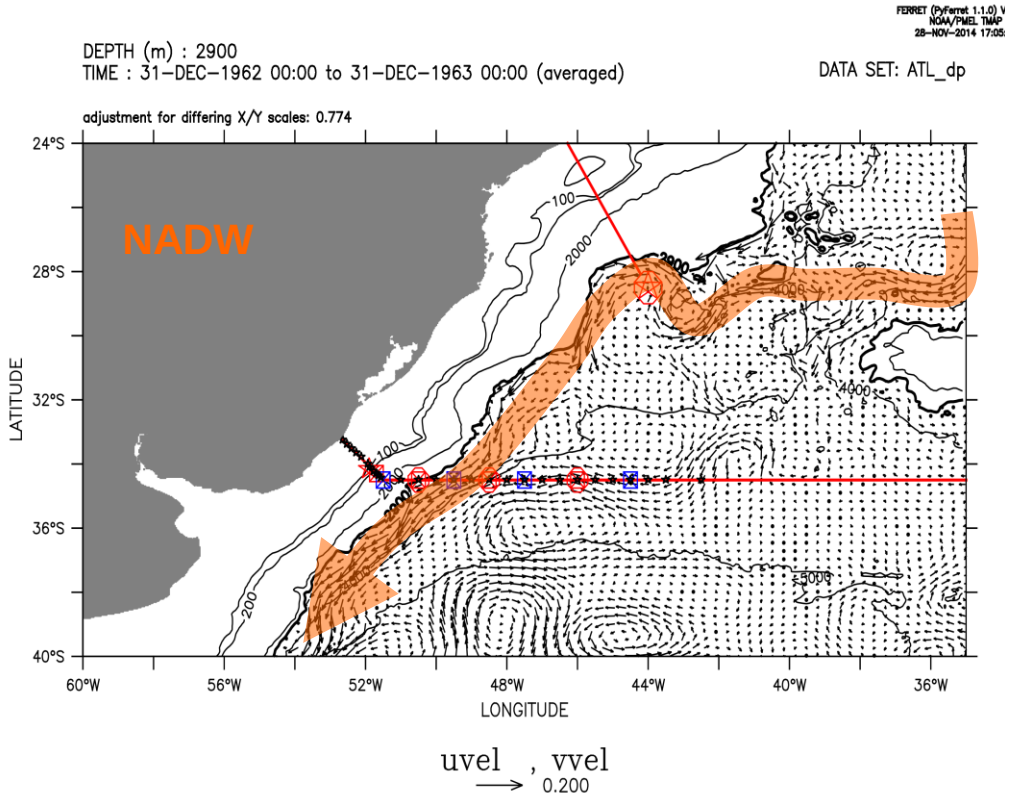
salinity [18.2H] (psu)

