

Salinity & Temperature Data assimilation

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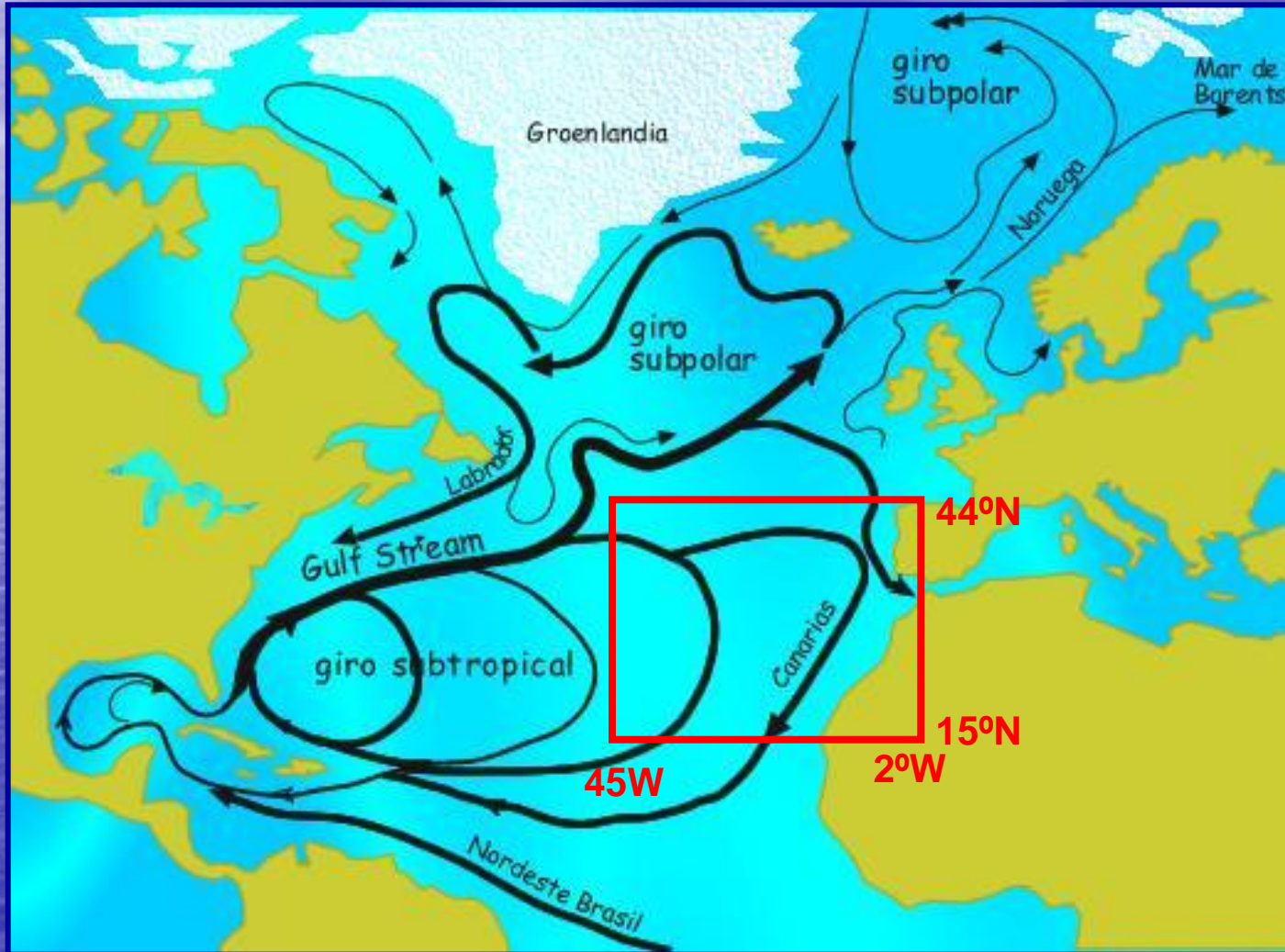
SUMMARY

- 1. Region of interest

- 2. NEMO-OPA
- 3. ARGO data
- 4. NUDGING, results ...

