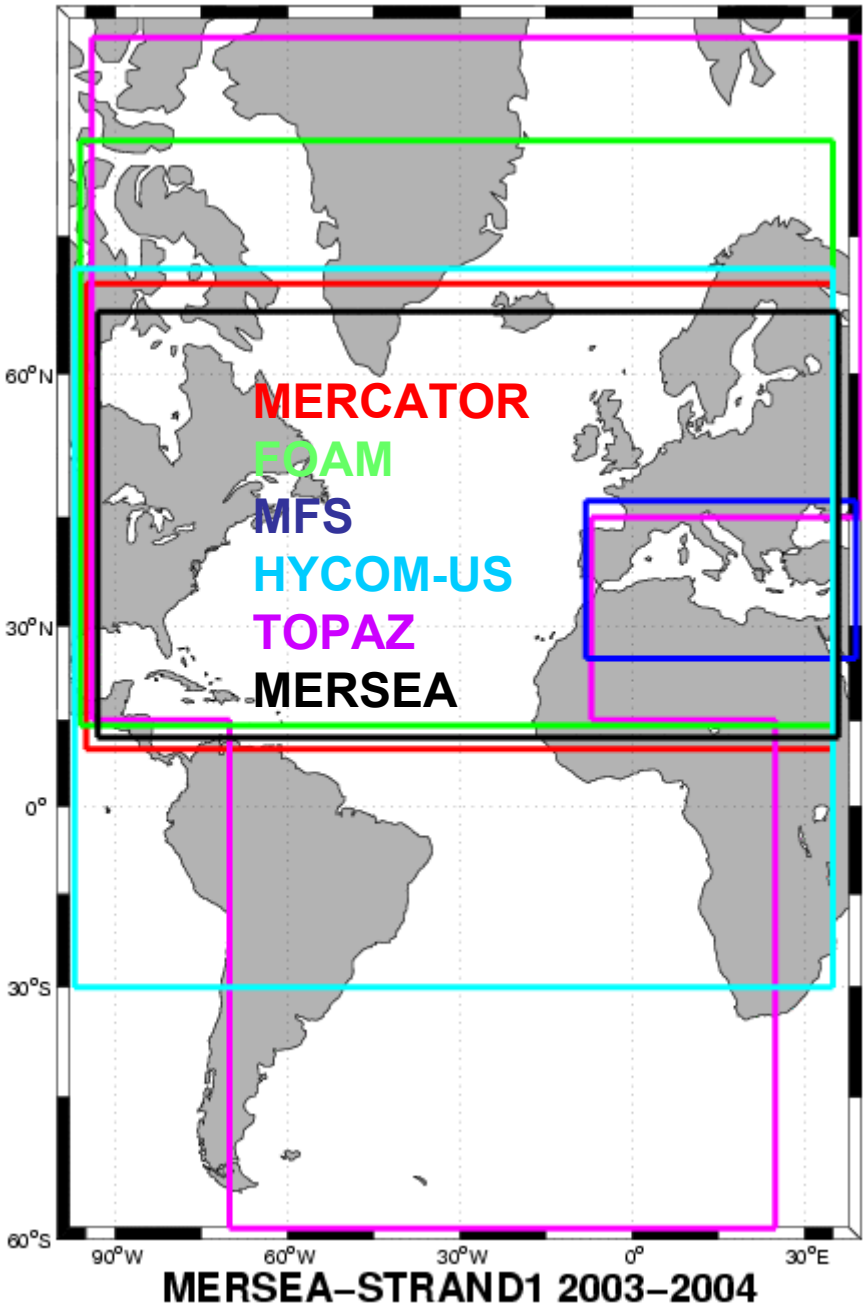
MERSEA Strand1
Atlantic and Mediterranean Sea prototype Project:
An Inter-comparison of 5 Forecasting Systems

Laurence Crosnier , Christian Le Provost and Mersea Team

GOAL=GMES +GODAE: Evaluate the strength/weakness of
[4 European + 1 US] Ocean monitoring and forecasting systems.

www.mersea.eu.org



MERSEA–STRAND1 2003–2004

MERCATOR FR	**OPA** **-Z coord./Rigid Lid**	**-horiz. 1/15° (5-7km)** **43 levels** -**Atl+Med** from 10 to 70°N.
FOAM UK	**HADLEY CENTRE** **-Z coord./Rigid Lid**	**-horiz. 1/9° (12km)** **20 levels** -**Atl+Med** from 10 to 70°N.
MFS IT	**MOM 1.1** **-Z coord./Rigid Lid**	**-horiz. 1/8°** **31 levels** - **Med only**
HYCOM US	**HYCOM *2.1*** **-Hybrid coord./Free surface**	**-Horiz 1/12° (6.5km)** **26 hybrid layers** -**Atl+Med** from 28°S to 70°N, 98°W to 36°W.
TOPAZ NO	**HYCOM** **-Hybrid coord/Free surface**	**-horiz. 20 to 30km** **22 hybrid layers** -**Artic+Atlantic** till 60°S. **No med basin.**

MERCATOR FR	**OPA** **-Z coord./Rigid Lid** -Simple thermo. ice model **-SPIN UP 15days** -TKE	**-horiz. 1/15° (5-7km)** **43 levels** -Atl+Med from 10 to 70°N. -Relaxation to Medatlas (T,S) in Gulf of Cadiz below 500m	**-Daily ECMWF forcing** -Relaxation to Reynolds SST and Reynaud SSS -Monthly river runoff -Data assimilation stopped at depth 500m	**-OI SOFA** **-SLA along track** (Jason1,ERS2/Envisat,GFO) once a week -MSSH from Rio et al.(data) in the Atlantic and blend of previous runs in MED	**ATL** **MED**
TOPAZ NO	**HYCOM** **-Hybrid coord/Free surface** -dyn./thermodynanic sea ice **-SPIN UP 20years** -KPP mixing	**-horiz. 20 to 30km** **22 hybrid layers** -Artic+Attlantic till 40°S. Closed boundary without relaxation. No med basin.	**-6 hourly ECMWF forcing (Bulk formulae momentum&heat)** -Precip Clim+ Relaxation to Levitus SSS(60days) -No river runoff -Data assimilation stopped at depth 300m	**-EnKF** **-SLA Maps**(SALTO-DUACS) once a week -**SST** from CLS AVHRR data once a week -**Maps of ice** concentration -MSSH from OCCAM run	**ATL**
FOAM UK	**HADLEY CENTRE** **-Z coord./Rigid Lid** -dyn./thermodynamic sea ice **-SPIN UP 5months** -Kraus-Turner	**-horiz. 1/9° (12km)** **20 levels** -Atl+Med from 10 to 70°N.	**-6 Hourly NWP-MetOffice forcing** -Weak relaxation to Levitus SST and SSS. -No river runoff -Data assimilation stopped at depth 300m	**-OI Cooper&Haines** **-SLA along track** (Jason1,GFO;Envisat) **-SST** 2.5° gridded (ARGO)Once a day. -**T+S profiles** at all depths **-gridded ice concentration** -MSSH from previous run	**ATL** **MED**
MFS IT	**MOM 1.1** **-Z coord./Rigid Lid** -no ice model **-SPIN UP:7years** -cst vertical mixing+vertical adjustment	**-horiz. 1/8°** **31 levels** - Med only -Transport through Gibraltar parameterized	**-6 Hourly ECMWF forcing (Bulk formulae momentum & heat)** -relaxation to satellite night time SST and SSS climato -No river runoff -Data assimilation stopped at depth 1000m	**-OI SOFA** **-SLA along track** (SALTO-DUACS) once a week **-SST+T profiles** along track once a week -MSSH from previous run with 1993-99 forcing.	**MED**
HYCOM US	**HYCOM *2.1*** **-Hybrid coord/Free surface** -no ice model **-SPIN UP 15years** -KPP mixing	**-Horiz 1/12° (6.5km)** **26 hybrid layers** -Atl+Med from 28°S to 70°N, 98°W to 36°W. -Entrainment param. of Med Water outflow	**-3 hourly NOGAPS forcing (Bulk formulae for heat)** -SSS= 50%(E-P) +50% relaxation to Levitus SSS -relaxation to MODAS SST ana. -monthly river runoff -Data assimilation stopped at	**-OI Cooper&Haines** **-SLA MODAS Maps** (Jason1 GFO ERS2) -MSSH from 1/12° MICOM (ECMWF)	**ATL**

Metrics have been defined for the North Atlantic and the Mediterranean Sea

- **Fields provided** : Daily mean Best Estimate + (T0+6) forecast.
- **1YEAR Time period** : JUNE 2003-JUNE 2004.
- **2 BASINS** : Atlantic + Mediterranean Sea

- **CLASS1** T, S, U, V, SSH, MLD, BSF, Tx, Ty, Qtot+relax., E-P-R +relax., MSSH

Interpolation on **1/8° horizontal grid**

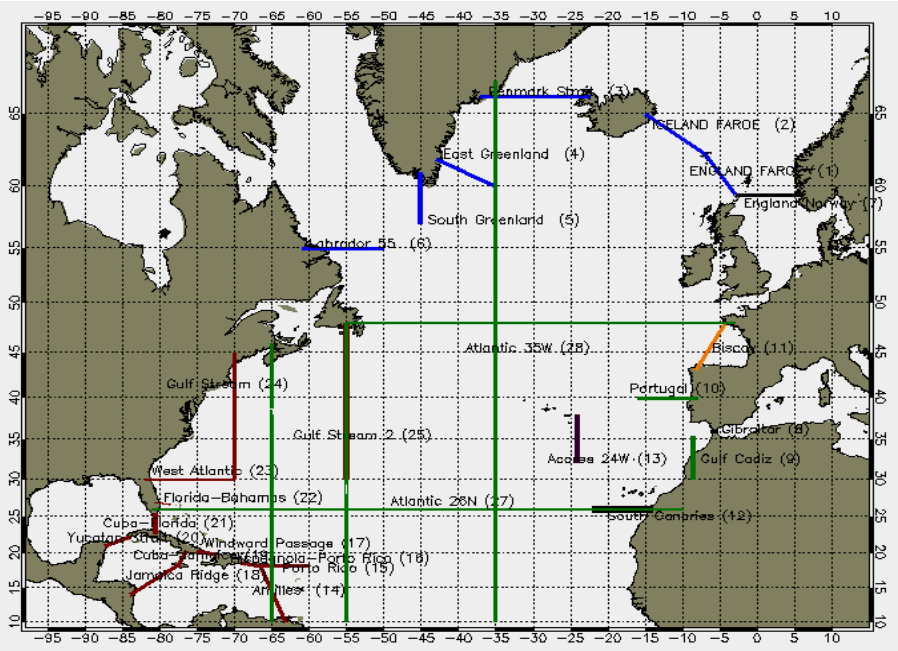
with 12 vert. levels in ATL (5;30;50;100;200;400;700;1000;1500;2000;2500;3000m)
8 vert. levels in MED (5;30;50;100;200;500;1000;2000m).

- **CLASS2** High resolution (T,S,U,V) sections/moorings.

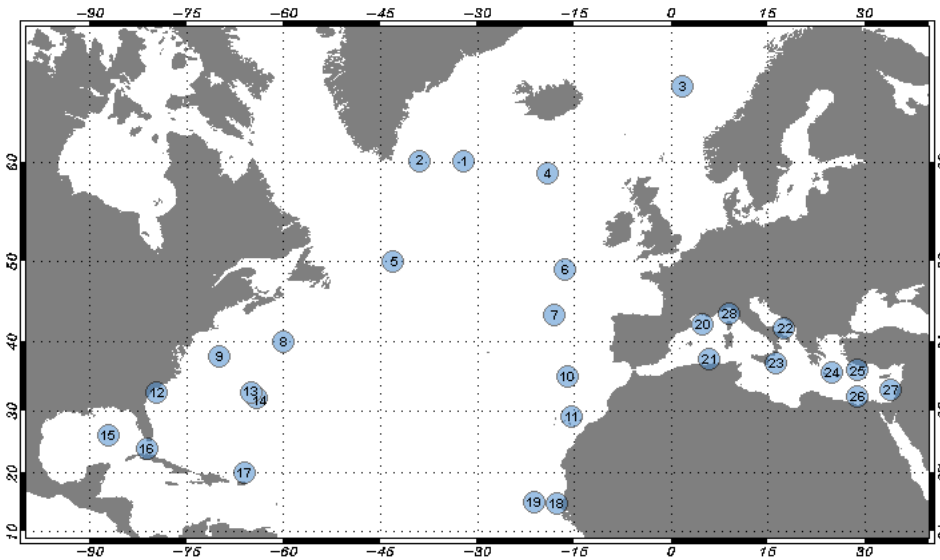
- **CLASS3** Daily mean volume transports through sections
  Meridional Heat Transport
  Overturning Stream Function /z/σ/θ

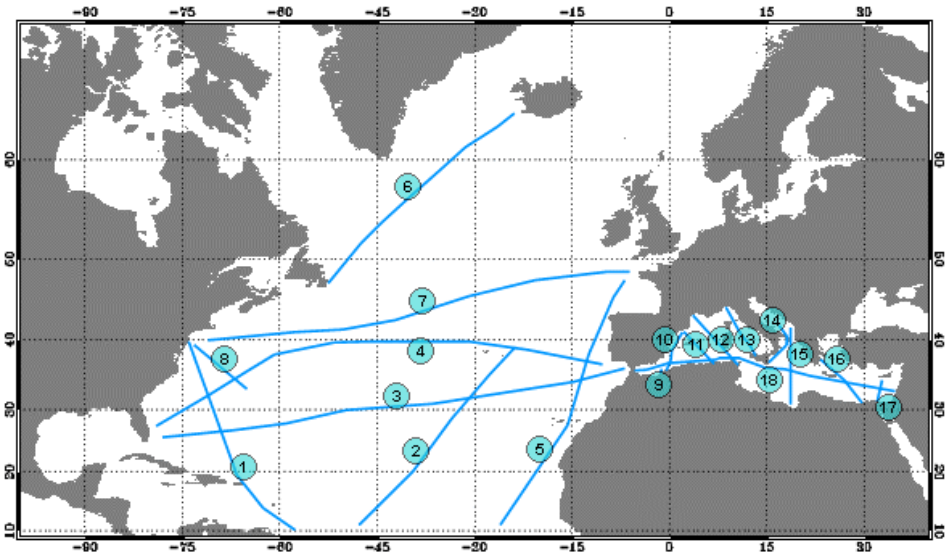
- **CLASS4** Test performance of analysis and forecasts.
- **Available : CLASS1 + CLASS2 + CLASS3**
- **working on CLASS4**

CLASS 2 in the Atlantic

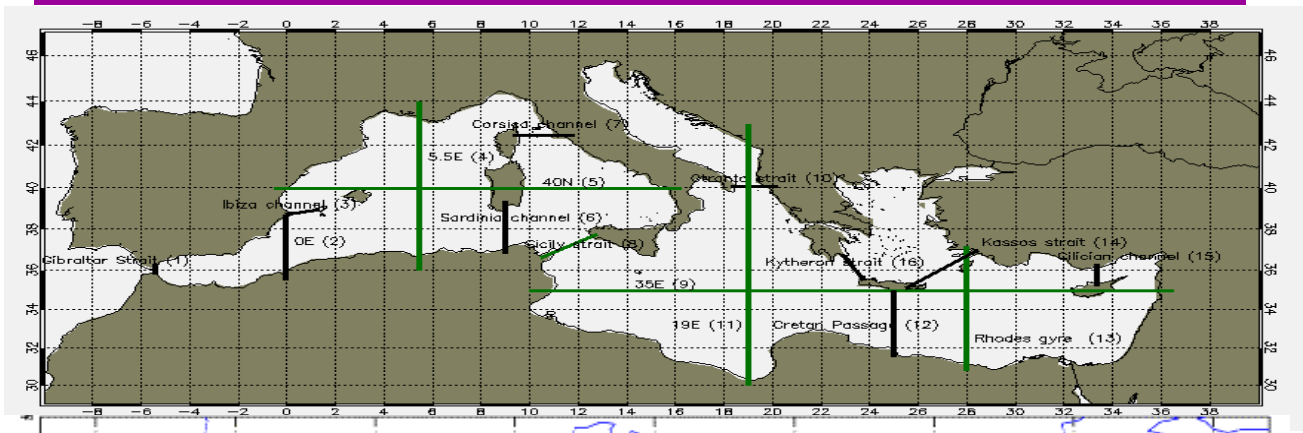


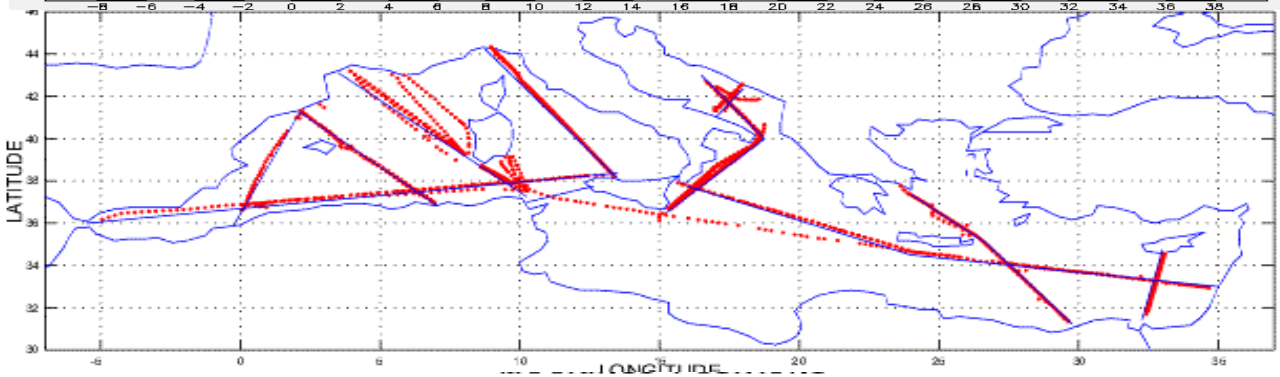
Mouillages MERSEA

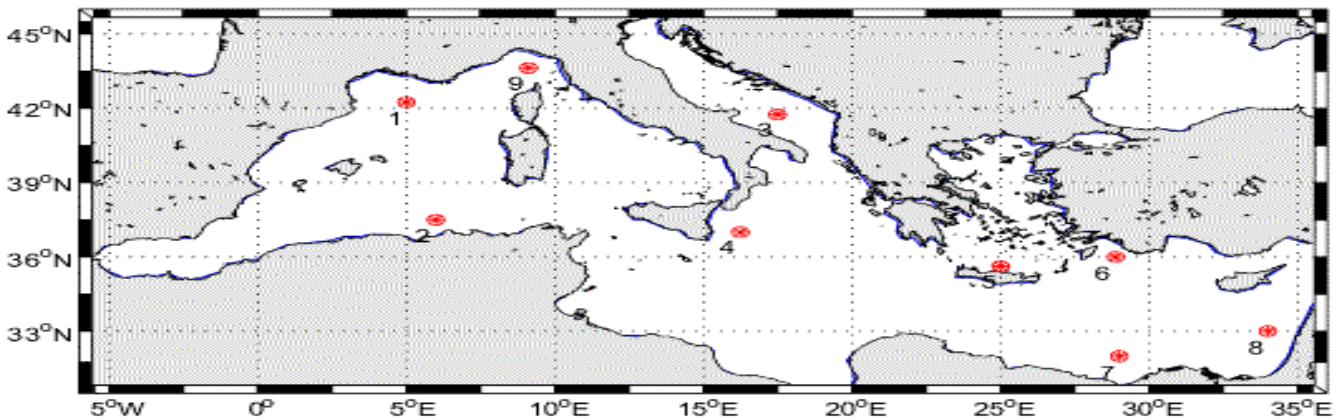




CLASS 2 In the Mediterranean Sea







STRATEGY BASED ON FOLLOWING TECHNOLOGY

- **Common GRID + Netcdf FORMAT**
- **DATA STORED ON OPENDAP SERVERS**

http://user:password@opendap.mercator-ocean.fr/dodsC/
http://thredds.sincem.unibo.it:8080/thredds/dodsC/
http://user:password@www.nerc-essc.ac.uk:9090/dodsC/
http://mersea.nersc.no/dodsC/
http://hycom.rsmas.miami.edu/dodsC/

- **DODS/MATLAB** or **DODS/IDL or DODS/Ferret**

>> loaddods('http://www.nerc-essc.ac.uk:9090/FOAM_NAT?temperature[0][0]')
Reading: http://www.nerc-essc.ac.uk:9090/FOAM_NATL_120_8th_ARC
Constraint: temperature[0][0]
Server version: catalogaggserver/0.8
Creating matrix temperature (1 x 1 x 441 x 869) with 383229 elements.
Creating vector time with 1 elements.
Creating vector depth with 1 elements.
Creating vector latitude with 441 elements.
Creating vector longitude with 869 elements.

Adresse http://las.mercator-ocean.fr

MERCATOR Live Access Server

Live Access to Data - Microsoft Internet Explorer

Fichier Edition Affichage Favoris Outils ?

Précédente Rechercher Favoris Média

Adresse http://las.mercator-ocean.fr/las/servlets/analysis

MERCATOR Live Access Server

Search dataset/variable: Go

single data set | compare two

Datasets > MERCATOR > MEDITERRANEAN > Mercator long term best estimate time serie

Variable(s): Sea water salinity (psu)

Create a new variable based on the the available analyses. Choose the axes and regions to apply and then click on Next > Help

Datasets
Variables
Constraints
Output
Output Options
Previous Output
Define variable
About LAS

Select analysis type: Average

Name for this variable: Sea water salinity

Apply to these axes: X ☐ Y ☐ Z ☐ T ☑

Mask: None ◉ Ocean ○ Land ○

Next > Cancel >

Other choices: min/max average variance

Select range for applicable axis:

Don't use map applet

46.0 N | 6.0 W | 36.5 E | 30.0 N

Zoom In Zoom Out

Z range: 5 to 5

T range: 01-Aug-2003 to 31-Aug-2003

Contact us Subscribe Search Site map Home Project group Scientific aspects

Live Access to Data - Microsoft Internet Explorer

Fichier Edition Affichage Favoris Outils ?