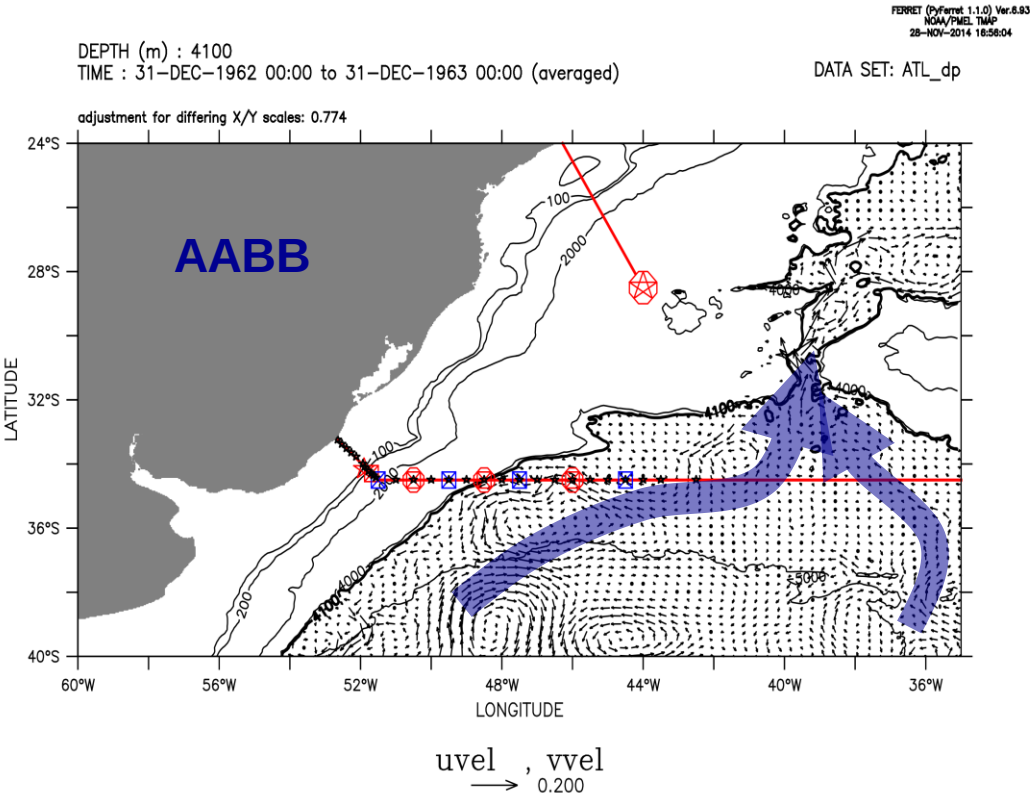


salinity [18.2H] (psu)

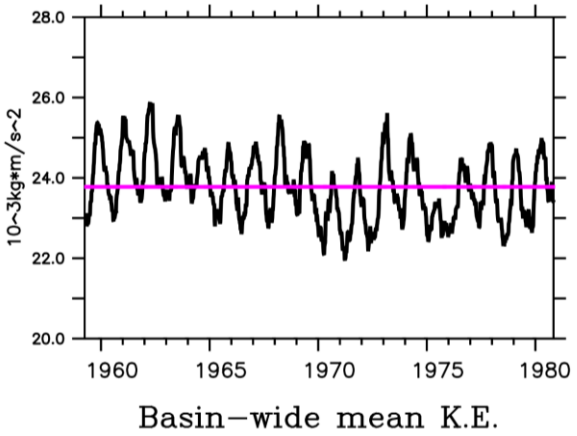

FERRET (PyFerret 1.1.0) Ver.6.93
NOAA/PMEL TMAP
28-NOV-2014 17:38:05
DEPTH (m) : 100
TIME : 31-DEC-1962 00:00 to 31-DEC-1963 00:00 (averaged)
DATA SET: ATL_dp
adjustment for differing X/Y scales: 0.774
Brazil Current
SACW+TW
LATITUDE
LONGITUDE
24°S
28°S
32°S
36°S
40°S
60°W
56°W
52°W
48°W
44°W
40°W
36°W
uvel , vvel

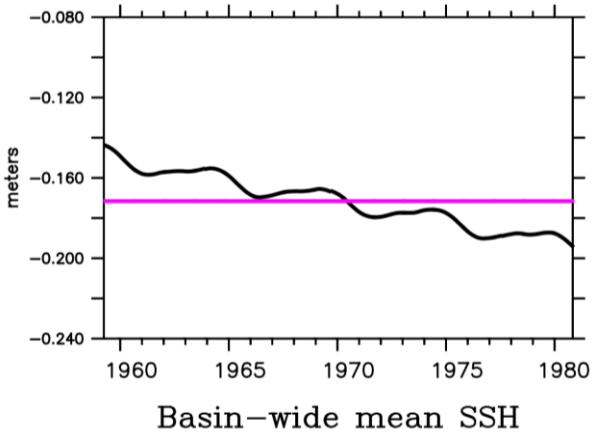

FERRET (PyFerret 1.1.0) Ver.6.93
NOAA/PMEL TMAP
28-NOV-2014 17:17:44
DEPTH (m) : 1000
TIME : 31-DEC-1962 00:00 to 31-DEC-1963 00:00 (averaged)
DATA SET: ATL_dp
adjustment for differing X/Y scales: 0.774
AAIW
LONGITUDE
24°S
28°S
32°S
36°S
40°S
60°W
56°W
52°W
48°W
44°W
40°W
36°W
uvel , vvel