- 5. Perspectives...

1. Region of interest

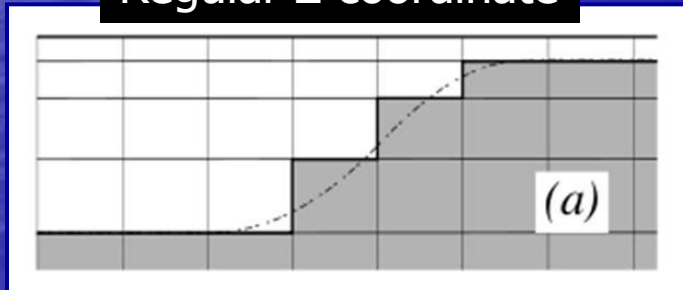


A region of validation for SMOS data ...

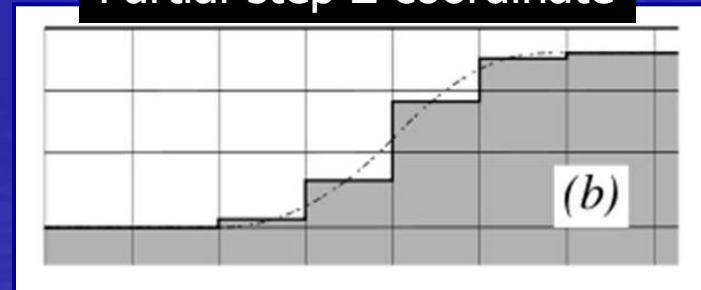
2. NEMO-OPA : model

- PE Model: NEMO-OPA
- $1/3^\circ$ horizontal resolution, 31 vertical levels.
 - Partial steps (better topography resolution)
 - Zero Eddy Induced Velocity (development of turbulence)
- Simulation period: 2000, Jan 1st – 2009, Dec 31.
- Spin up: 15 years simulation from Levitus, at rest, and climatological forcing (Dr. *Baptiste Moure*, *MIDAS-4 and 5*).
- Open boundary conditions, seasonal data (MERCATOR).
- Atmospheric forcing (NCEP-NCAR):
 - DAILY: Wind stress, 10m Wind speed, 2m Air temperature
 - MONTHLY: Precipitation rate, Cloud cover and Humidity