Précédente Rechercher Favoris Média

Adresse http://las.mercator-ocean.fr/las/servlets/data

MERCATOR Live Access Server

single data set | compare two

Datasets > MERCATOR > MEDITERRANEAN > Mercator long term best

Variable(s): Sea water salinity averaged (psu)_1 (from Sea water salinity

You may modify the appearance of
The navigation bar on the left will

Datasets
Variables
Constraints
Output
Output Options
Previous Output
Define variable
About LAS

DEPTH (m) : 5
TIME : 01-AUG-2003 00 to 31-AUG-2003 00

LATITUDE 46°N 42°N 38°N 34°N 30°N

LONGITUDE 0°E 10°E 20°E 30°E

Sea water salinity averaged (psu)_1

Send all plot output to new window

MERCATOR

DEPTH (m) : 5
TIME : 01-AUG-2003 00 to 31-AUG-2003 00

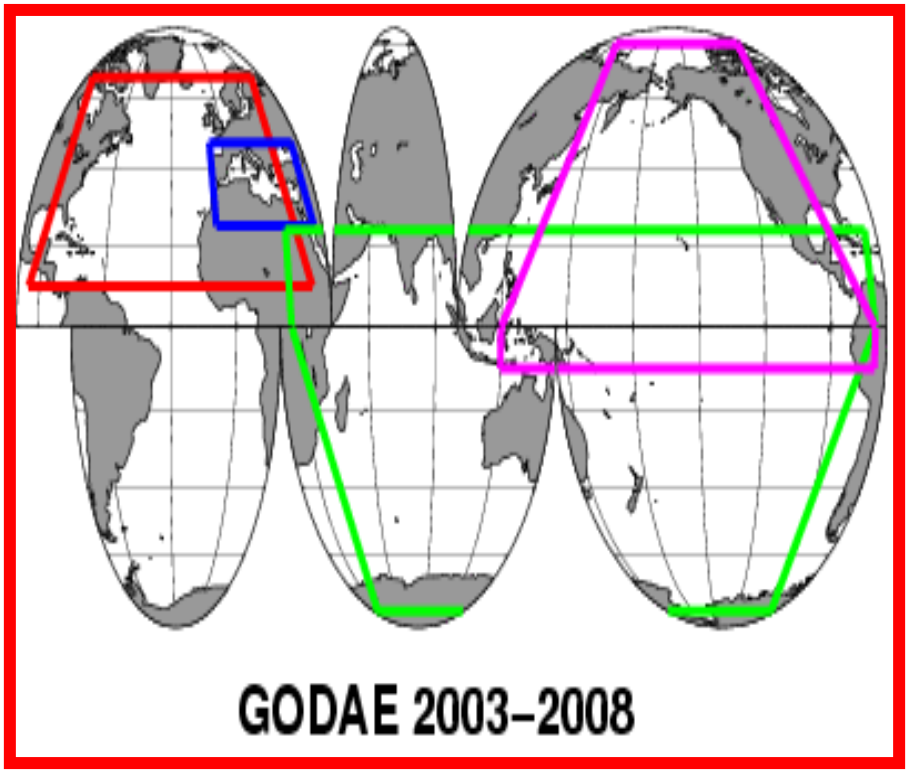
LATITUDE 44°N 40°N 36°N 32°N

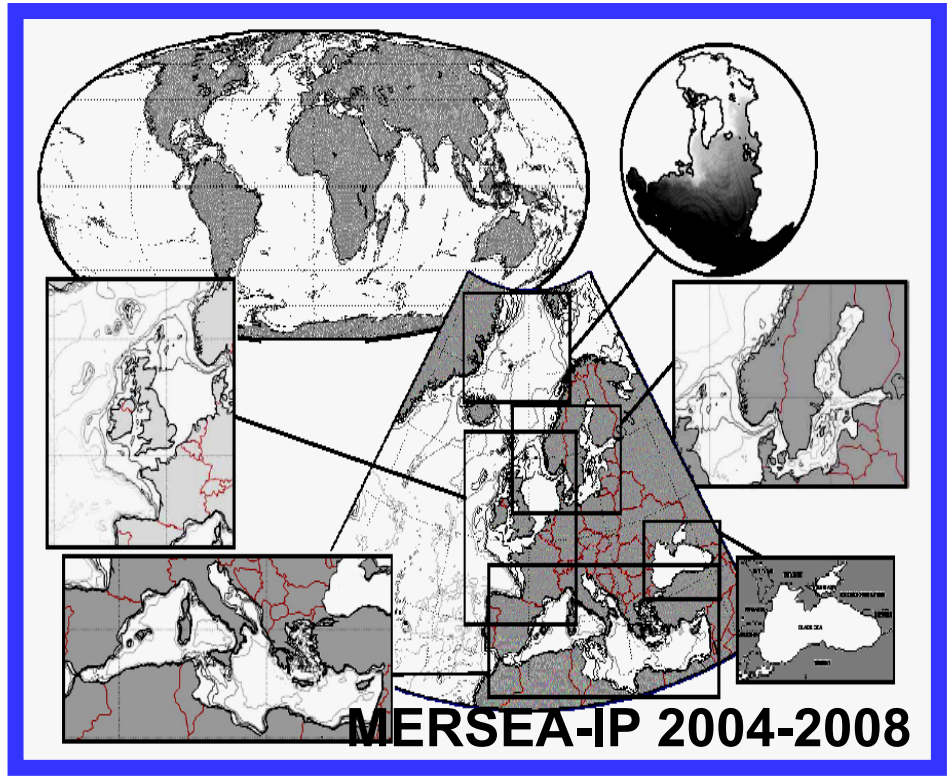
LONGITUDE 8.0°W 4.0°W 2.0°W 0.0°E 2.0°E 4.0°E 6.0°E 8.0°E

averaged Sea water salinity (psu)_1

LAS USE EXAMPLE

http://las.mersea.eu.org





GLOBAL (France, US)
North ATLANTIC + Mediterranean SEA (Mersea systems)
INDIAN , SouthPACIFIC, AUSTRAL Ocean (Blue Link, Australia)
North PACIFIC (Japan)

North ATLANTIC
Baltic
Arctic
Mediterranean Sea
(16 countries, 40 organizations)

Inter-Comparison

- MODEL-MODEL-CLIMATOLOGY (« Dynamo like »)

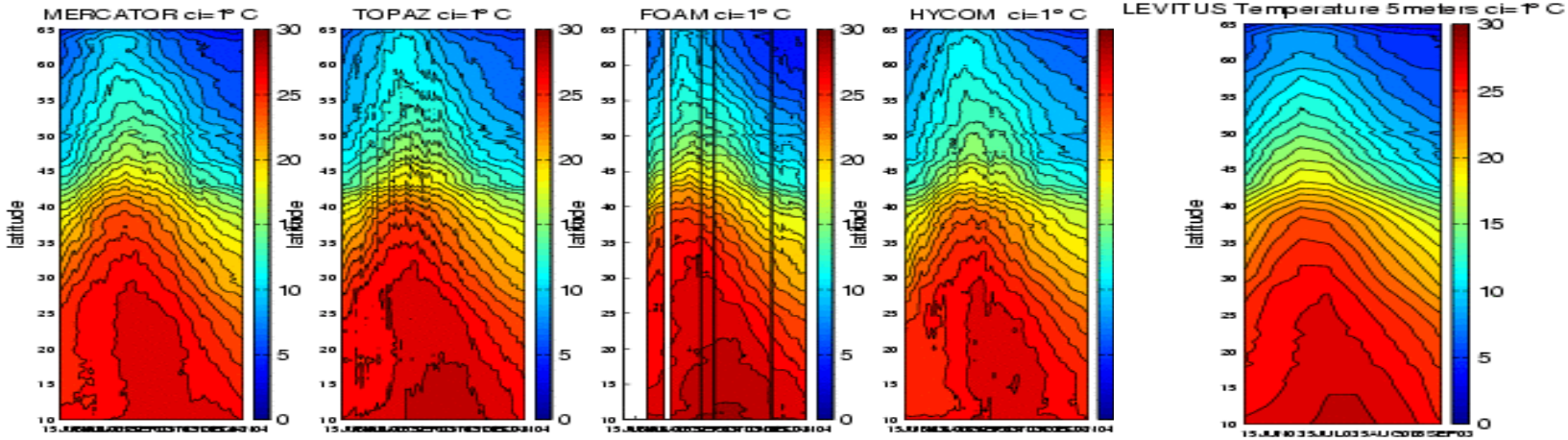
  Willebrand, J., B. Barnier, C. Böning, C. Dieterich, P.D. Killworth, C. LeProvost, Y. Jia, J.-M. Molines and A.L. New, 2001: Circulation characteristics in three eddy-permitting models of the North Atlantic. *Progress in Oceanography, 48, 2-3, 123-161.*

- MODEL-Real time OBSERVATIONS

Hovmuller plots of ZONAL MEAN SURFACE (5meters) Atlantic TEMPERATURE

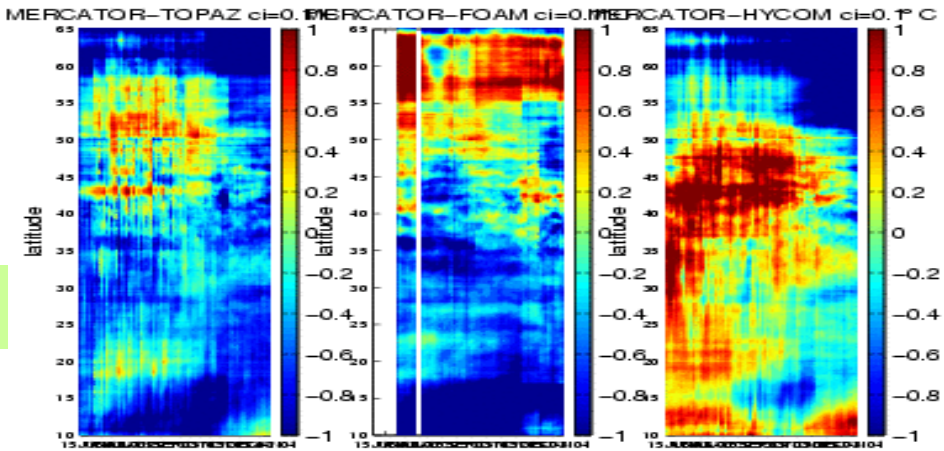
ZONAL MEANS

MERCATOR **TOPAZ** **FOAM** **HYCOM-US** **LEVITUS01**

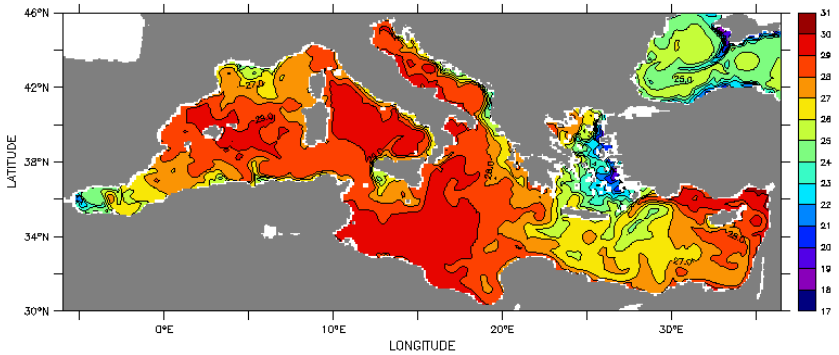


ZONAL MEANS DIFFERENCES

MERCATOR – TOPAZ **MERCATOR – FOAM** **MERCATOR – HYCOM US**

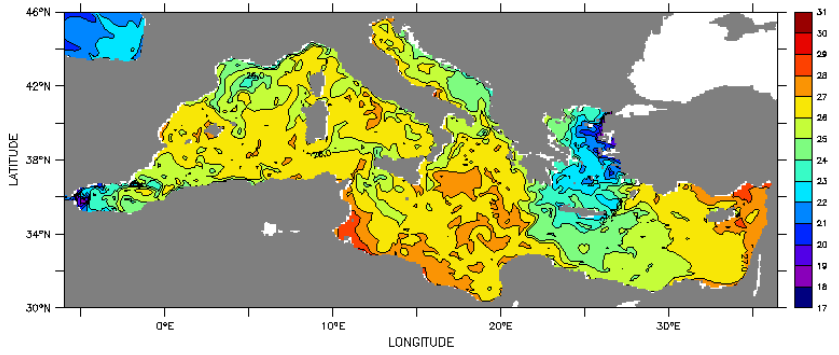


FOAM



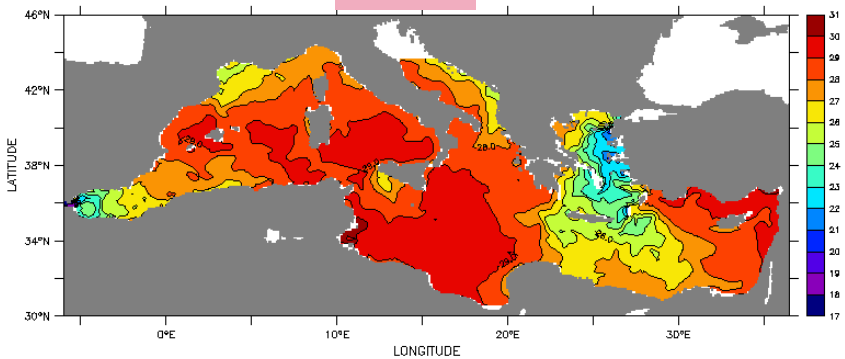
temperature (C)

MERCATOR



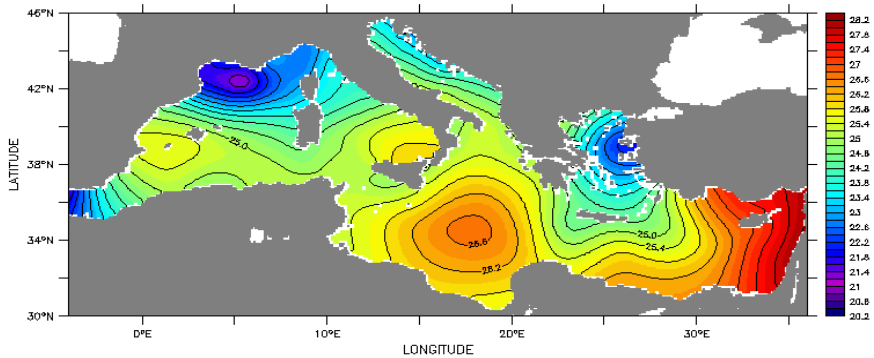
temperature (degC)

MFS



temperature (degC)

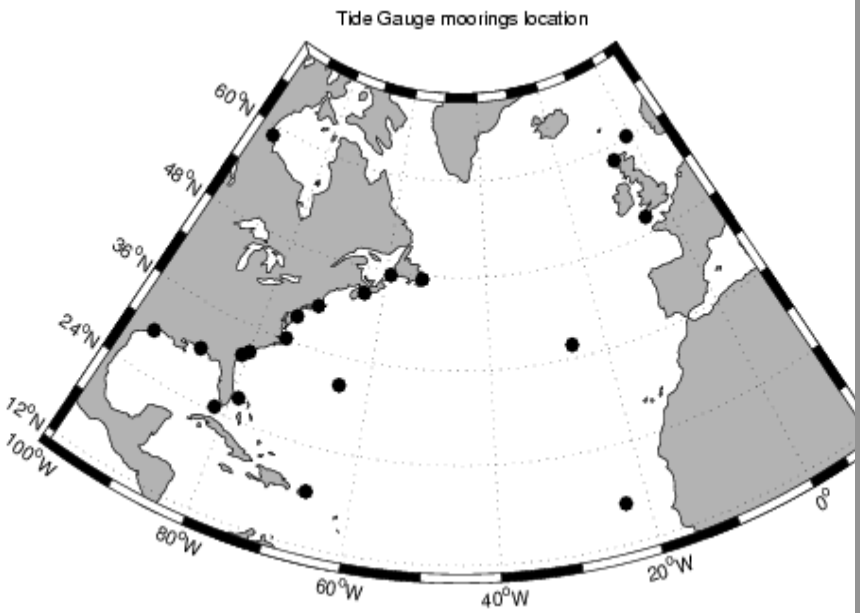
MEDATLAS



temperature (degC)

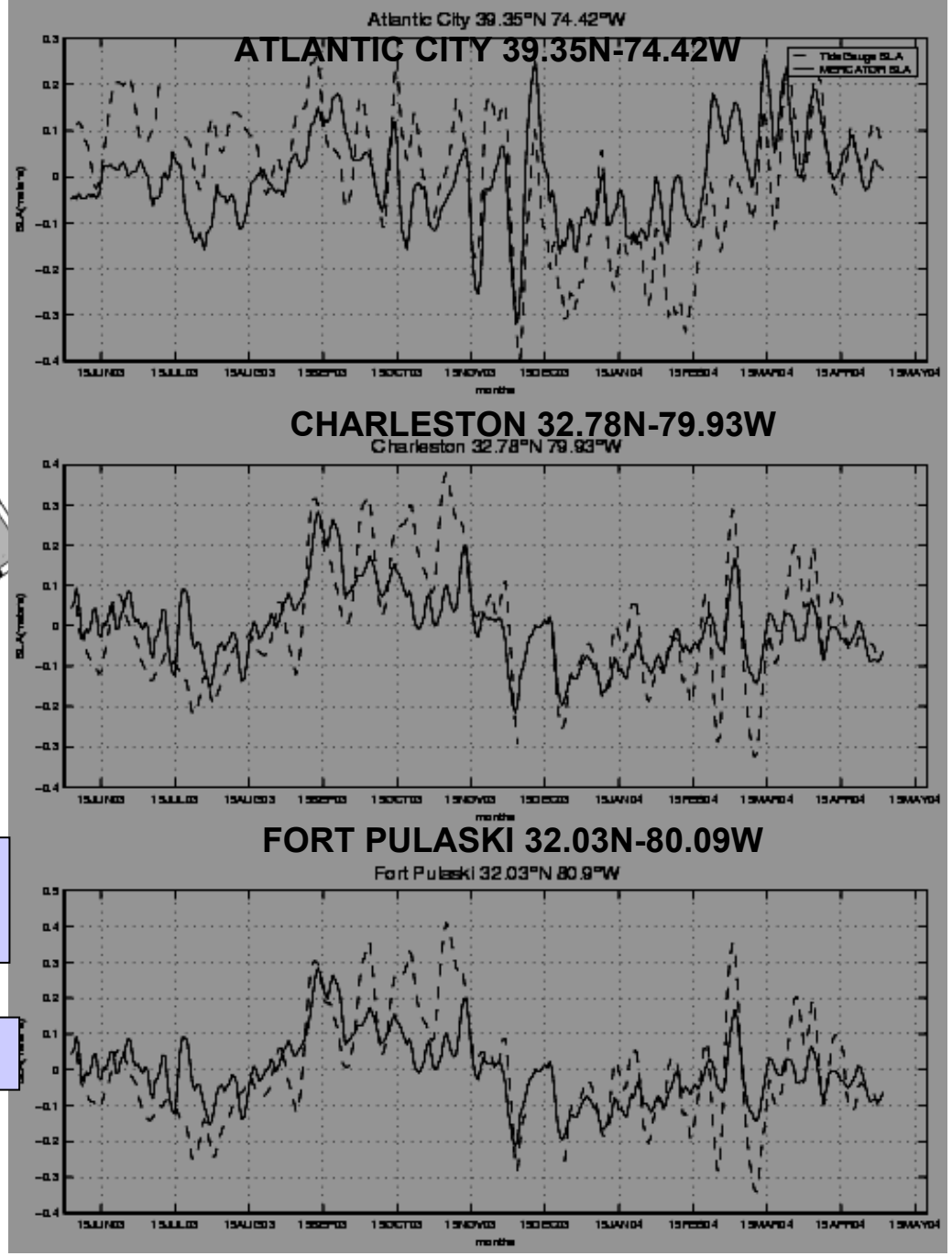
HEAT WAVE EVENT SUMMER 2003

5 meters depth TEMPERATURE AUGUST 2003



TIDE GAUGE SLA MEASUREMENTS
(not delivered on real time basis)