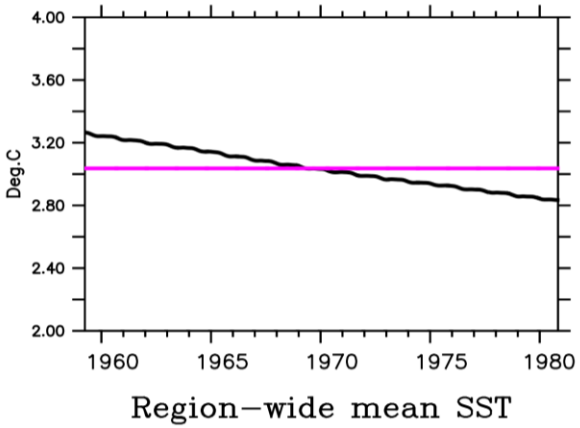

FERRET (PyFerret 1.1.0)
NOAA/PMEL TMAP
28-NOV-2014 17:05
DEPTH (m) : 2900
TIME : 31-DEC-1962 00:00 to 31-DEC-1963 00:00 (averaged)
DATA SET: ATL_dp
adjustment for differing X/Y scales: 0.774
NADW
LATITUDE
LONGITUDE
24°S
28°S
32°S
36°S
40°S
60°W
56°W
52°W
48°W
44°W
40°W
36°W
uvel , vvel
0.200

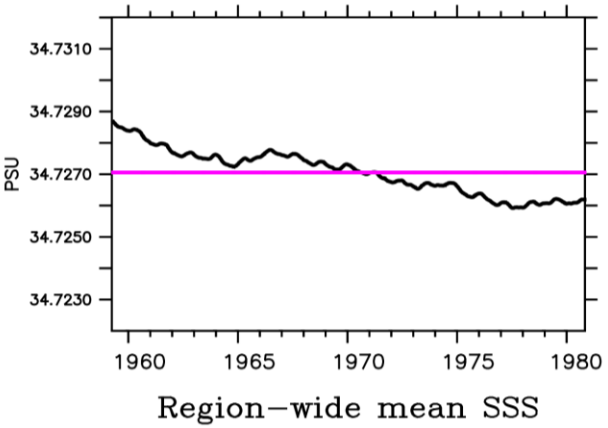

FERRET (PyFerret 1.1.0) Ver.6.93
NOAA/PMEL TMAP
28-NOV-2014 16:58:04
DEPTH (m) : 4100
TIME : 31-DEC-1962 00:00 to 31-DEC-1963 00:00 (averaged)
DATA SET: ATL_dp
adjustment for differing X/Y scales: 0.774
AABB
LATITUDE
LONGITUDE
24°S
28°S
32°S
36°S
40°S
60°W
56°W
52°W
48°W
44°W
40°W
36°W
uvel , vvel
0.200

Signs of problem?









expt_18.2

Negative trends in the region-wide variables were interpreted as a sign of problem.

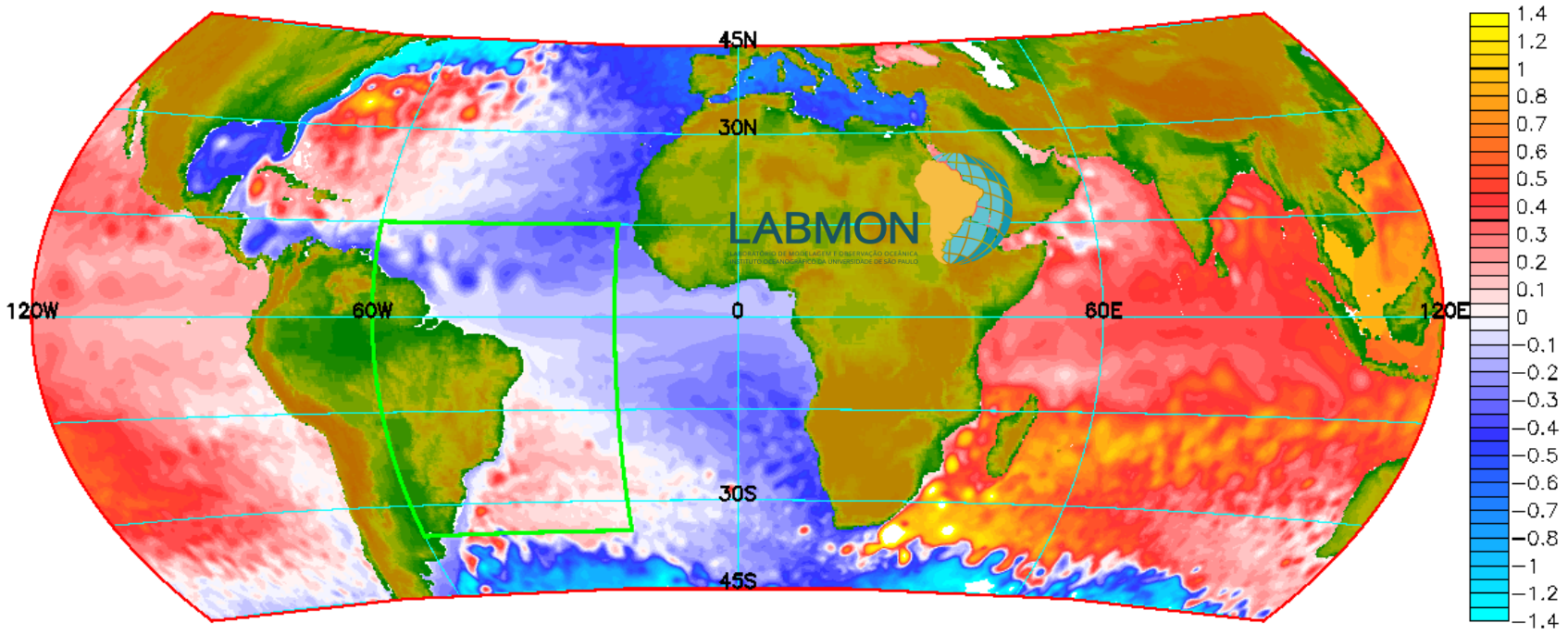
Thermobaric ref. states?

Ice model?

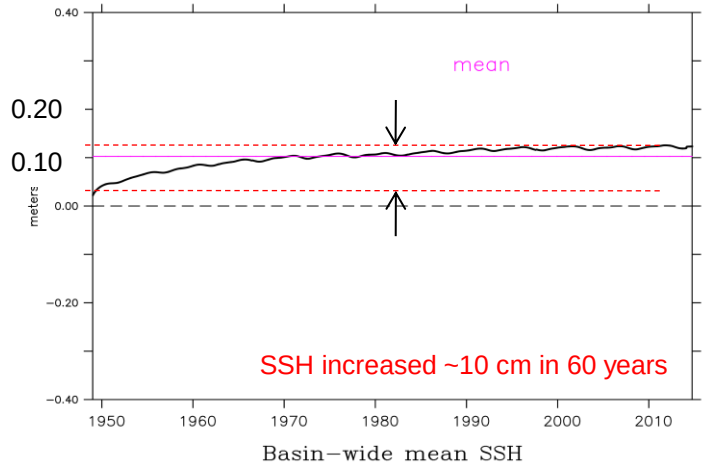
???

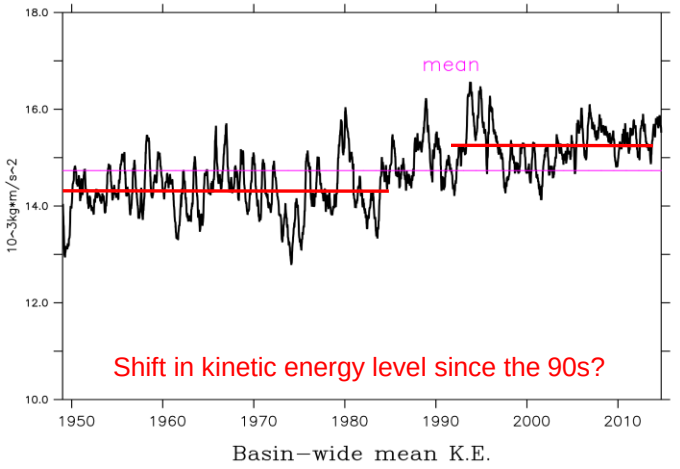
GLBa0.08, expt_18.3

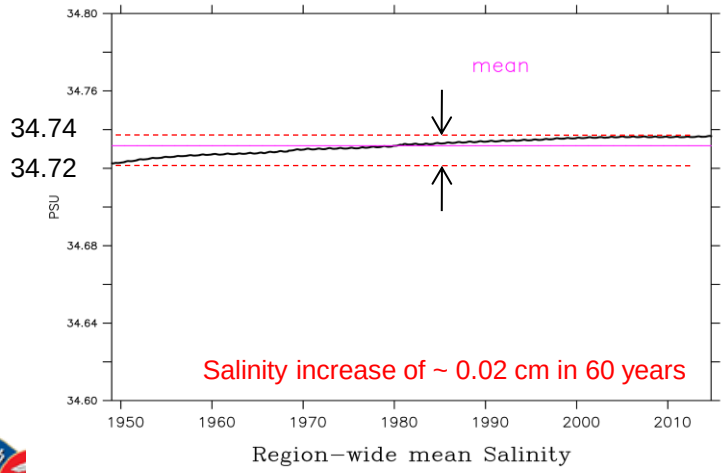
expt_18.3: kapref = -1; vsigma = 1; ticegr = 0; iceflg = 1; flxoff = 1; priver = 1