No data assimilation in coastal areas



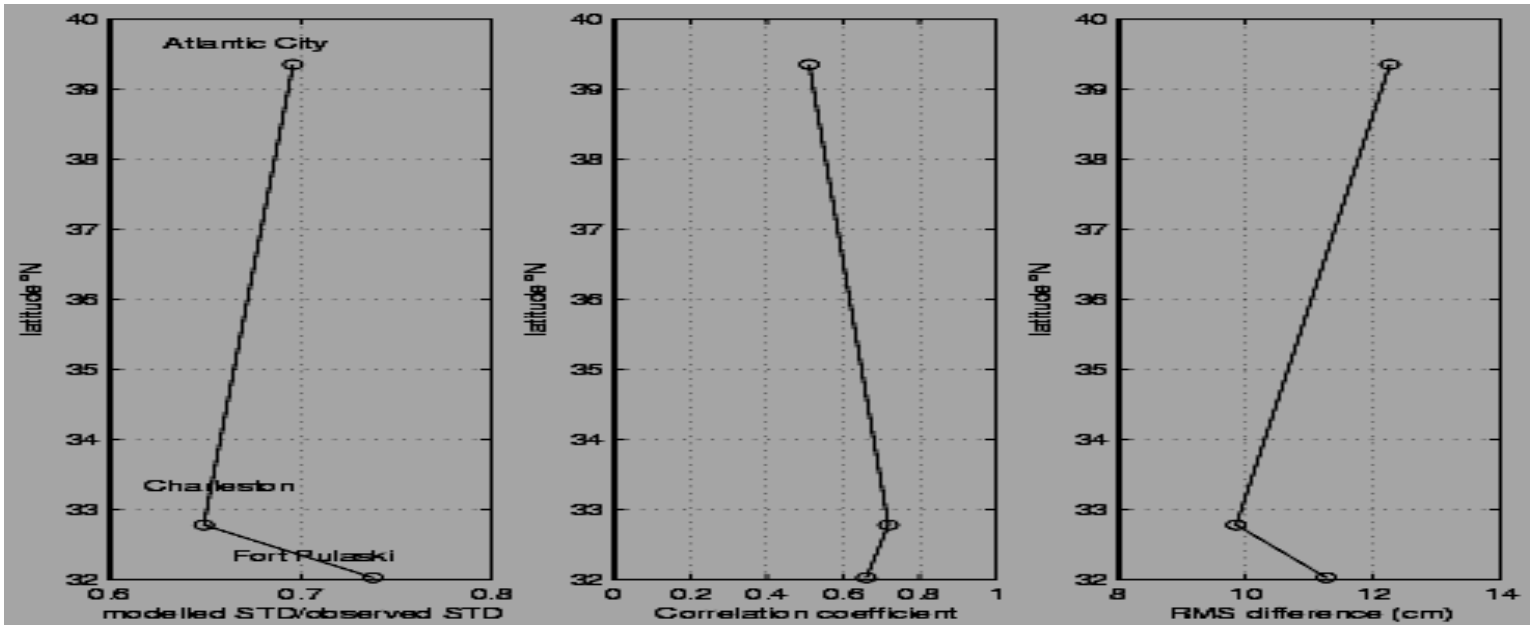
JUNE 1st 03

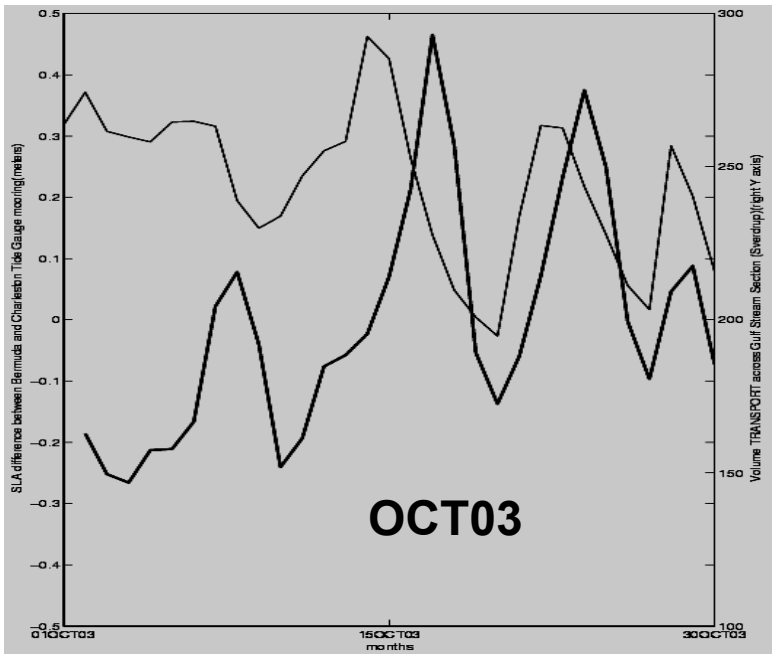
MAY 31st 04

Modelled STD/Observed STD

Correlation coeff

RMS difference (cm)



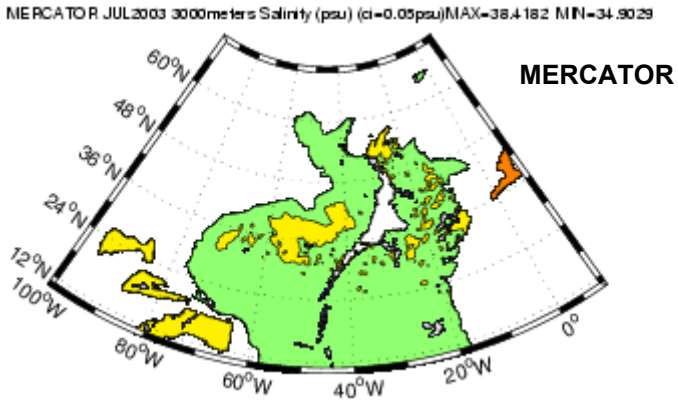


_____SLA DIFFERENCE CHARLESTON-BERMUDA

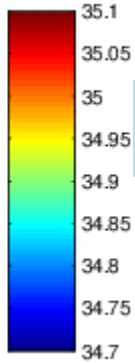
_____ VOLUME TRANSPORT (MERCATOR) through GS at 30N

- Impact from Spin up length on deep ocean

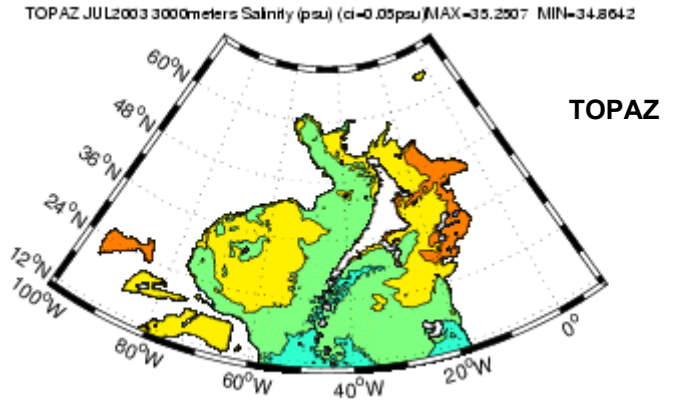
CLASS1 July mean salinity at 3000m depth (ci=0.05psu)



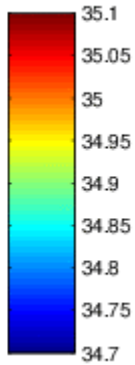
MERCATOR

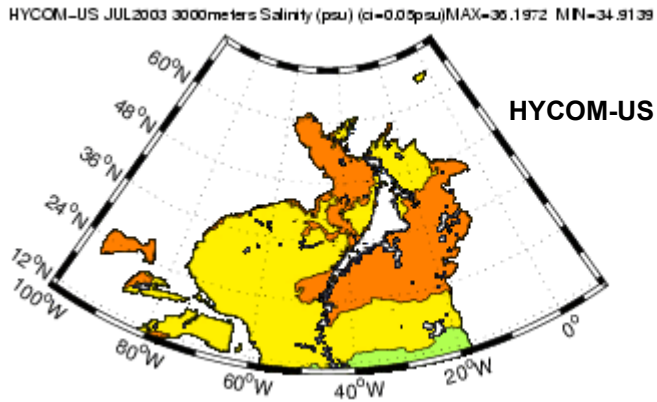


DRIFT from SPIN UP length

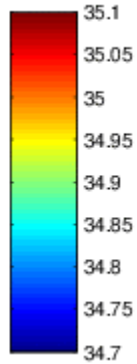


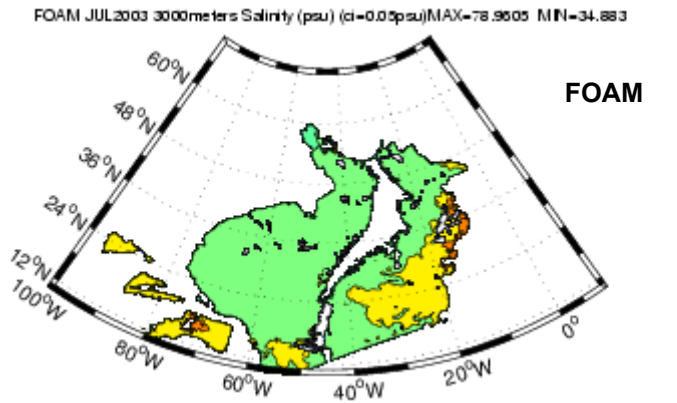
TOPAZ



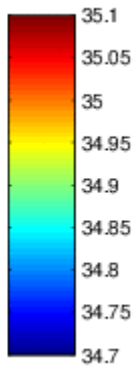


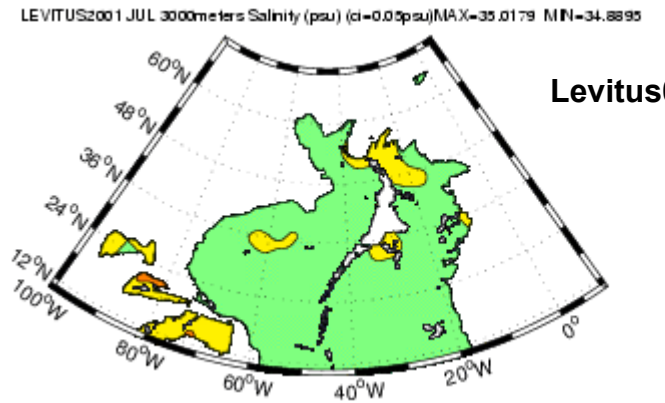
HYCOM-US



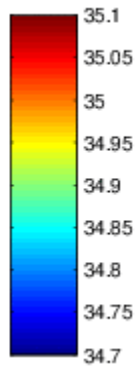


FOAM



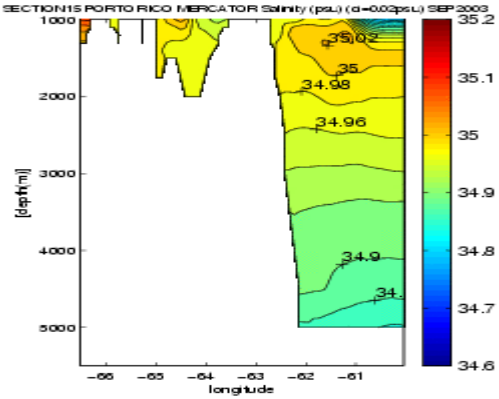


Levitus01



Salinity DWBC at 17°N

MERCATOR



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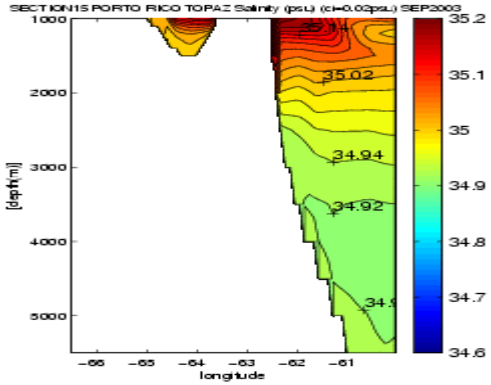
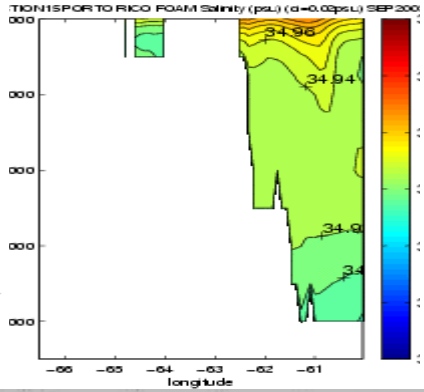
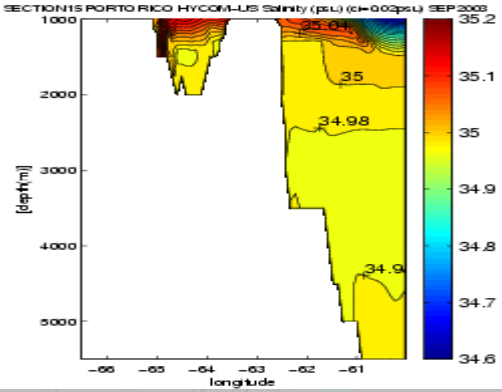
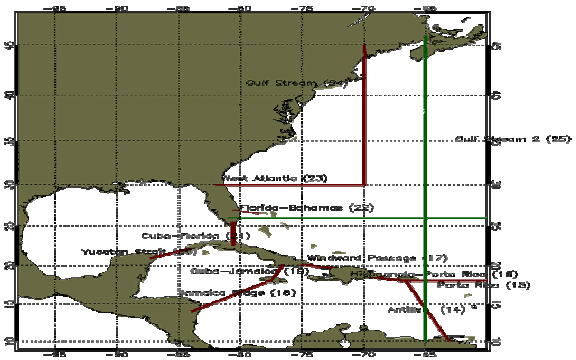