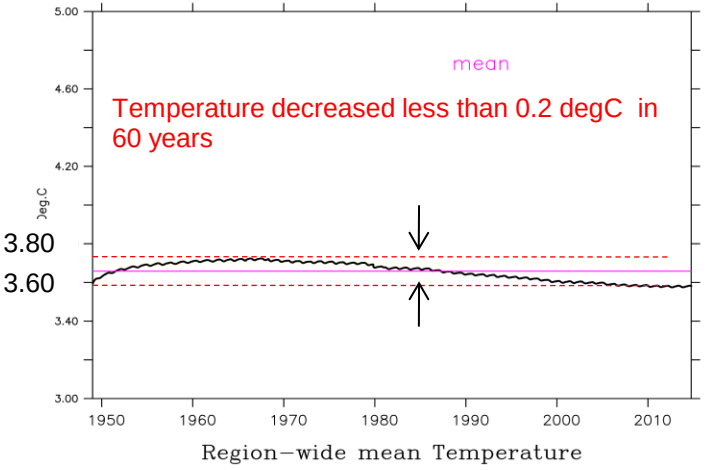


Problems solved ...?

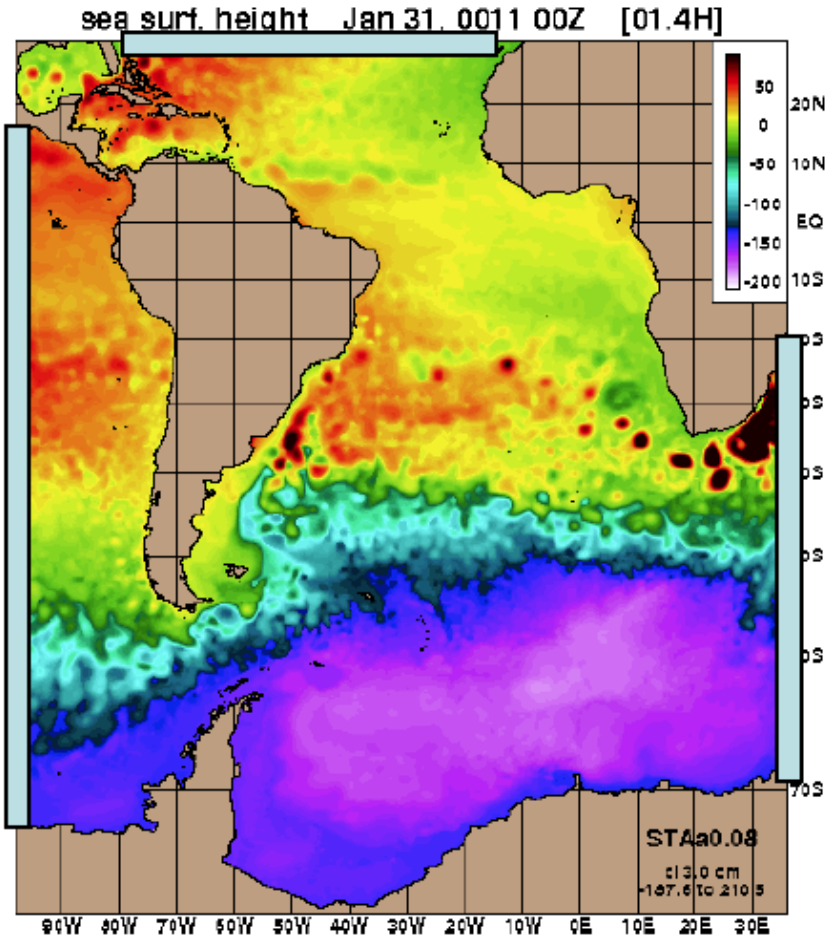




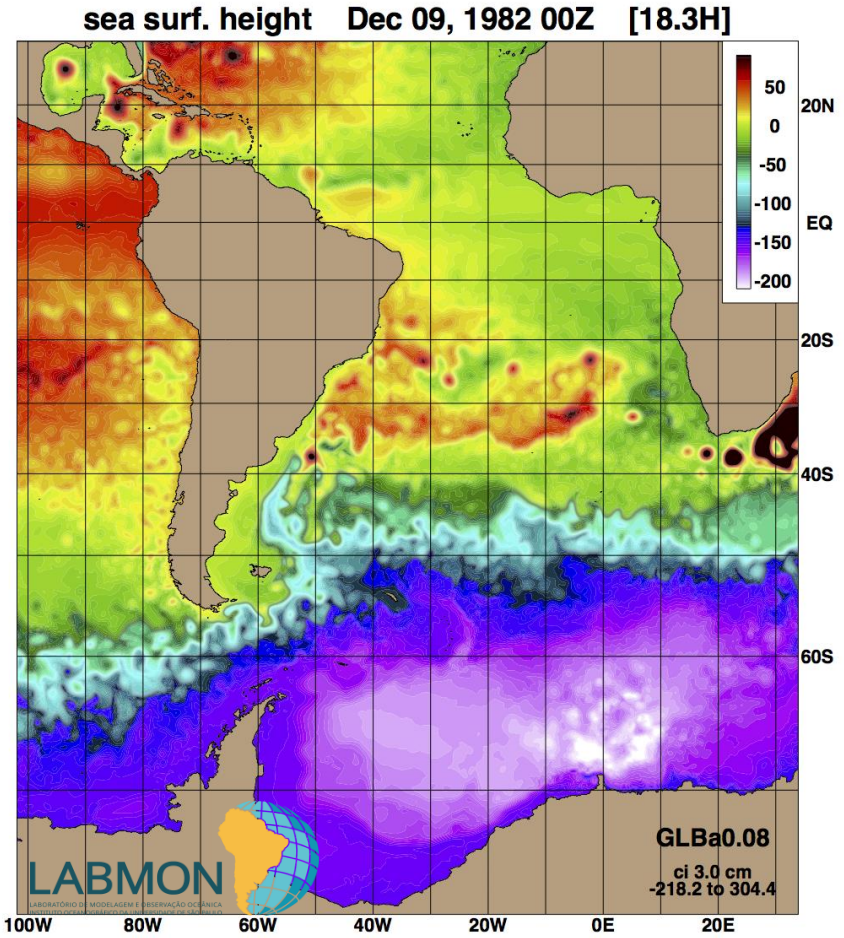




Evaluation



Garrafo et al., LOM09