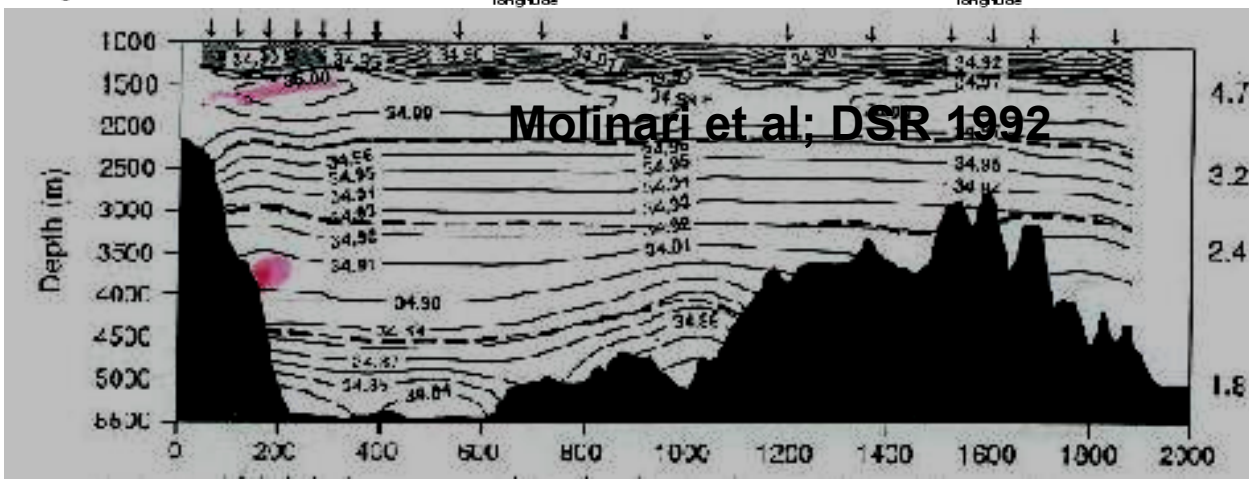
FOAM



HYCOM-US

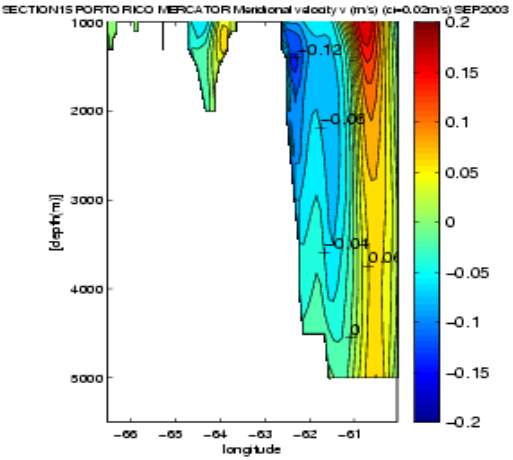




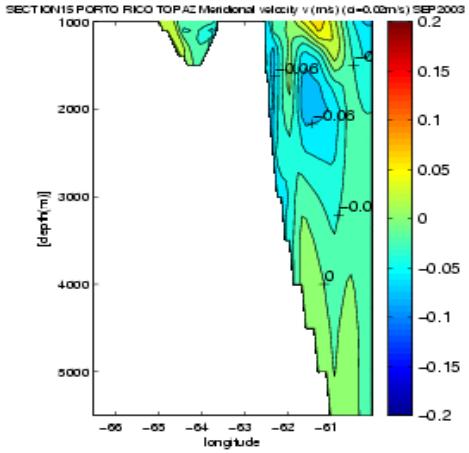


SEP03- Meridional Velocity DWBC at 17°N

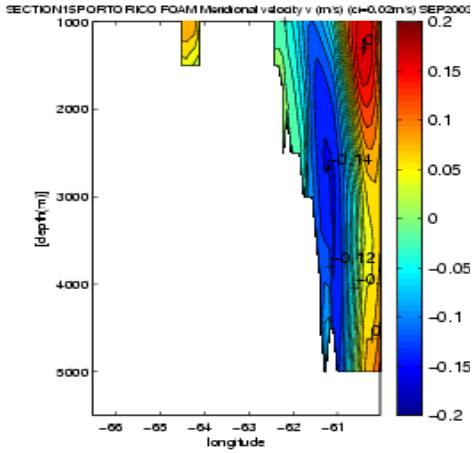
MERCATOR



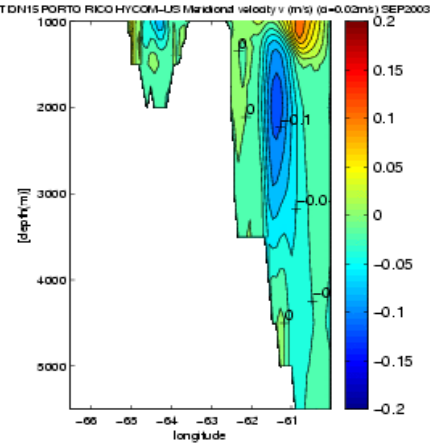
TOPAZ



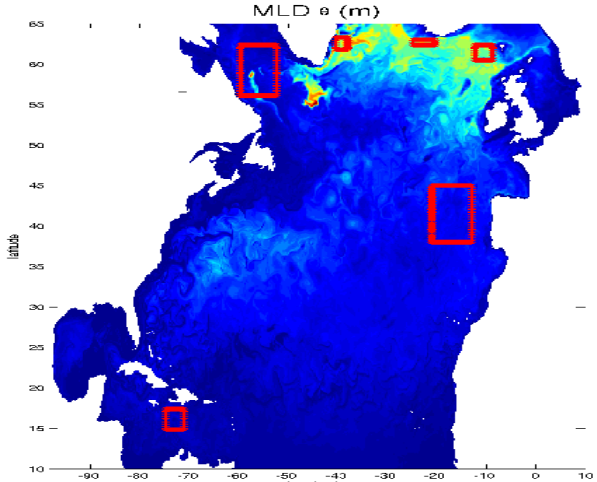
FOAM

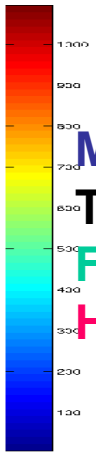


HYCOM US

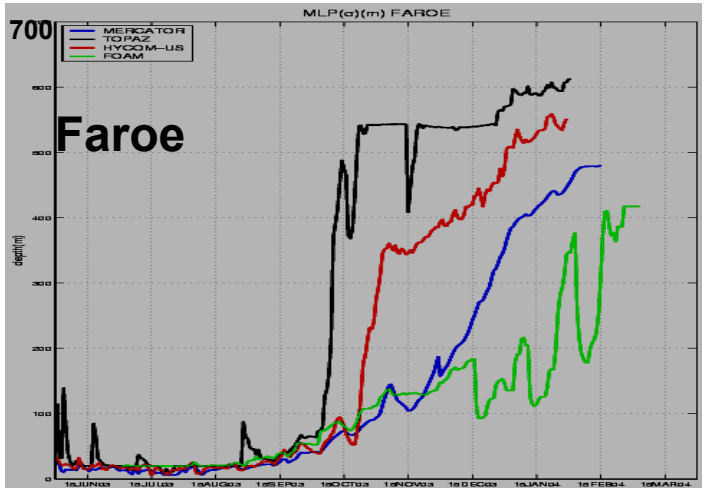


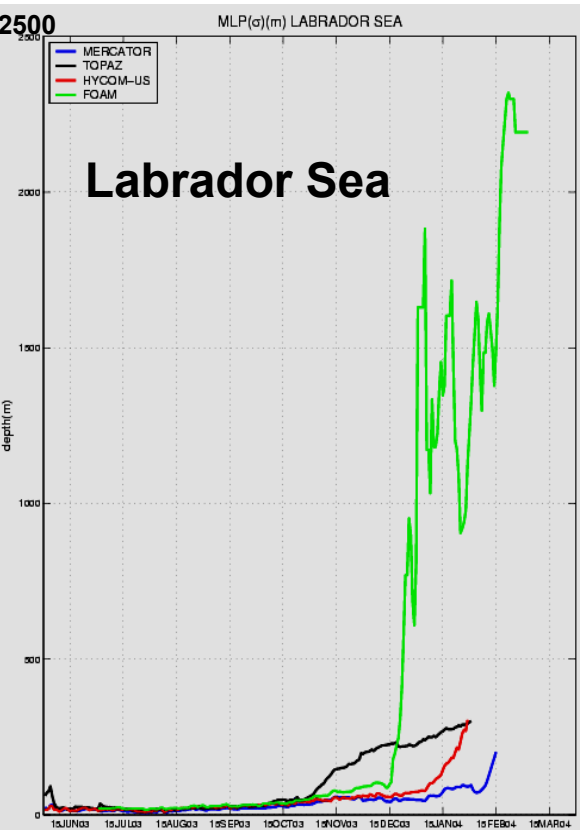
- Impact from Mixing Parameterization

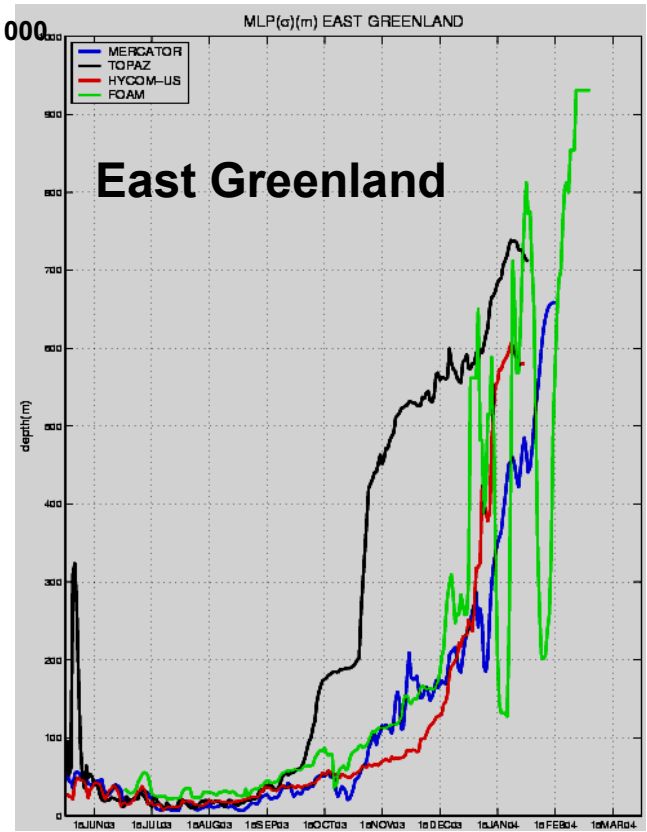


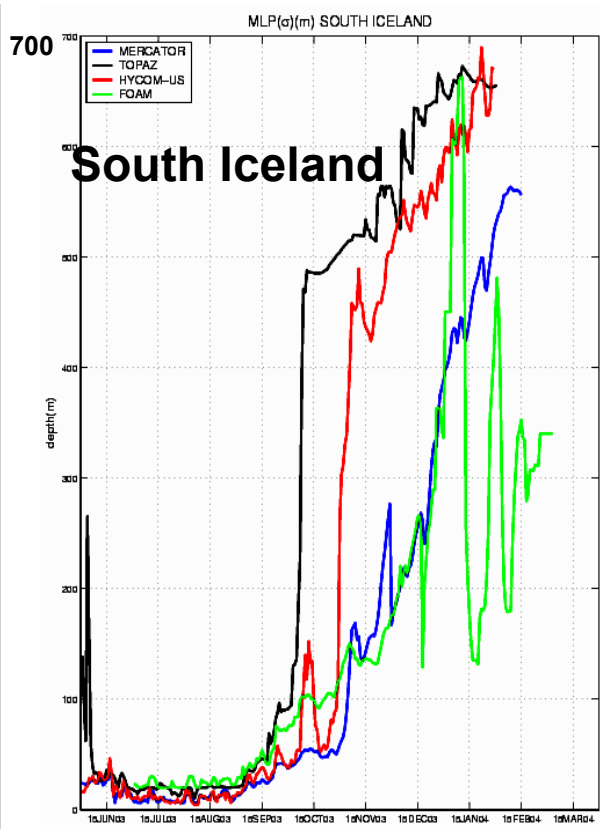


MERCATOR
TOPAZ
FOAM
HYCOM



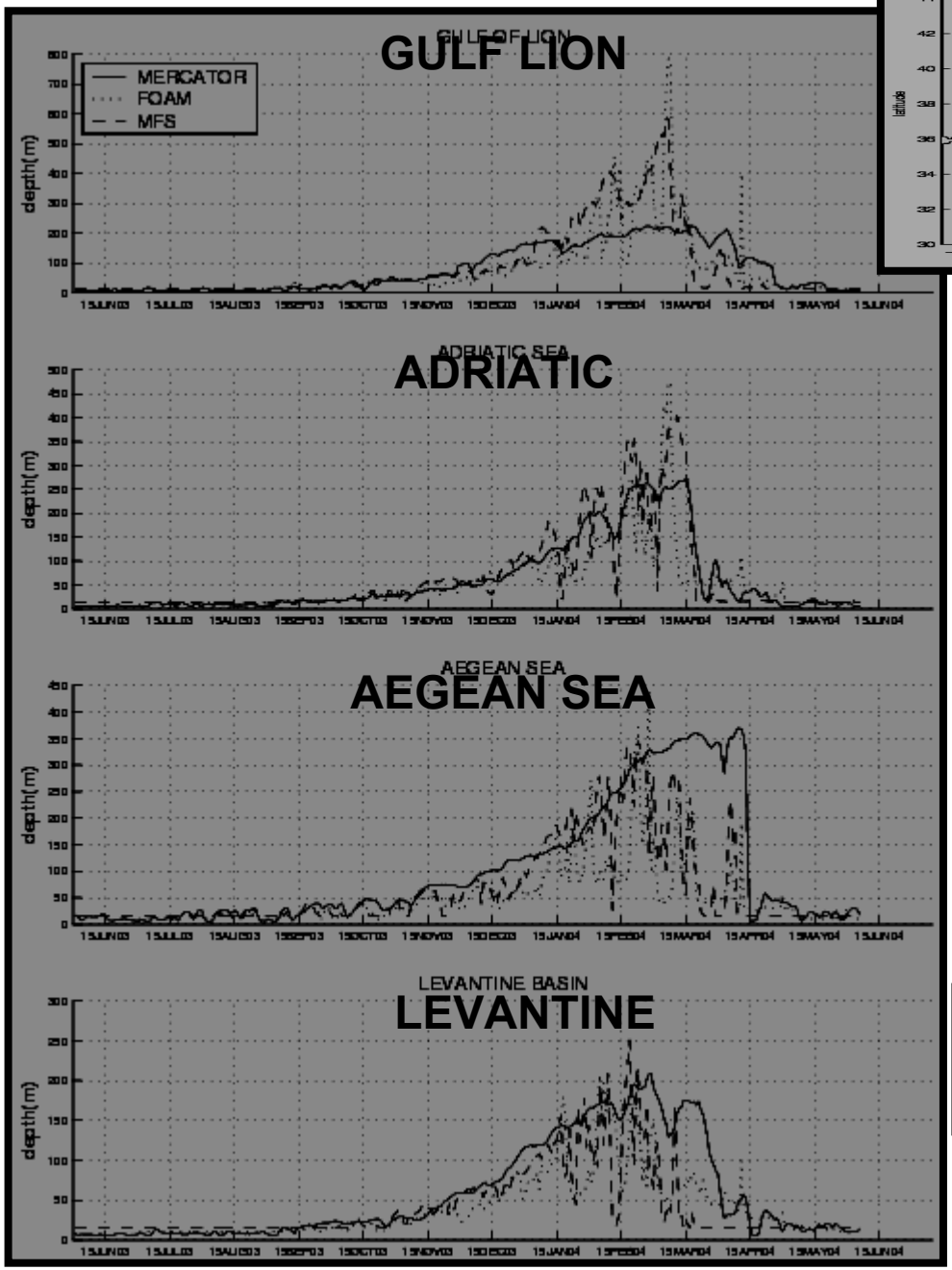






JUNE 1st 03

APR 1st 04



Convection Zones in Mediterranean Sea

JUNE 1st 03

JUNE 1st 04

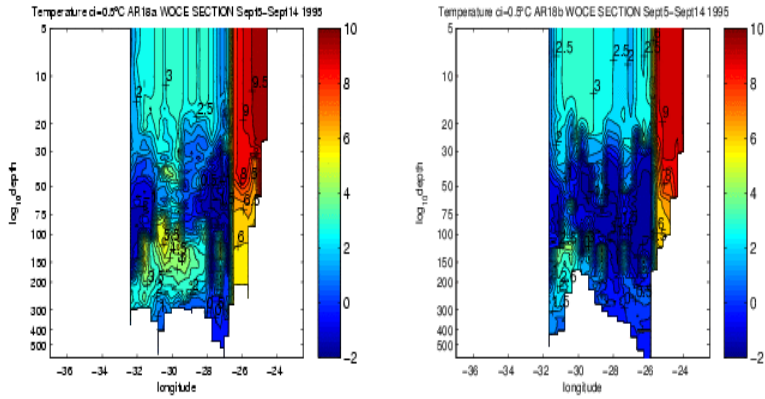
- Impact from Ice Model and assimilation of ice concentration not clear.

→Need for New insight from Mersea-IP :

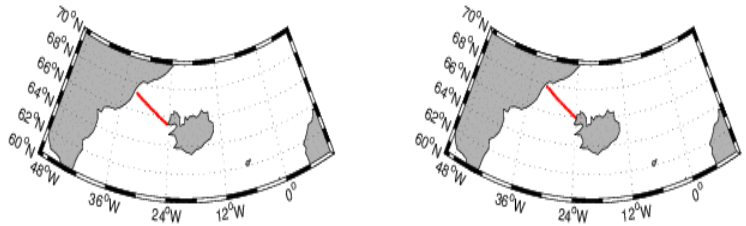
Arctic Ocean included

Denmark Strait Section

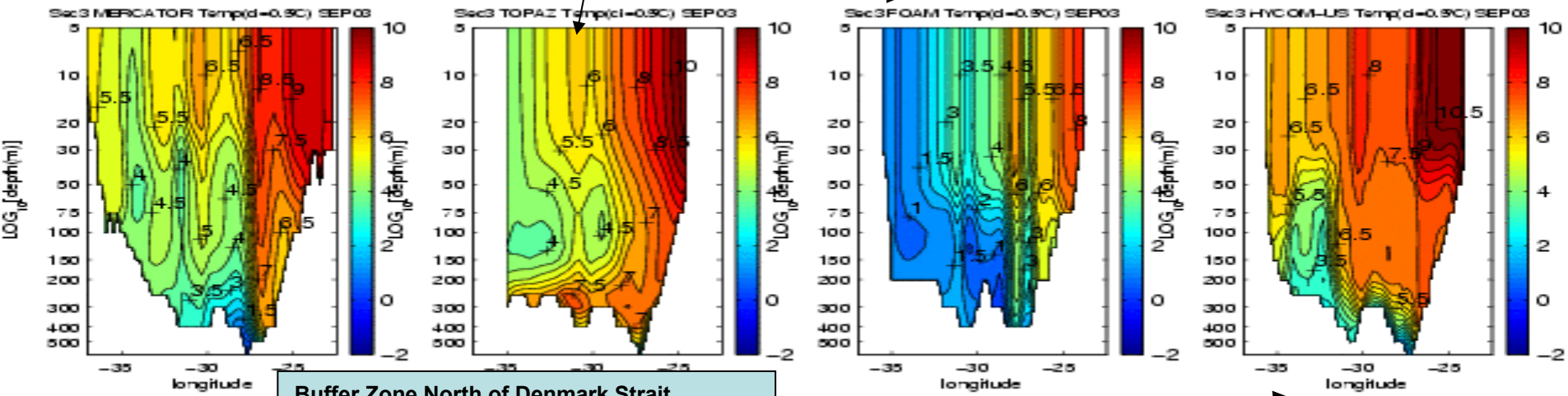
Potential Temperature



WOCE



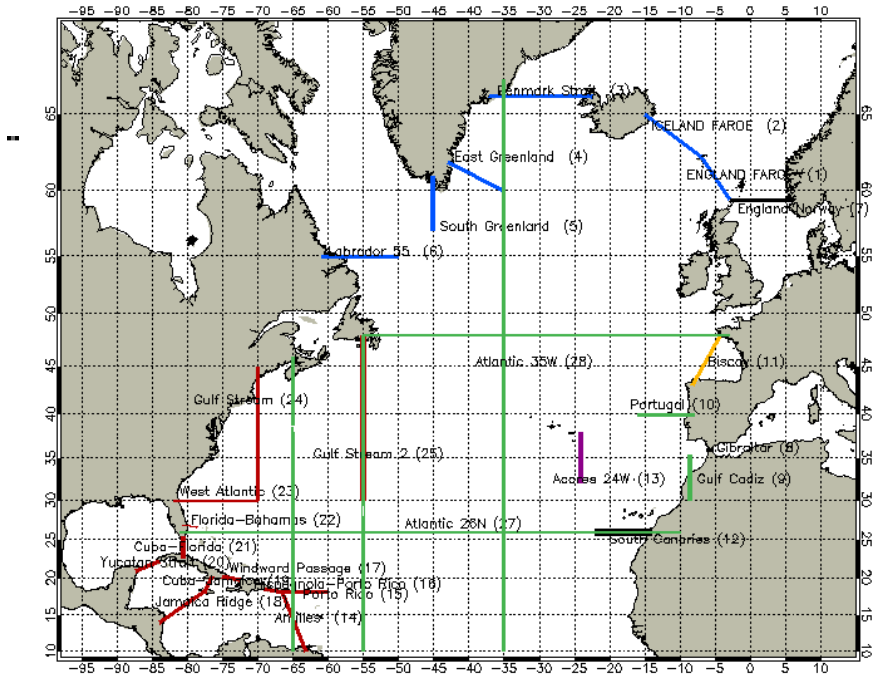
Ice model+
Ice concentration assimilation



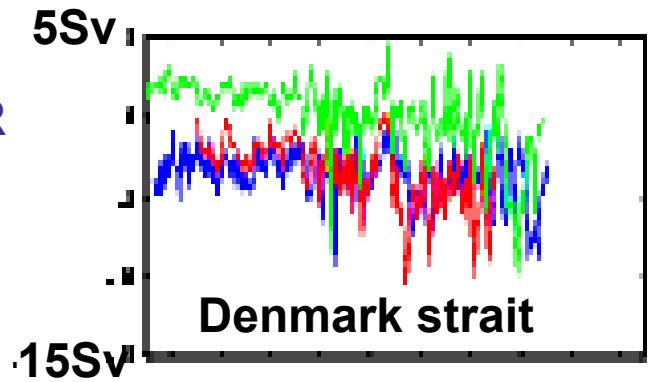
Buffer Zone North of Denmark Strait
With Relaxation to Climatology

MERCATOR **TOPAZ** **FOAM** **HYCOM-US**

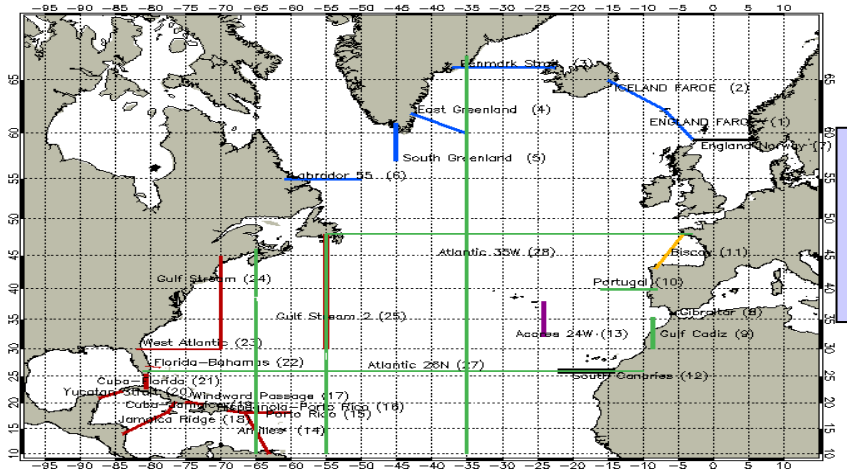
OVERFLOWS SECTIONS
TOTAL VOLUME TRANSPORTS



MERCATOR
FOAM
TOPAZ



JUNE 1st 03 FEB 1st 04



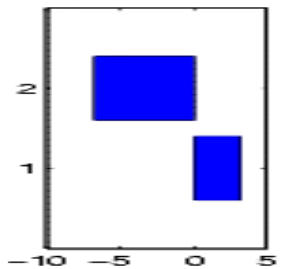
OVERFLOWS SECTIONS
VOLUME TRANSPORTS
per density class

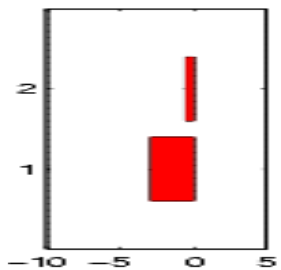
Denmark strait

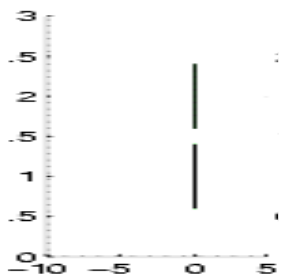
JUN03-JAN04 MEAN

25≤ ρ ≤27.8

27.8≤ ρ ≤29





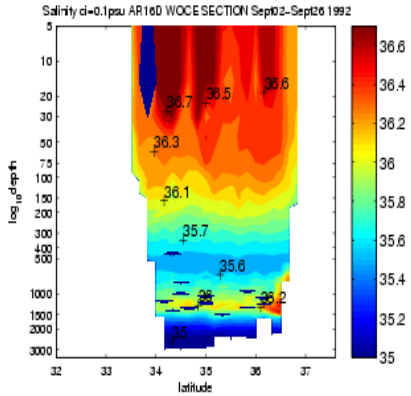


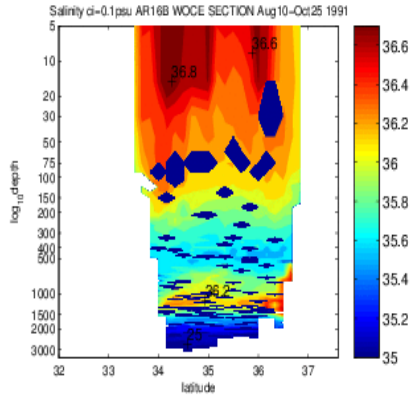
MERCATOR
FOAM
TOPAZ

- Impact from Mediterranean Outflow Water relaxation

Or MOW entrainment parameterization

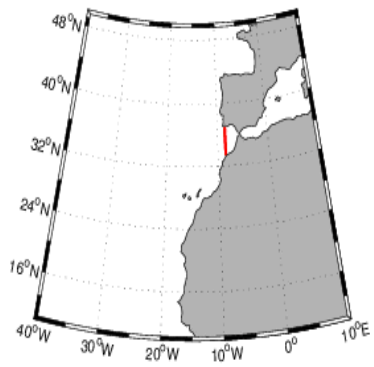
Gulf Cadiz Section 9°W Salinity

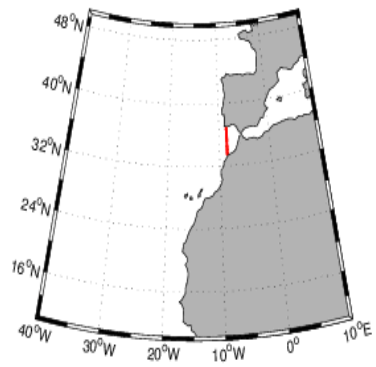


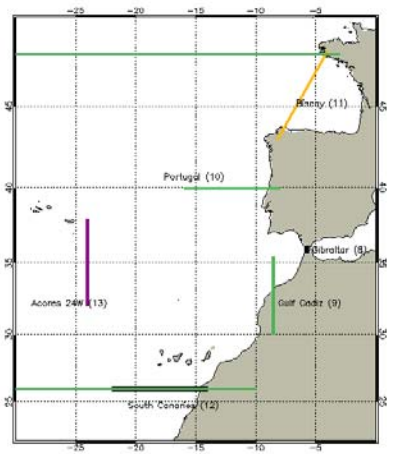


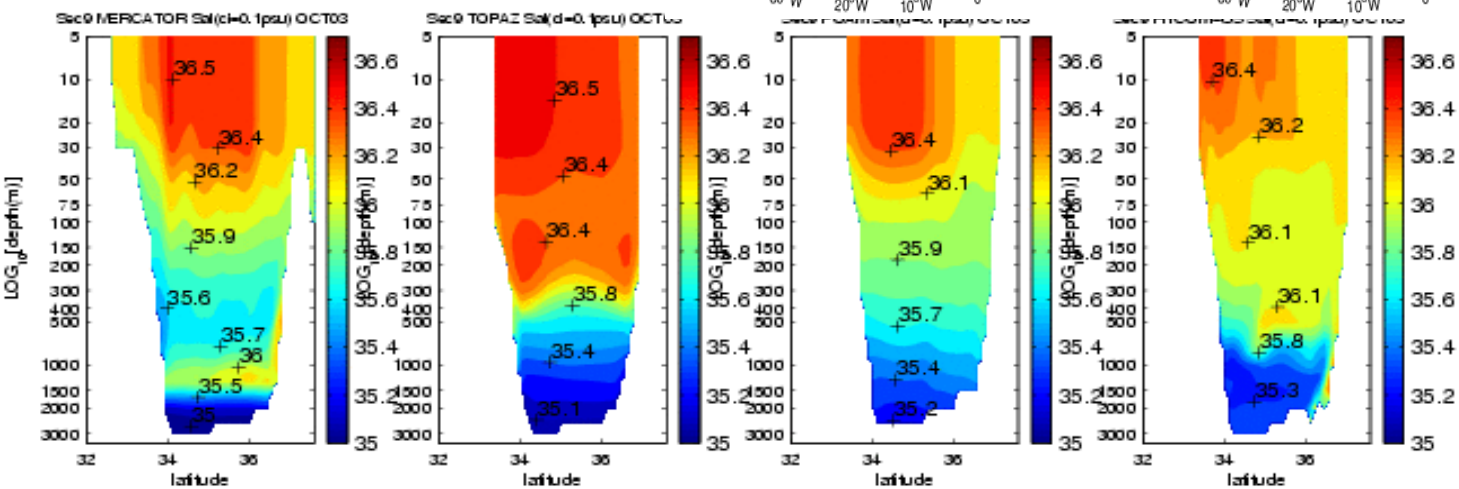
WOCE AR16D SEP 1992

WOCE AR16B AUG OCT 1991









MERCATOR **TOPAZ** **FOAM** **HYCOM**

- Impact from MSSH
  (Mean Sea Surface Height)
  used as a reference
  for Data Assimilation

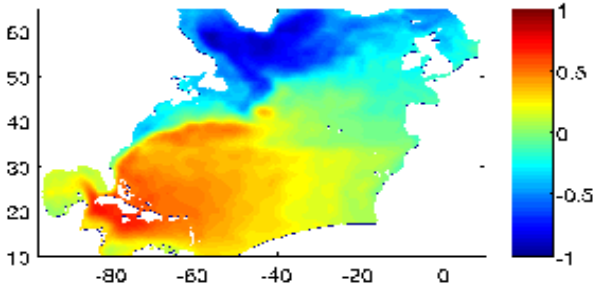
Mean Sea Surface Height (MSSH) (in meters) Basin Mean Removed

MERCATOR → MSSH based on gravity, altimetry and In Situ observations, (Rio et al.)
FOAM → MSSH based on previous run + observations in GS (Singh & Kelly)

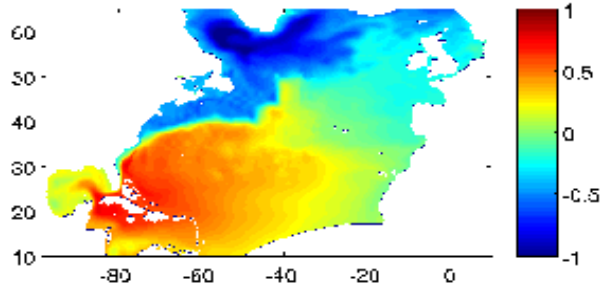
TOPAZ → MSSH based on previous run
HYCOM → MSSH based on previous 1/12° MICOM free run (ECMWF)

Birol et al. 2004 : Hard to judge which MSSH is best for assimilation (depends on region considered).

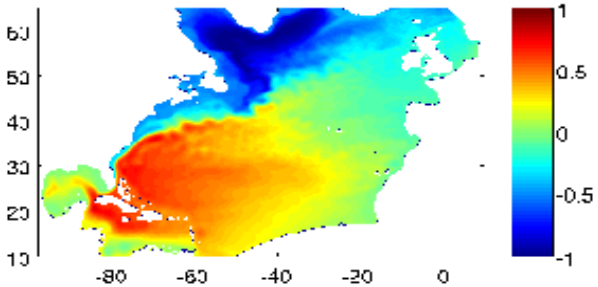
MSSH MERCATOR Basin mean removed



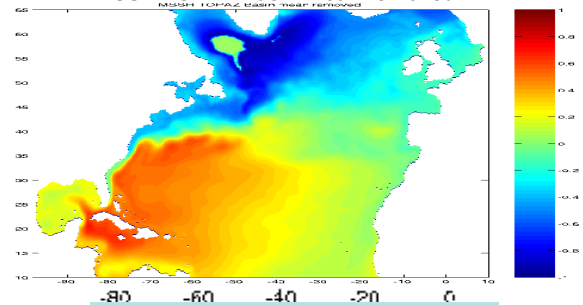
MSSH FOAM Basin mean removed



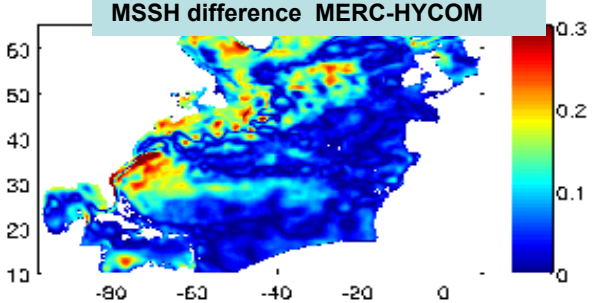
MSSH HYCOM Basin mean removed



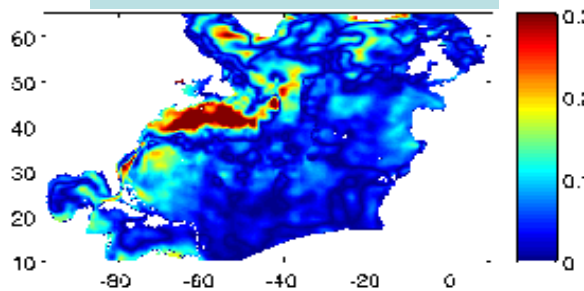
MSSH TOPAZ Basin mean removed



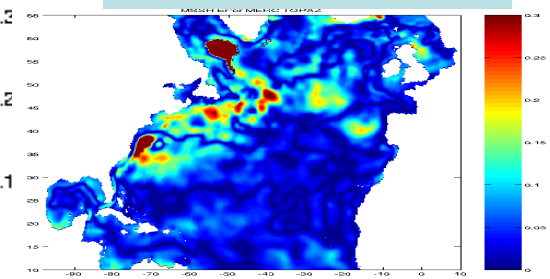
MSSH difference MERC-HYCOM



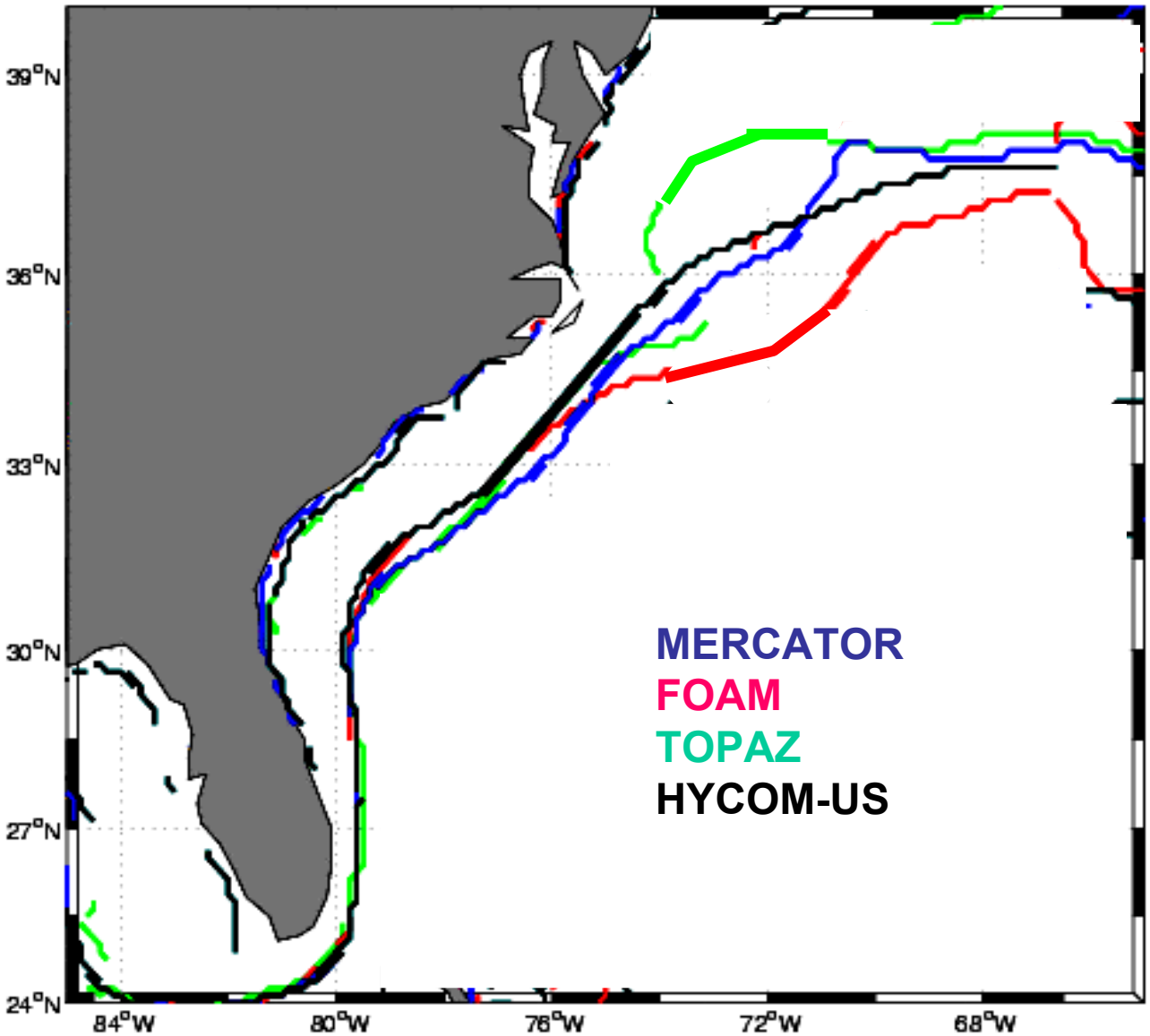
MSSH difference MERC-FOAM



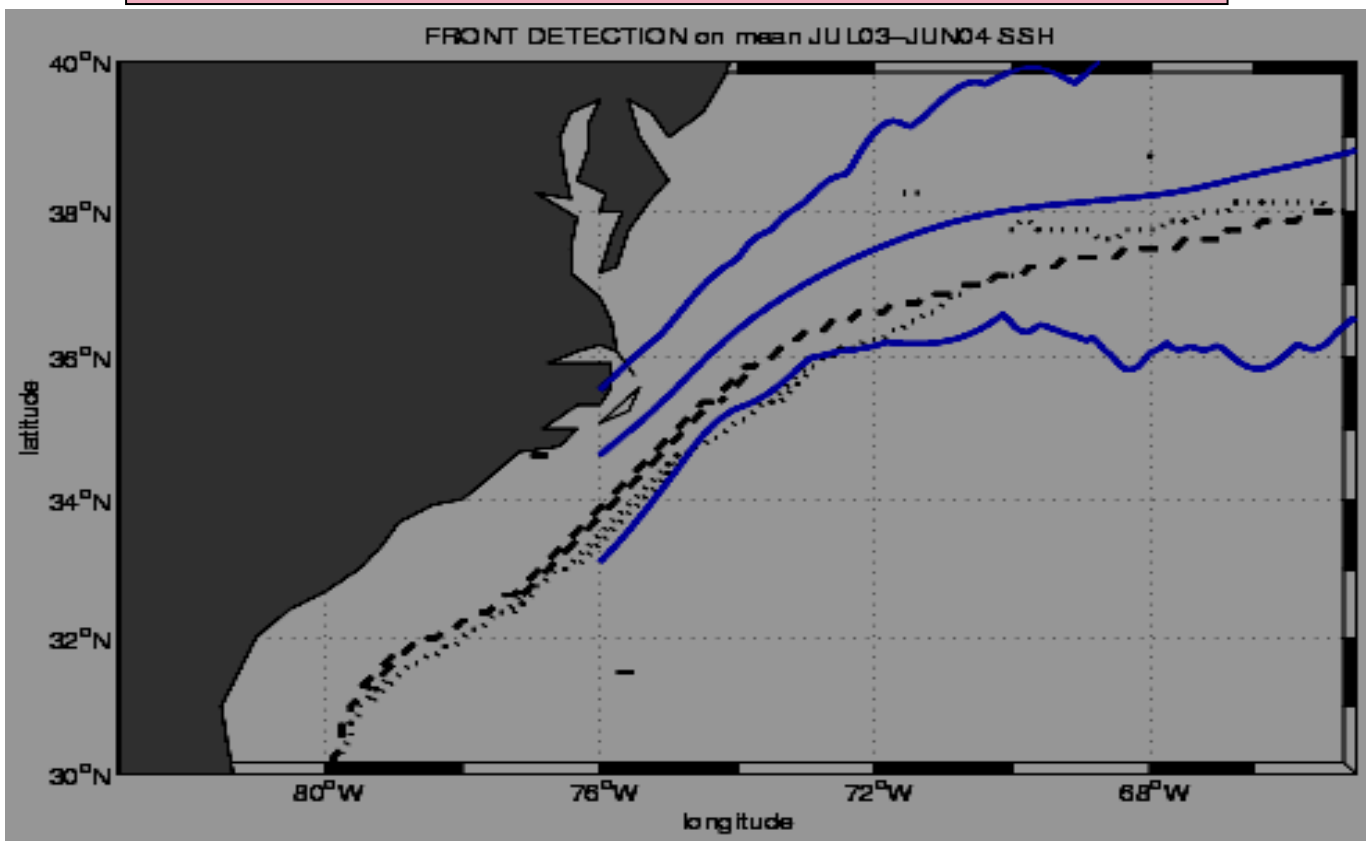
MSSH difference MERC-TOPAZ



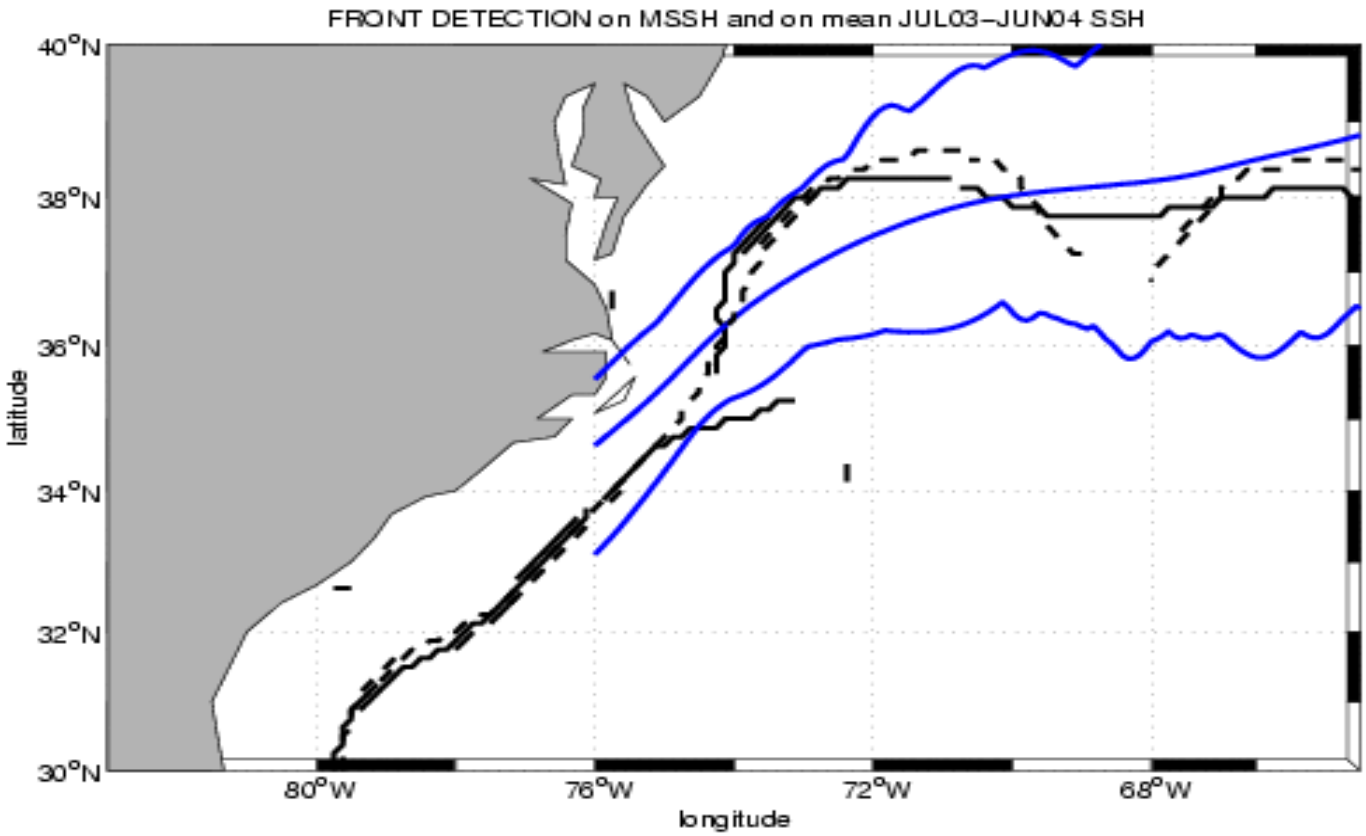
FRONT DETECTION for mean JUL-DEC 03 SSH

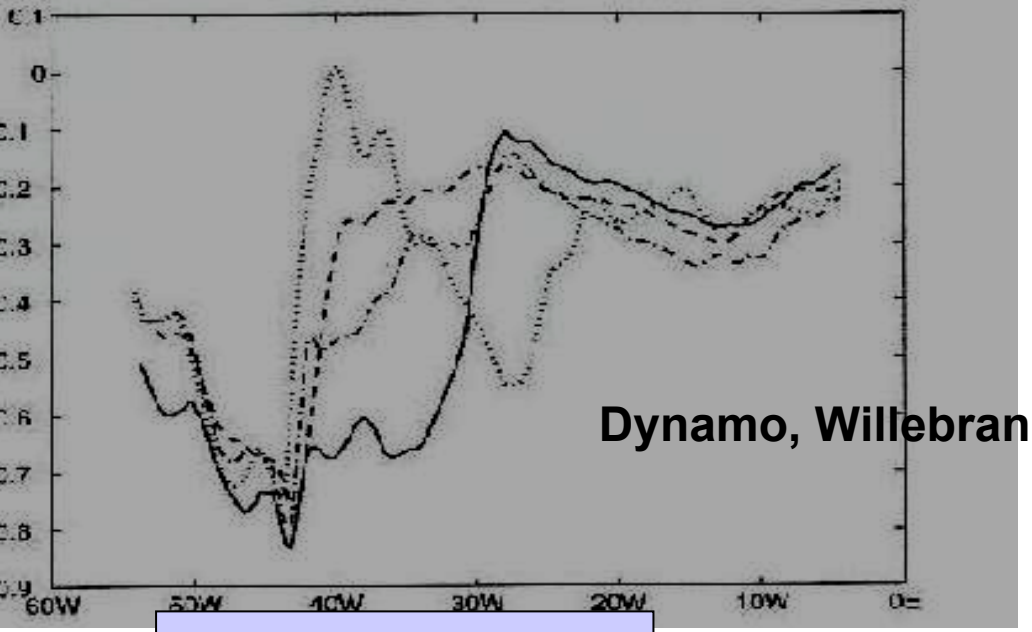


FRONT DETECTION
for mean JUL03-JUN 04 SSH
MERCATOR (dotted line)
HYCOM-US (dashed line)



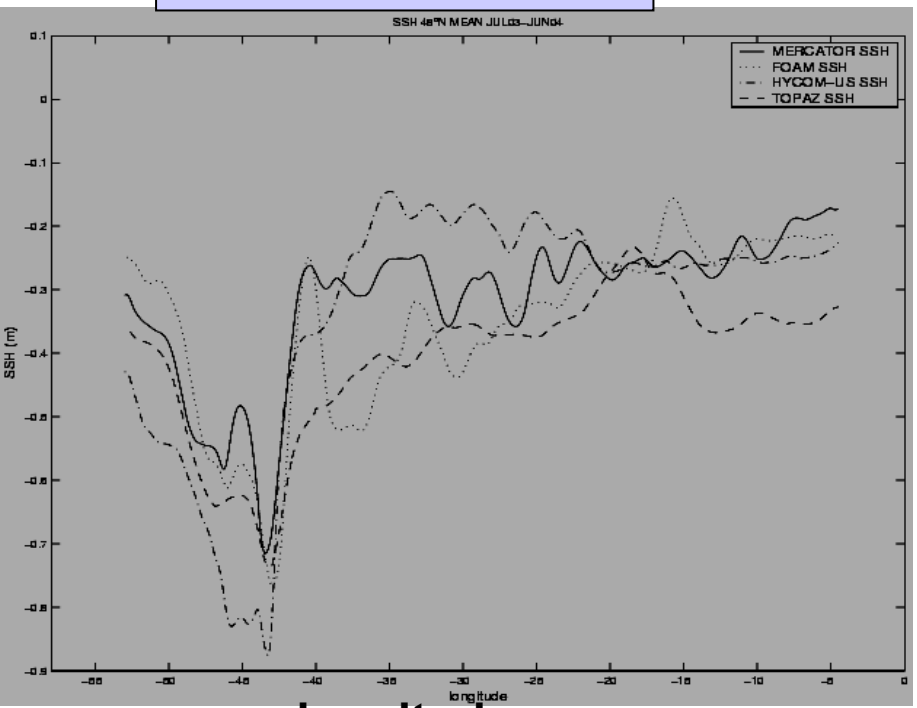
FRONT DETECTION
for mean JUL03-JUN 04
SSH TOPAZ (solid line)
MSSH TOPAZ (dashed line)





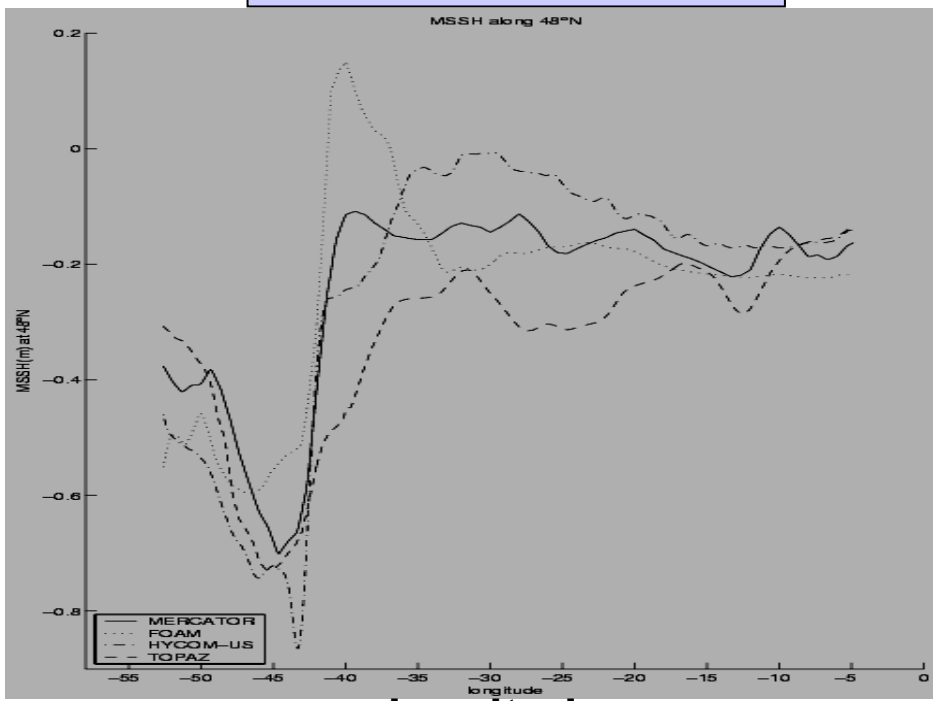
Dynamo, Willebrand et al.