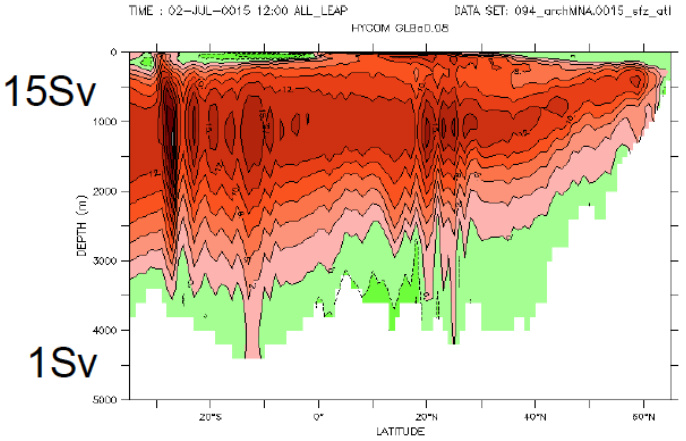


LABMON GLBa0.08

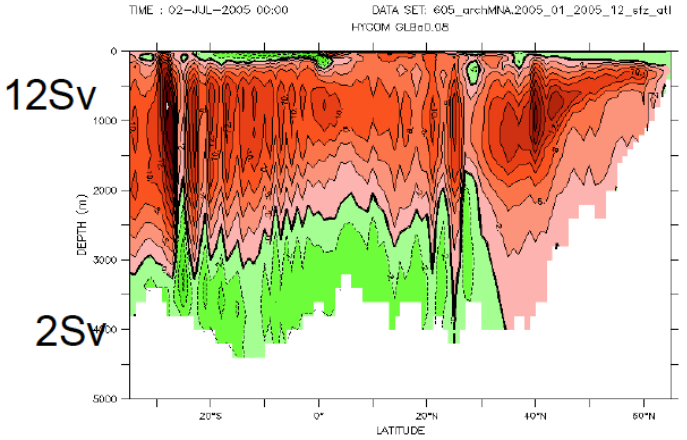
The Atlantic MOC

Garrafo et al., LOM09

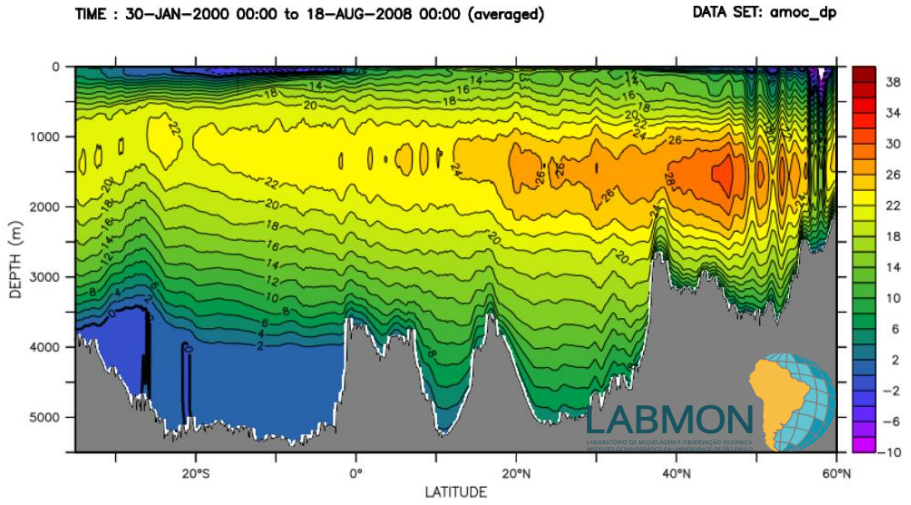