SSH section at 48°N



longitude

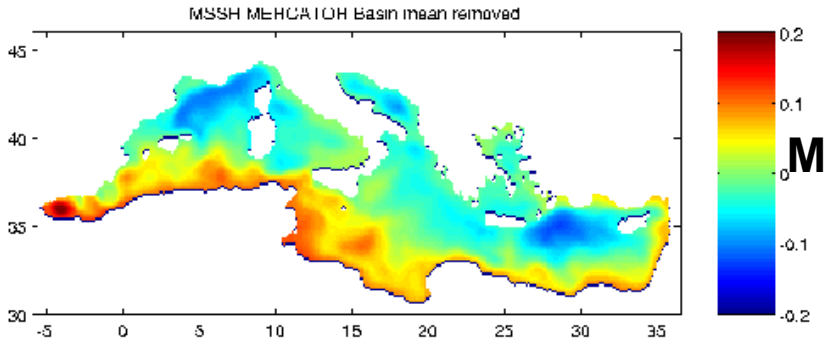
MSSH section at 48°N



longitude

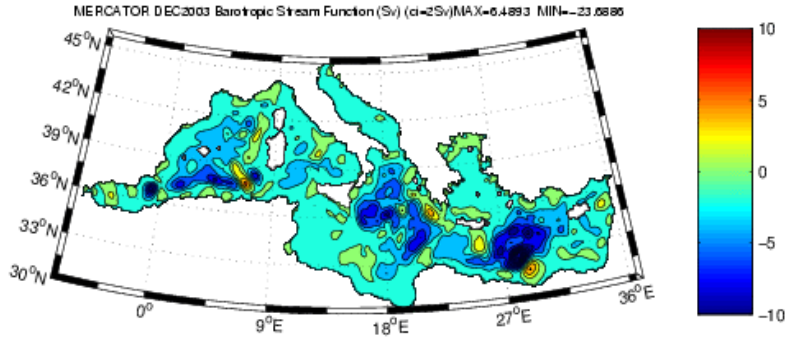
IMPACT OF MEAN SEA SURFACE HEIGHT(MSSH) ON MEDITERRANEAN CIRCULATION

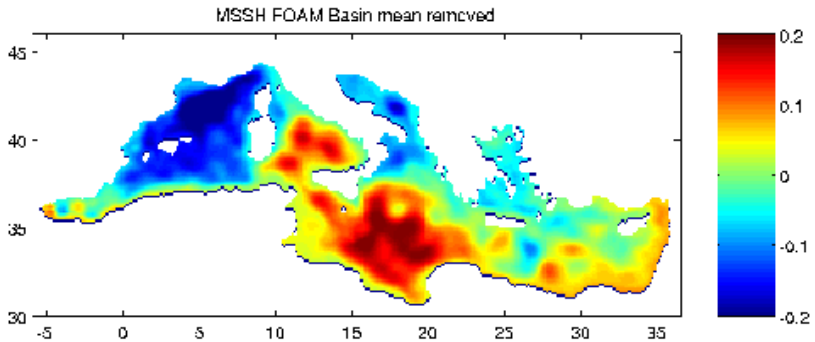
MSSH



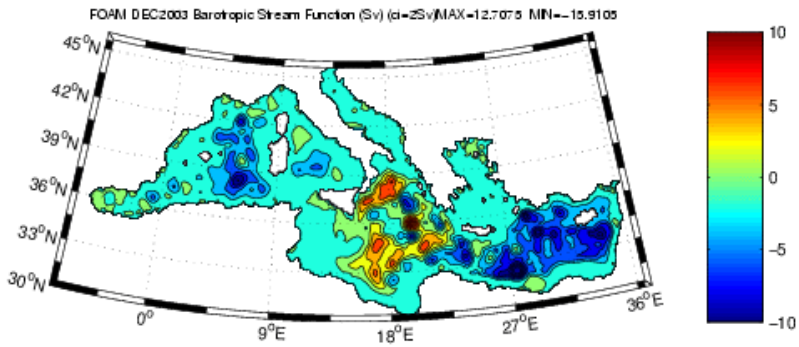
BAROTROPIC STREAM FUNCTION (DEC03)

MERCATOR



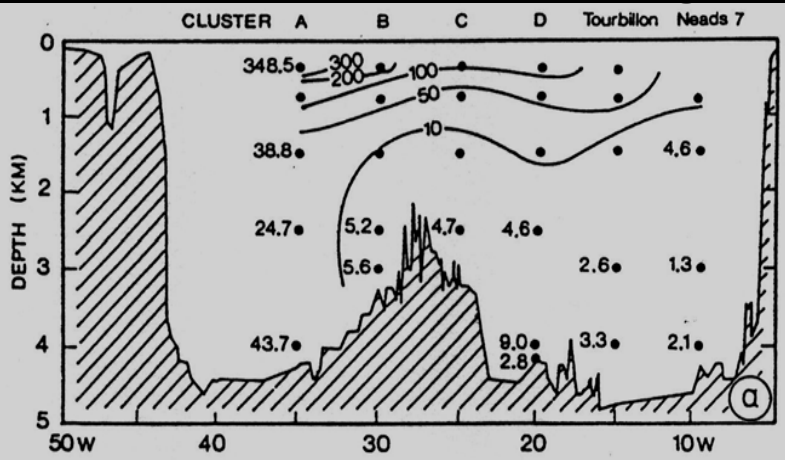


FOAM

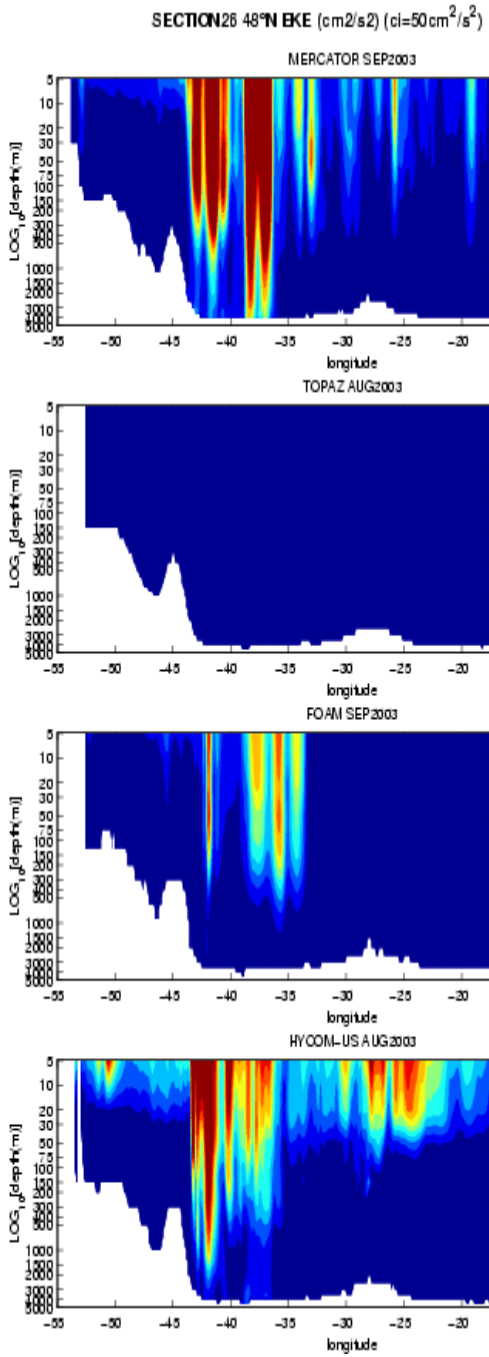


- Impact from horizontal resolution

Vertical EKE distribution along 48 ° N



EKE estimated from current meter moorings
Colin de Verdiere et al. 1989



MERCATOR
5-7km
43levels

TOPAZ
20-30km
22layers

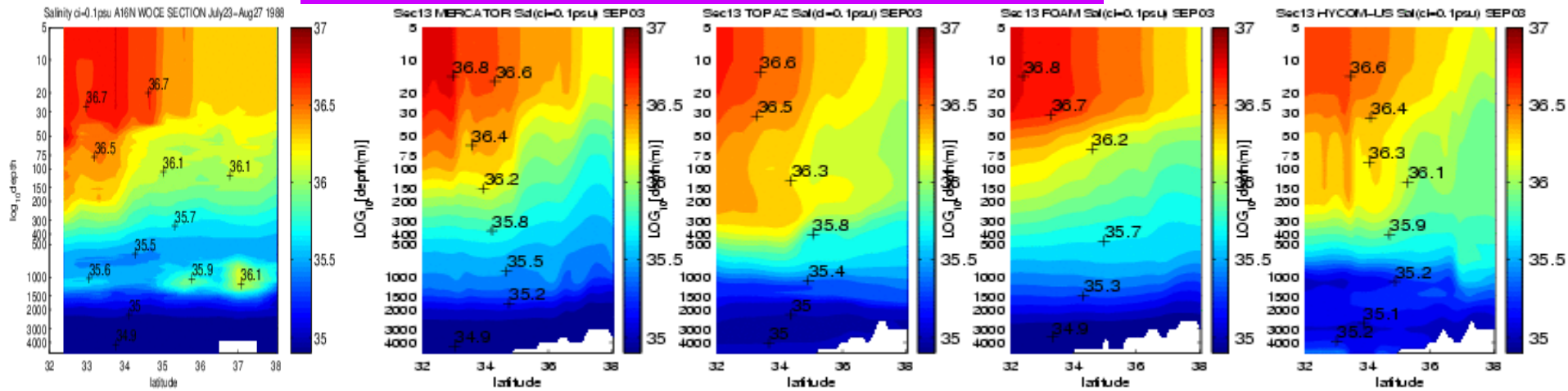
FOAM
12km
20levels

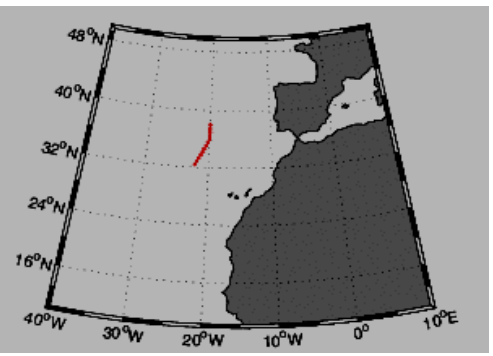
HYCOM-US
6.5km
26layers

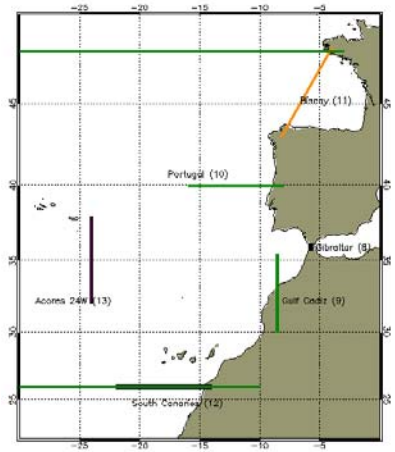
- Impact of vertical coordinates

Azores Section 20°W Salinity

MADEIRA MODE WATER, 20W, SALINITY







WOCE A16N JUL AUG 1988

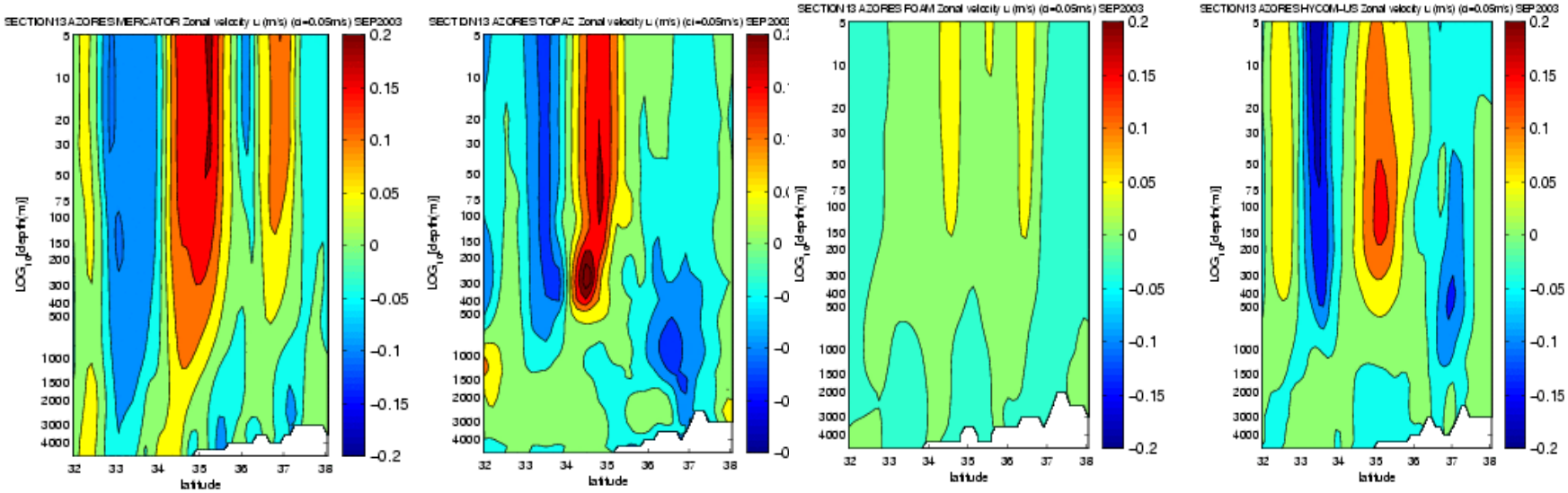
MERCATOR

TOPAZ

FOAM

HYCOM

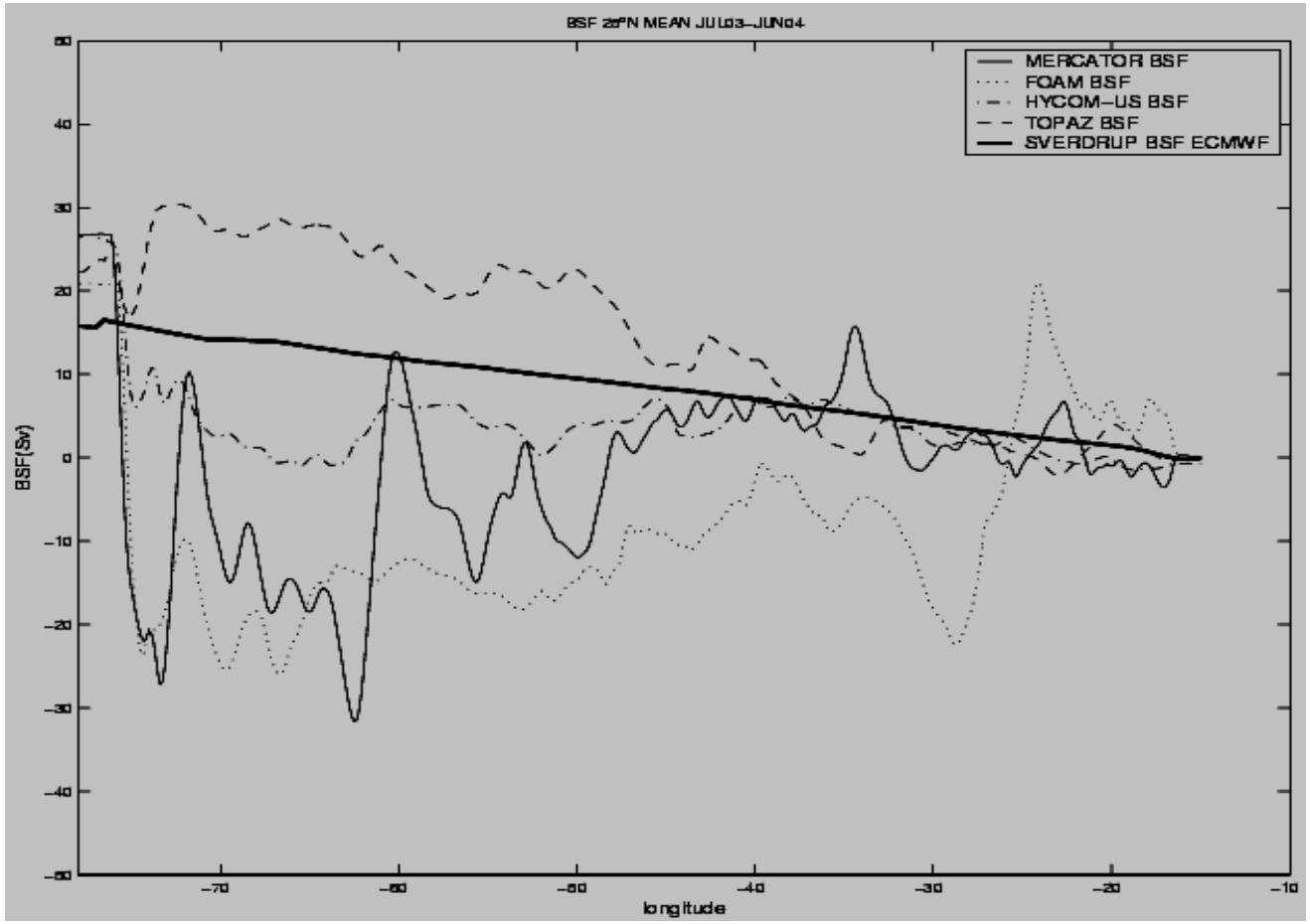
ZONAL VEL -SECTION 13 - AZORES - SEPT2003



MERCATOR **TOPAZ** **FOAM** **HYCOM-US**

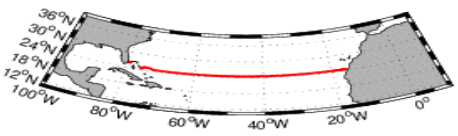
- Impact from assimilated data
  (SLA and/or ARGO)

Barotropic Streamfunction at 25N
Sverdrup Stramfunction

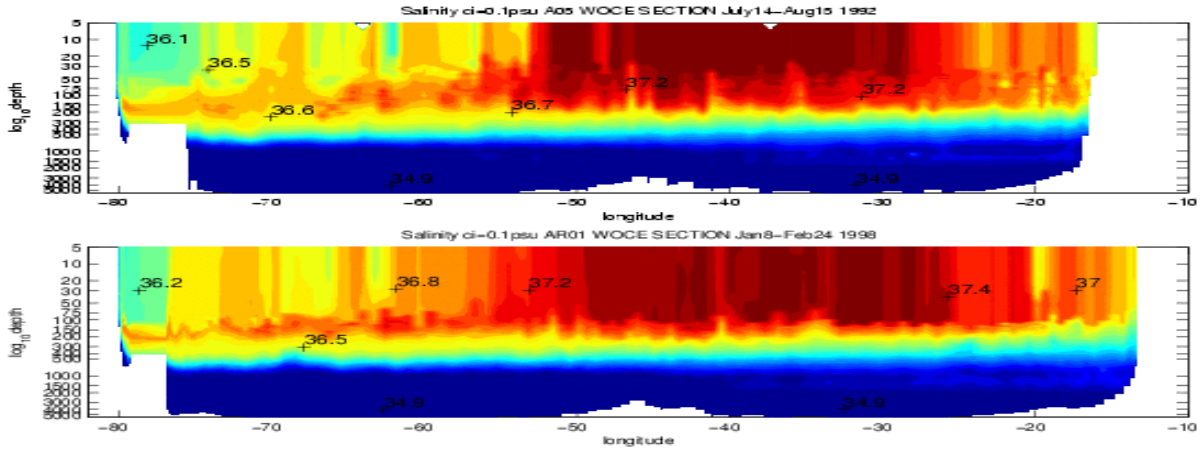


IMPACT OF ASSIMILATION OF ARGO SALINITY PROFILE

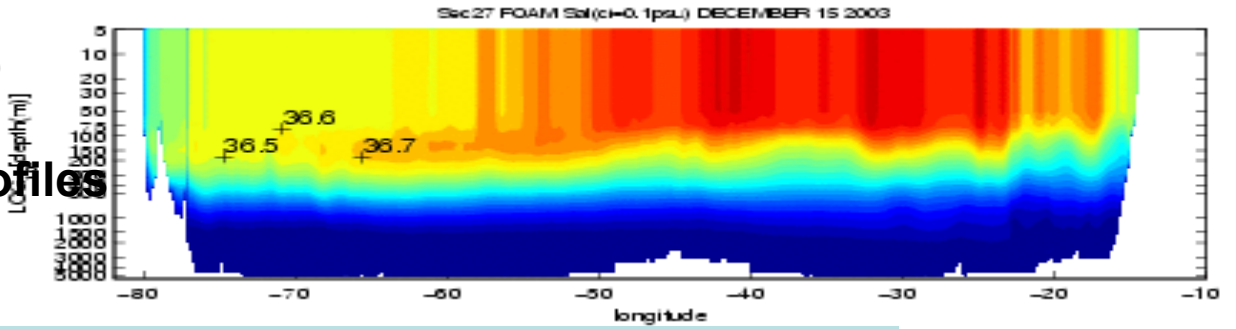
WOCE



Class2 Zonal Section 26°N Salinity

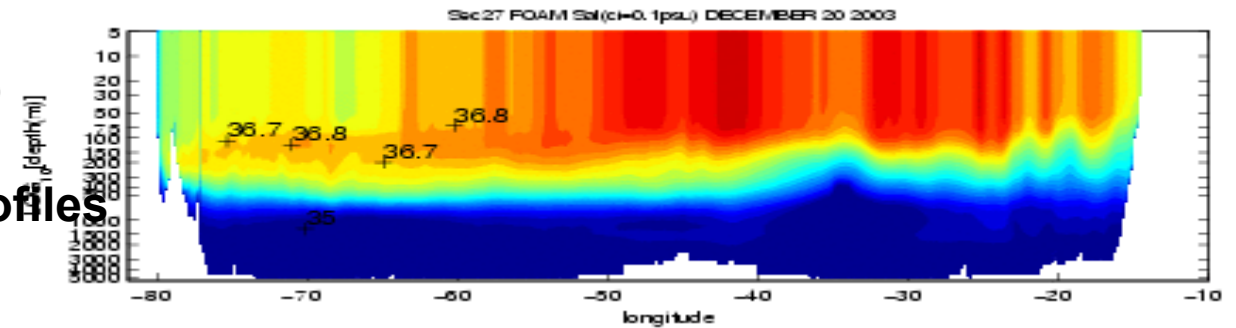


FOAM (DEC15 2003)
Before assimilation
of ARGO salinity profiles

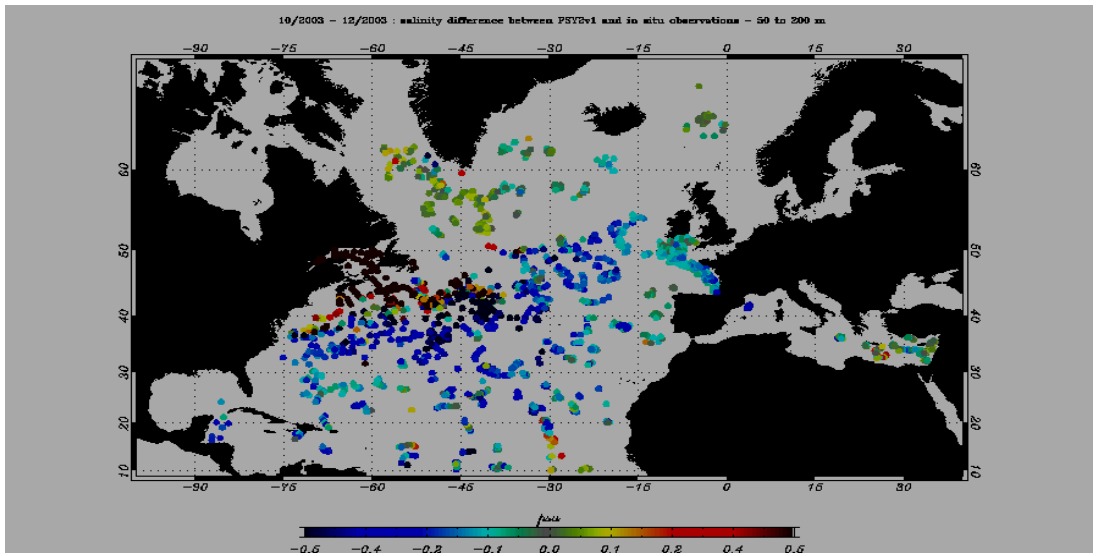


assimilation of ARGO salinity profiles from DEC17 2003 on

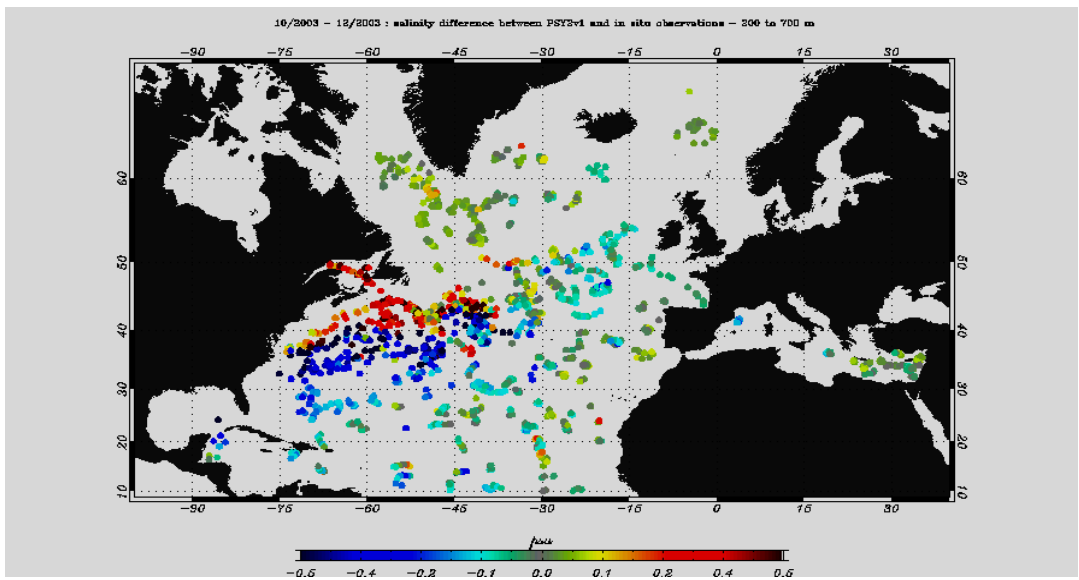
FOAM (DEC20 2003)
After assimilation
of ARGO salinity profiles



In situ Salinity data available from 10-2003 to 12-2003

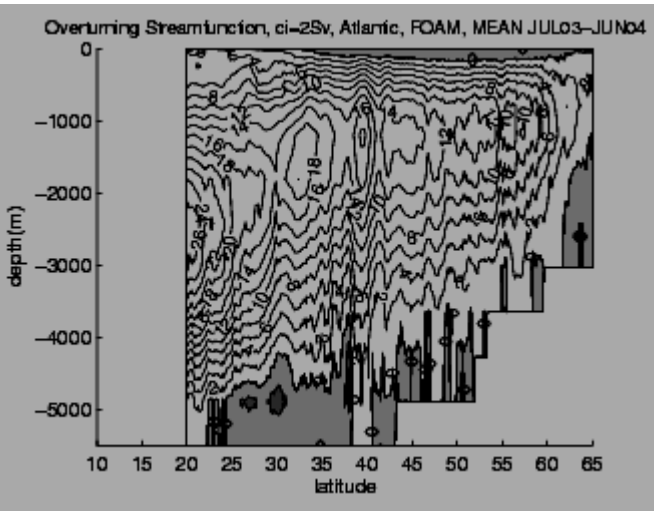


50-200m

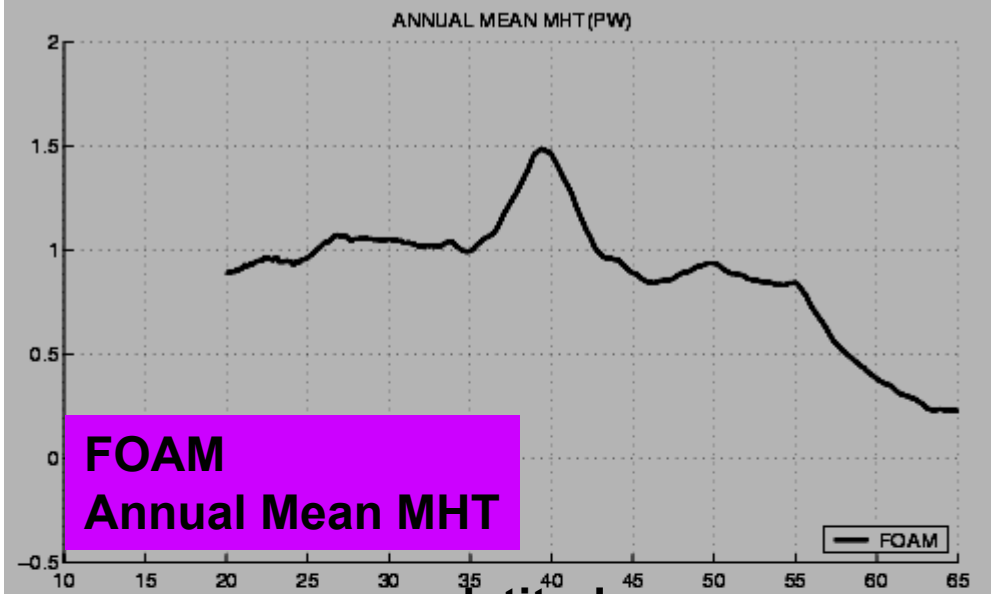


200-700m

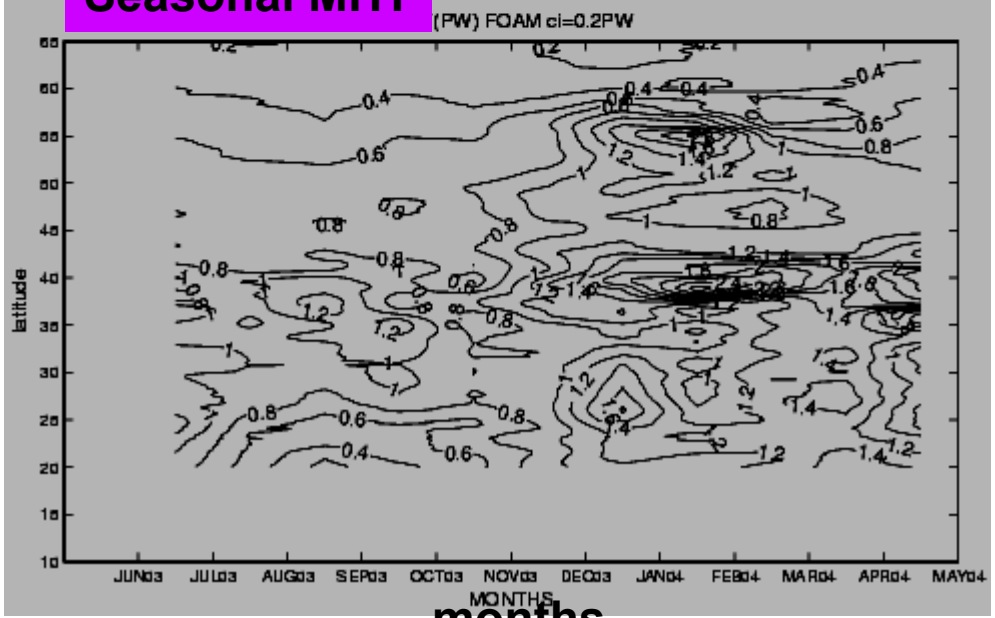
FOAM OVERTURNING



FOAM Annual Mean MHT



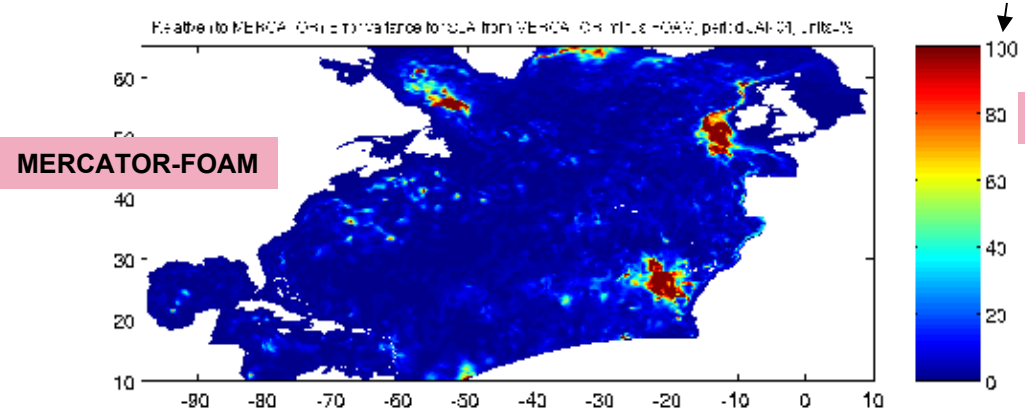
FOAM Seasonal MHT

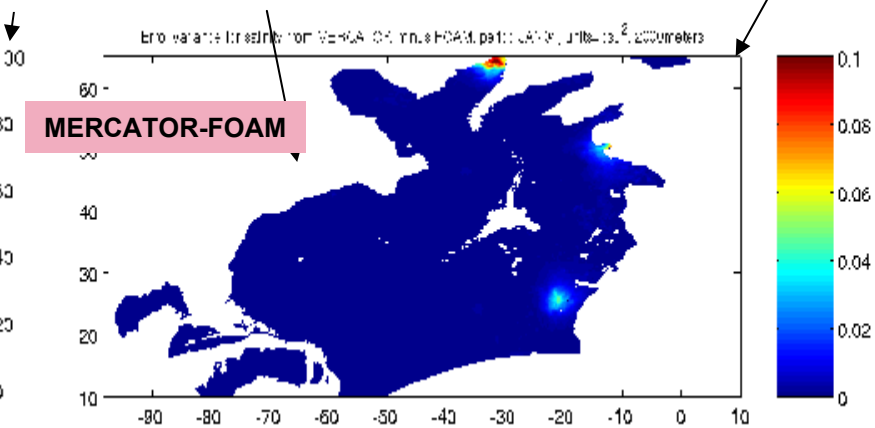


Relative Variance of the Differences for High frequency, JAN04

Variance of the differences for SLA, JAN04, units=%

Variance of the differences for Salinity, JAN04, units=psu^2, 2000meters

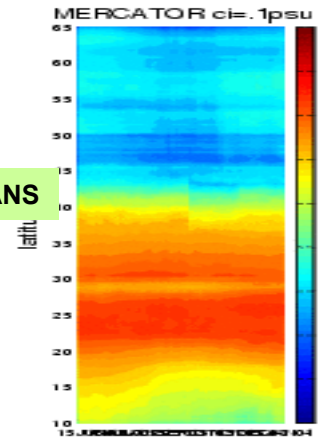




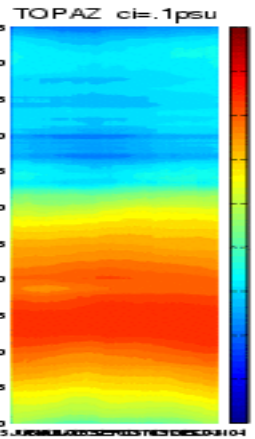
Hovmuller plots of ZONAL MEAN SURFACE (5meters) Atlantic SALINITY

ZONAL MEANS

MERCATOR



TOPAZ



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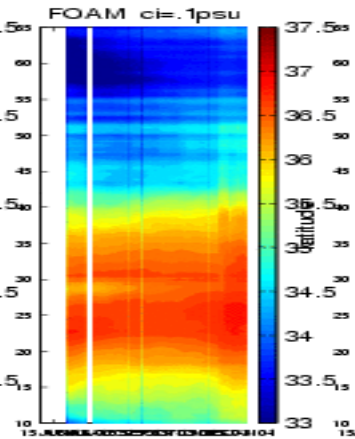
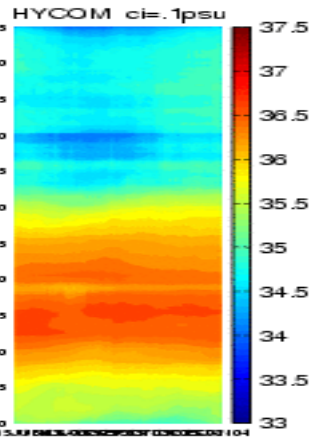
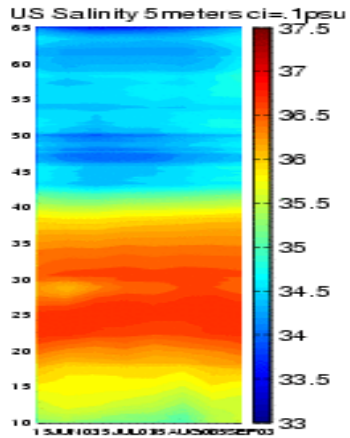


HYCOM-US

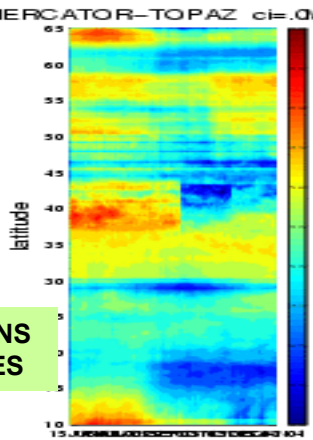


LEVITUS01



ZONAL MEANS DIFFERENCES

MERCATOR – TOPAZ



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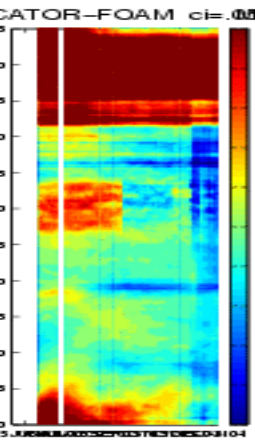
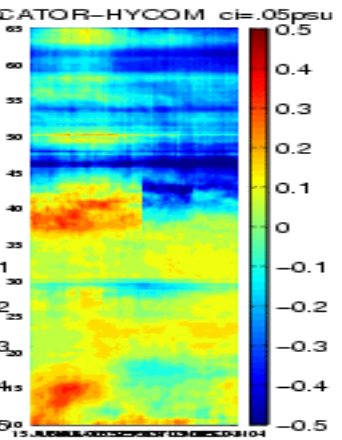


MERCATOR – HYCOM US



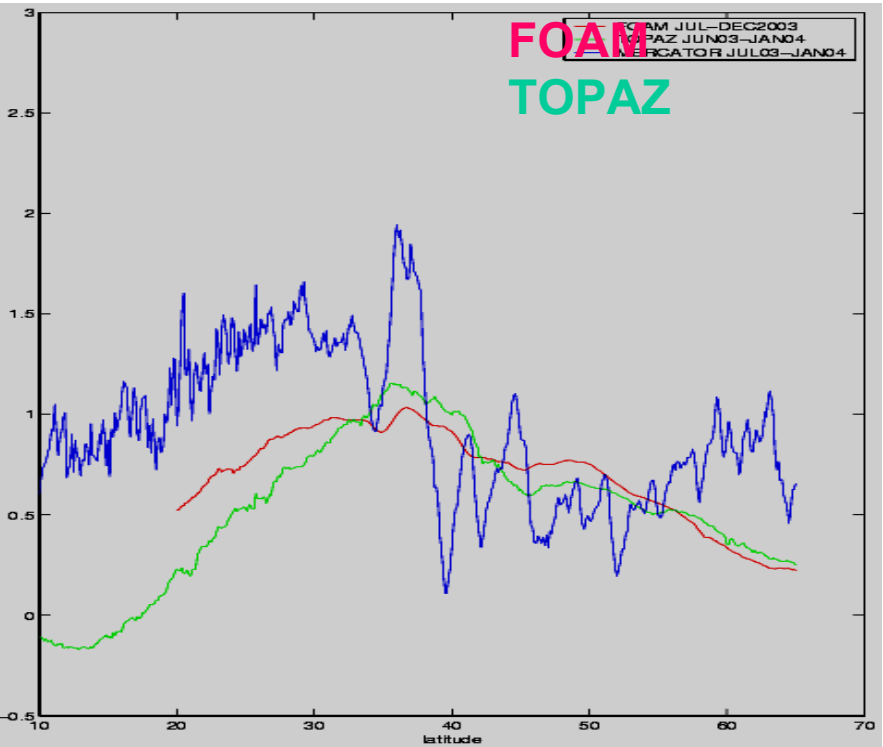
- Class3

MERIDIONAL HEAT TRANSPORT
JUL 1st 03- DEC 1st 03

MERCATOR

FOAM

TOPAZ



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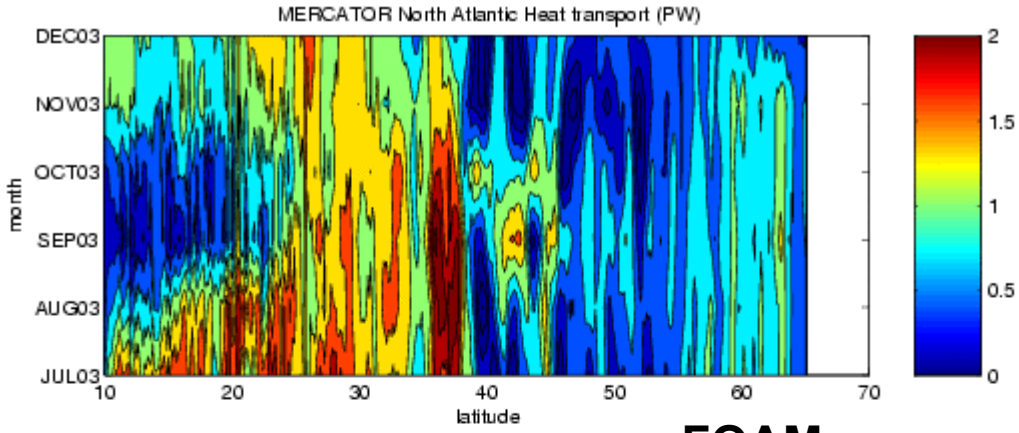
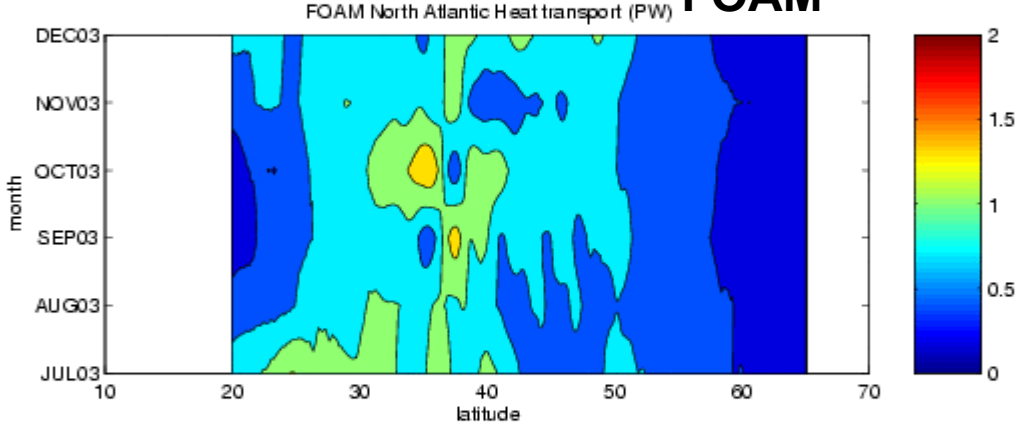