Climatological model AMOC (yr 15)



Hindcast AMOC (yr 2005)



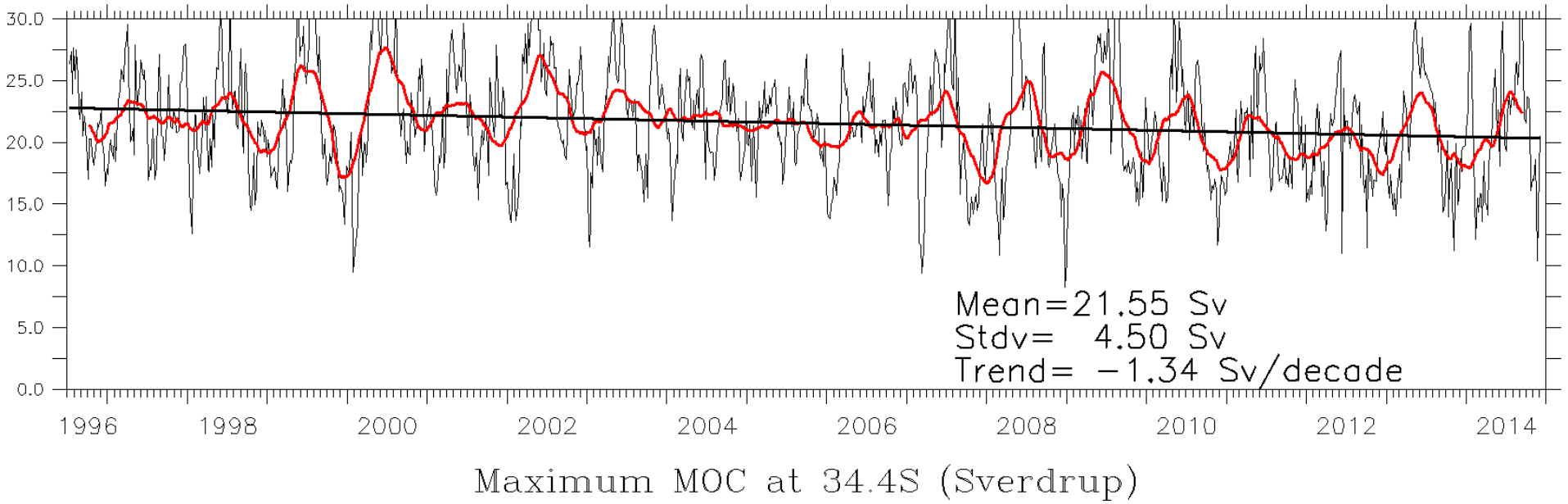
tr.strfn mean [60.5H] (Sv)



AMOC (Sverdrups)(box smoothed by 12 pts on Y)

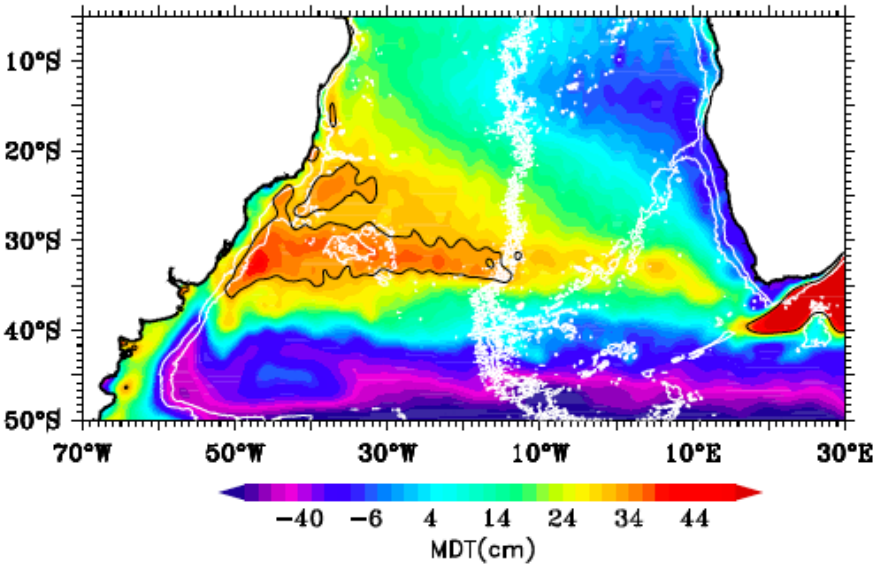
LABMON GLBa0.08

Variability of the AMOC ar 34.5ºS

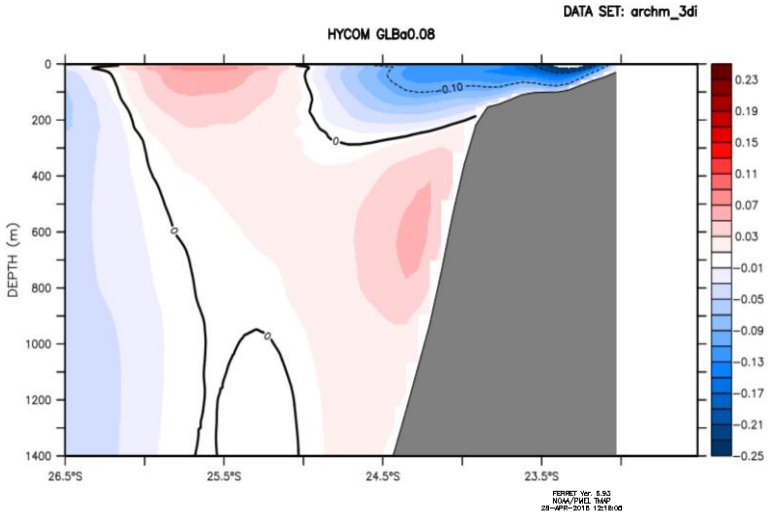


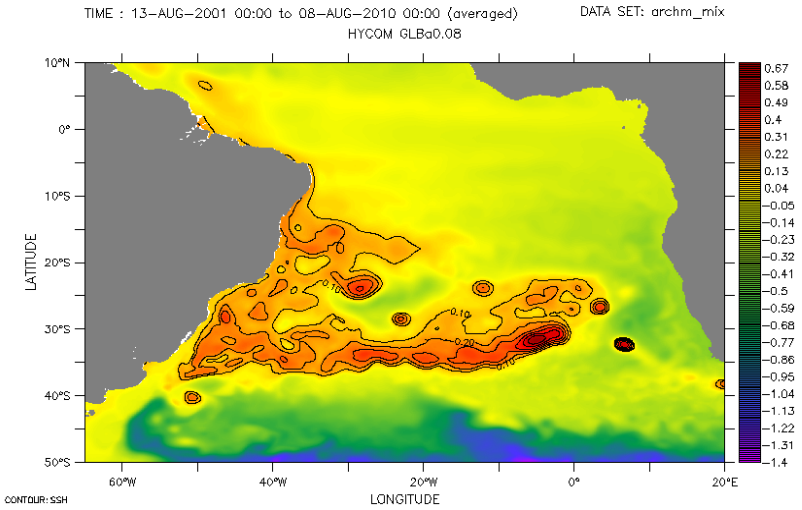
Double-celled Gyre in the South Atlantic?

In the 1/12-degree simulation, the South Atlantic subtropical gyre is splitted in two cells, as suggested by previous work (e.g: Tsuchya, 1985; Memery et al, 2000; and Viana and Menezes, 2011);



Viana & Menezes, JGR 2011





sea surf. height mean [18.3H] (m)

Conclusions

- Model runs fine for the entire period;
- Large scale features seems to be in accordance with other numerical experiments;
- Double-Celled gyre in the south Atlantic;
- More diagnostics and Model-Data comparison needed