FOAM



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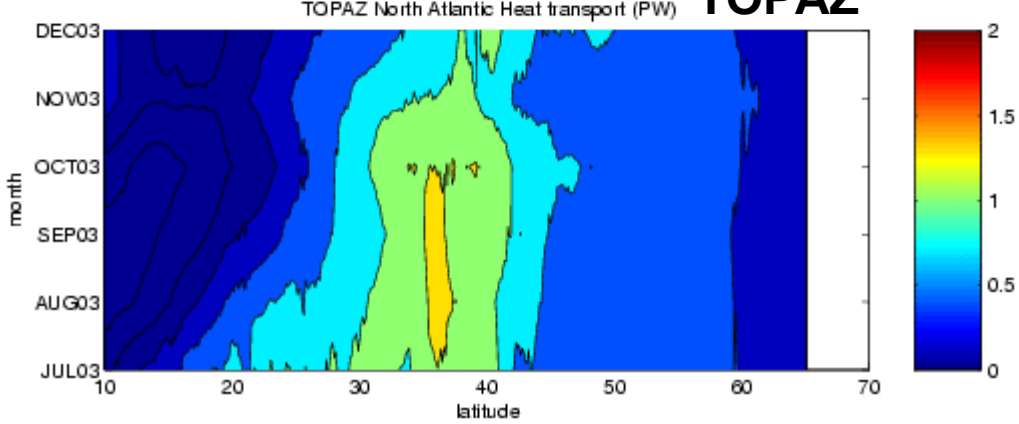
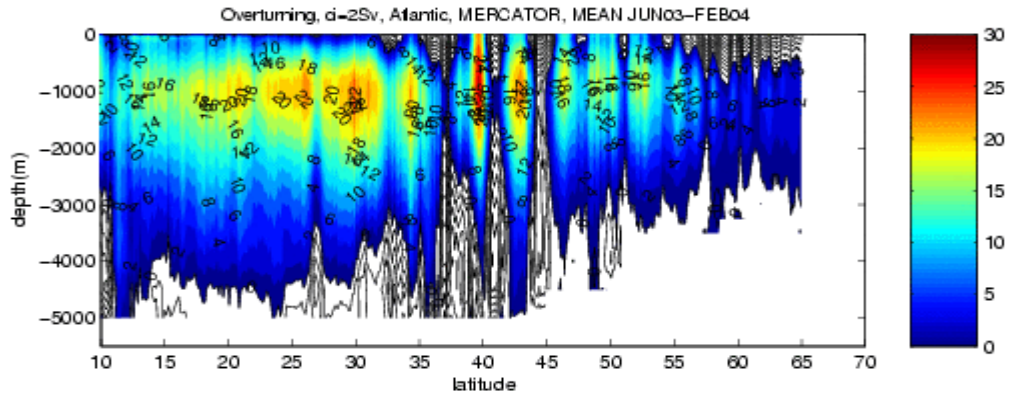


OVERTURNING STREAM FUNCTION CI=2sV

MERCATOR



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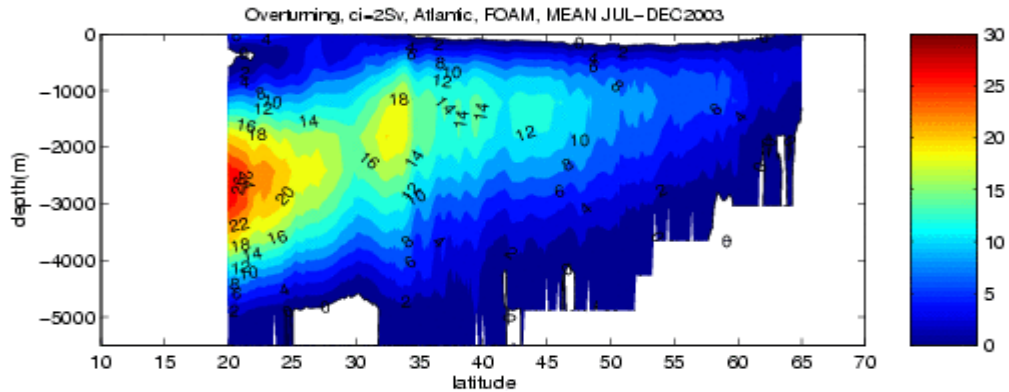

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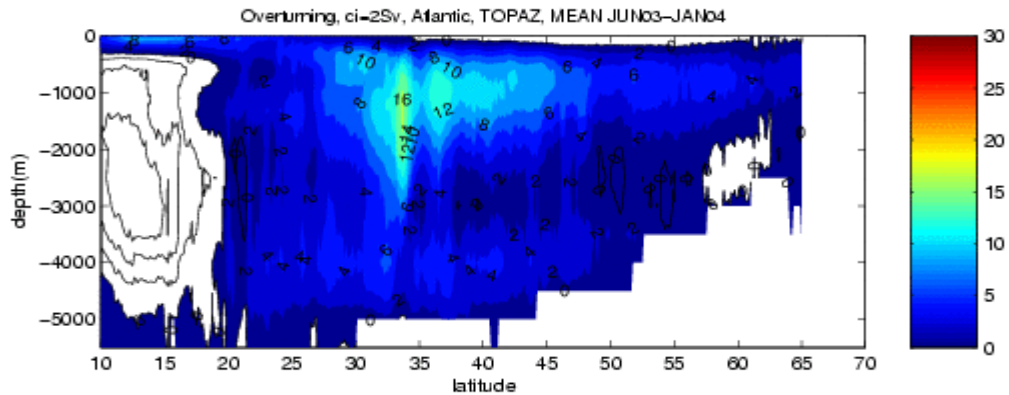
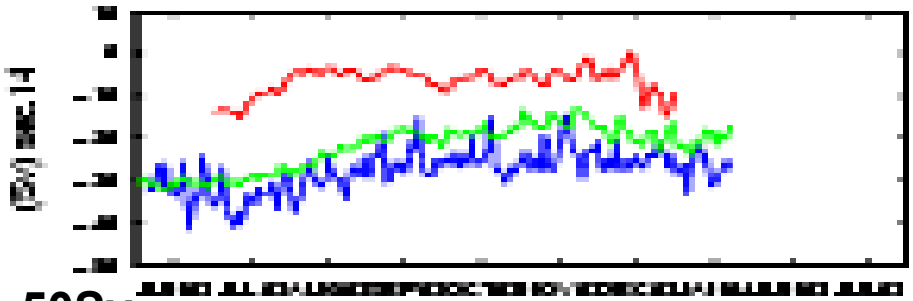


No AABW=
No Isobaric effect
in Hycom
Sigma_0 discretization
(Sun et al. 1999)

MERCATOR
FOAM
TOPAZ

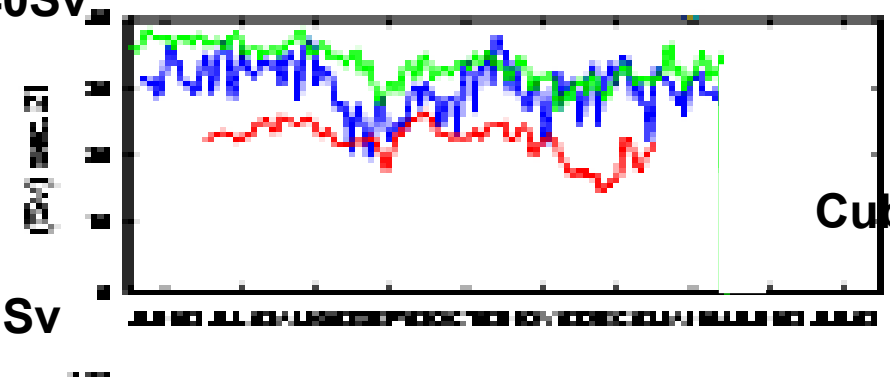
10Sv



Antilles

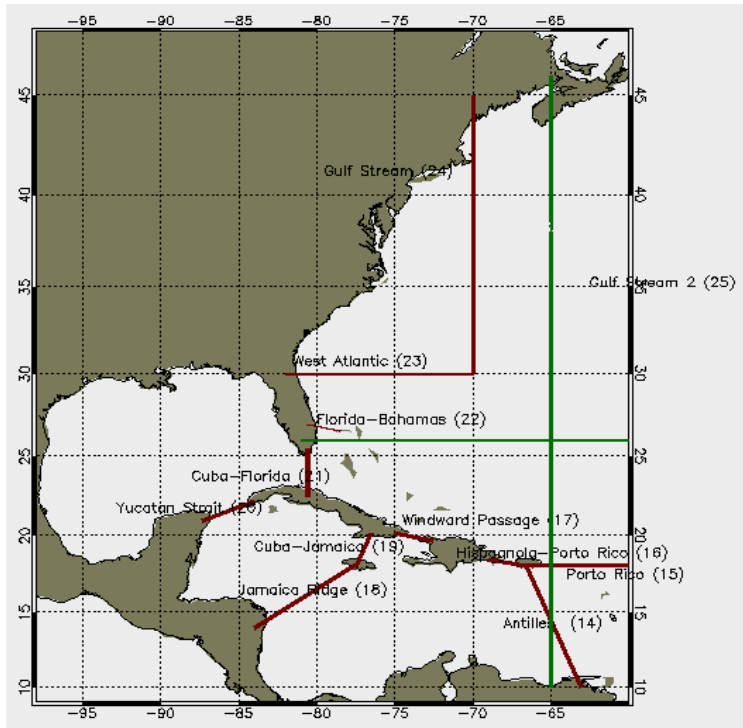
-50Sv

40Sv



Cuba Florida

0Sv



Constant Upgrade of the systems Main events

- Mercator Oct1 03 and Nov26 03 : upgrade MSSH
  Vertical diffusivity in Mediterranean basin
  New system with multivariate data assimilation

- Topaz June04 : upgrade Hycom version
  Correction on assimilation of SLA
  Inverse barometer effect removed

- Foam Dec18 03 : Assimilation of Argo at all depth
  March10 04 : Correction of altimeter Assimilation
  Change of viscosity (Gulf stream path)
  Better quality control for Salinity profiles

- Mfs June04 : Use of 20 Eofs (rather than 1)
  Runoff

Conclusion

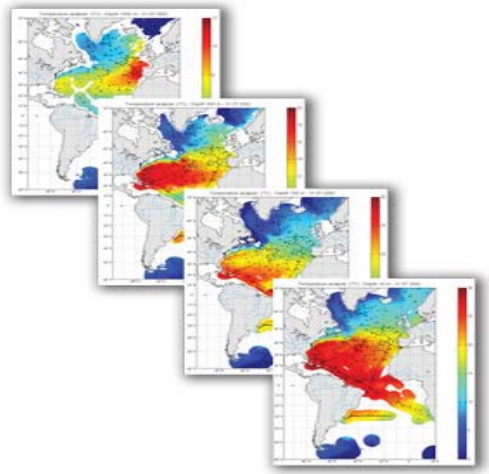
MERSEA web site: www.mersea.eu.org

- **1st time such an inter-comparison exercise is conducted on 5 forecasting systems over Atlantic & Mediterranean Basins. Successful prototype. Strength and weakness shown. Soon Global ocean. Methodology adopted by GODAE.**
- Class1-2-3 ready. Working on Class4.
- Common methodology+inter-comparison fosters interactions
- Order ~0 intercomparison but it triggered many changes in the systems

- **Watch length of spin up for deep water masses (drift away from Clim if spun up too long).**
- **No clear differences on Mixed Layer Depths between KPP/TKE/Kraus-Turner mixing parameterization.**
- **The higher the horizontal resolution, the more realistic the EKE.**
- **Huge importance of choice of MSSH on system behavior.**
- **Northern overflows: Models with relaxation or Ice model with assimilation of ice concentration are too warm. Check the Arctic behavior during Mersea-IP.**
- **Med Water Overflows : Relaxation or entrainment parameterization to MOW not well done.**
- **Multivariate data assimilation improve the systems (but watch data quality control !) .**
- **Mersea-strand1 is over. More work to be done during MERSEA-IP:**
  - **Class4 diagnostics results**
  - **Comparison with IN SITU DATA : Coriolis/Armor/ADCP/XBT data sets.**
  - **Need for definition of synthetic indicators.**
  - **Look at Arctic region**
  - **Definition of Metrics for GODAE basins/Arctic ocean…**

CORIOLIS OBJECTIVE ANALYSIS For the Atlantic Ocean

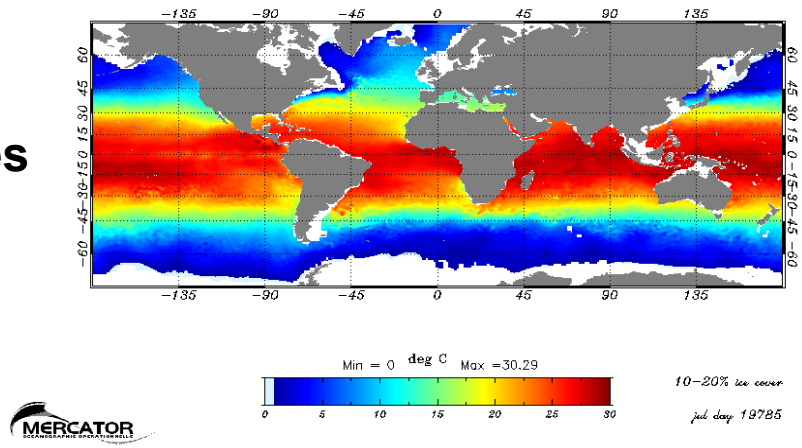
T/S Coriolis profiles



ARMOR analysed temperature : T on 03-03-2004 near 0m

ARMOR ANALYSIS For the Global Ocean

MSLA Salto/Duacs+ T/S Coriolis profiles + SST Reynolds + Coriolis drifters



ADCP, XBT(Meds), SEA LEVEL GAUGE in MED, …….

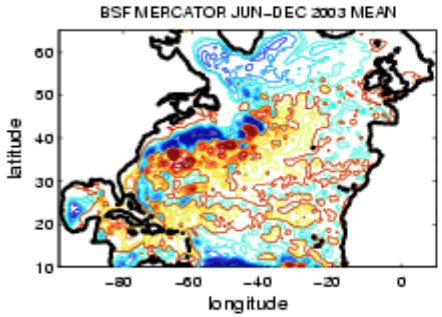
The class 4 metrics in the observational space

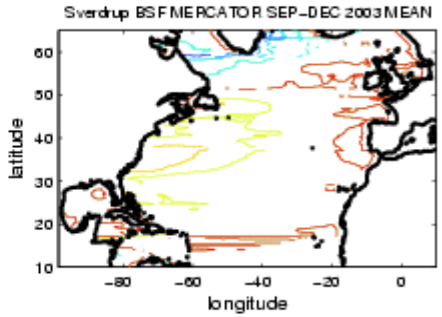
RMSINNOV	$\frac{1}{N-1}\sqrt{\sum (o-Hh)^2}$	$\frac{\sum (o-Hc)(Hh-Hc)}{\sqrt{\sum (o-Hc)^2}\sqrt{\sum (Hh-Hc)^2}}$
RMSCLIM	$\frac{1}{N-1}\sqrt{\sum (o-Hc)^2}$	Undefined
RMSINNOV1	$\frac{1}{N-1}\sqrt{\sum (o-Hf)^2}$	$\frac{\sum (o-Hc)(Hf-Hc)}{\sqrt{\sum (o-Hc)^2}\sqrt{\sum (Hf-Hc)^2}}$
RMSRESID	$\frac{1}{N-1}\sqrt{\sum (o-Ha)^2}$	$\frac{\sum (o-Hc)(Ha-Hc)}{\sqrt{\sum (o-Hc)^2}\sqrt{\sum (Ha-Hc)^2}}$
RMSPERS	$\frac{1}{N-1}\sqrt{\sum (o-Hp)^2}$	$\frac{\sum (o-Hc)(Hp-Hc)}{\sqrt{\sum (o-Hc)^2}\sqrt{\sum (Hp-Hc)^2}}$

JUNE_DEC2003 Mean Barotropic Stream Function (ci=10Sv)

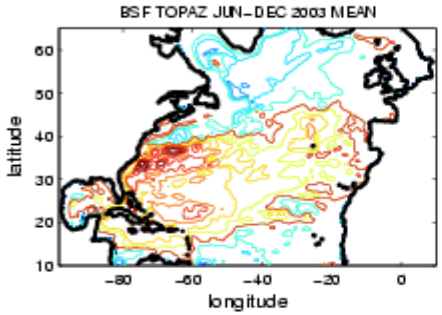
And Sverdrup Barotropic Stream Function (ci=10Sv)

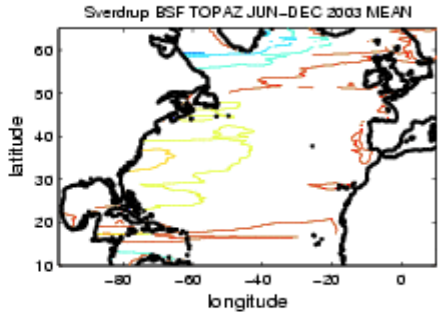
MERCATOR



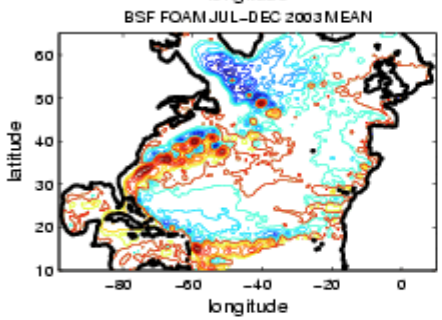


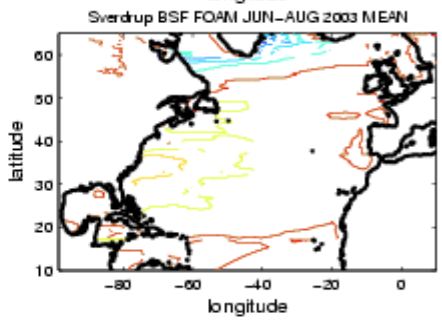
TOPAZ



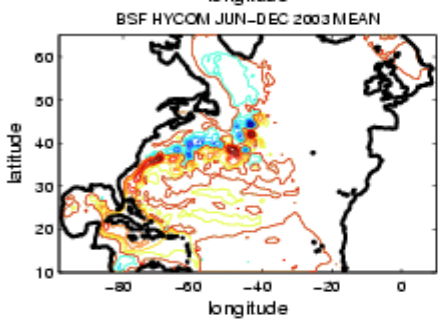


FOAM



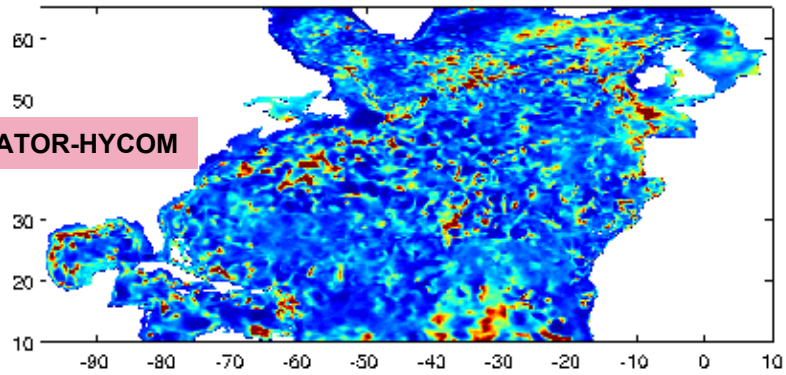


HYCOM-US



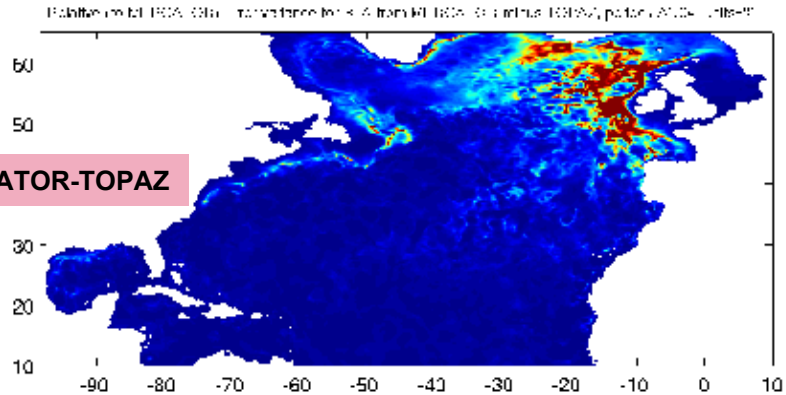
Relative (to Mercator) Variance of the Differences for High frequency SLA, JAN04, units=%

MERCATOR-HYCOM



5%

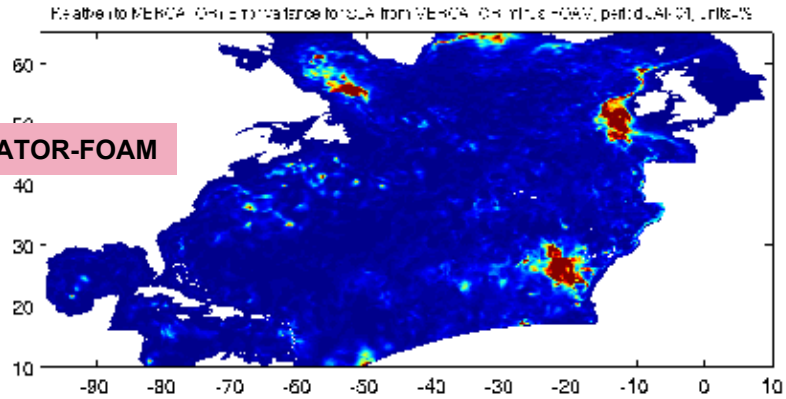
MERCATOR-TOPAZ



100%

Inverse Barometer

MERCATOR-FOAM



Argo Salinity profiles

Variance of the differences for Salinity, JAN04,
units=psu^2, 2000meters

MERCATOR-FOAM