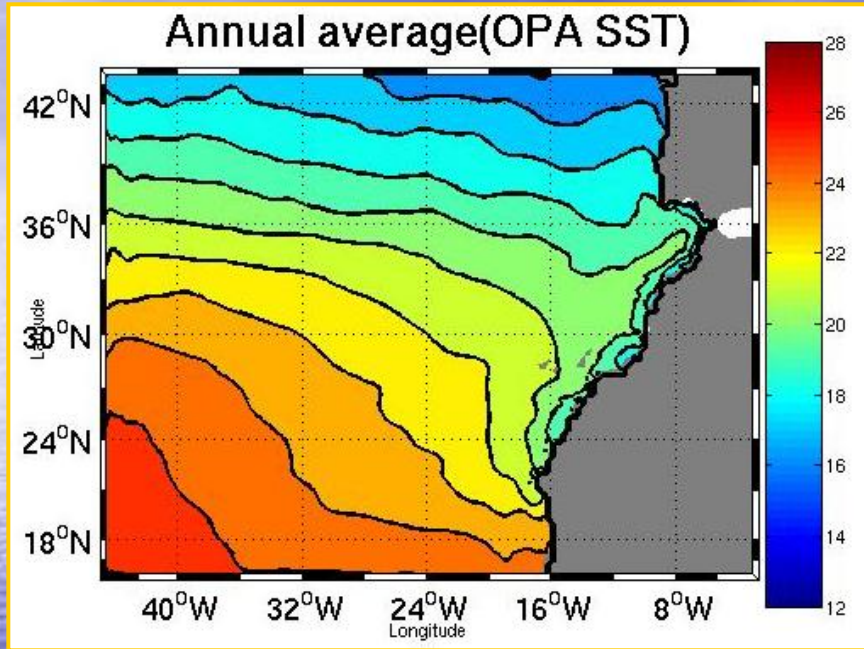
Regular Z coordinate



Partial-step Z coordinate



2. NEMO-OPA : Mean value (SST, SSS)



Temperature gradient SW-NE

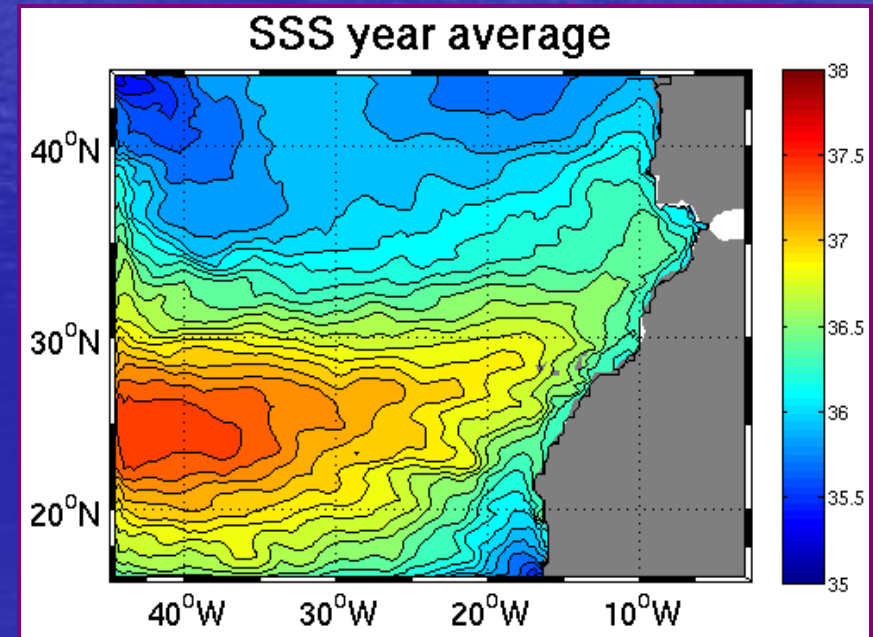
Max=26°C, Min=16°C

Upwelling off the coast

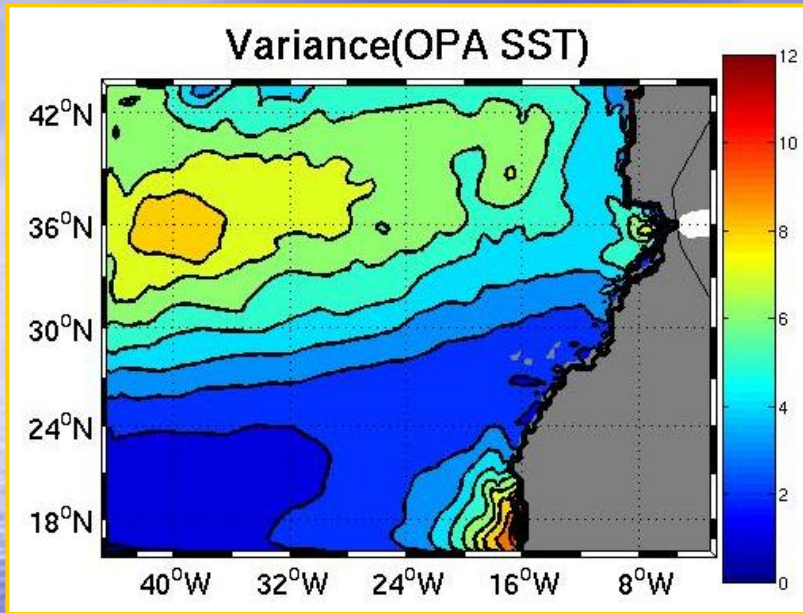
Tongue of salty water in SW

Max=37.5 ; Min=35

Strong meridional gradient



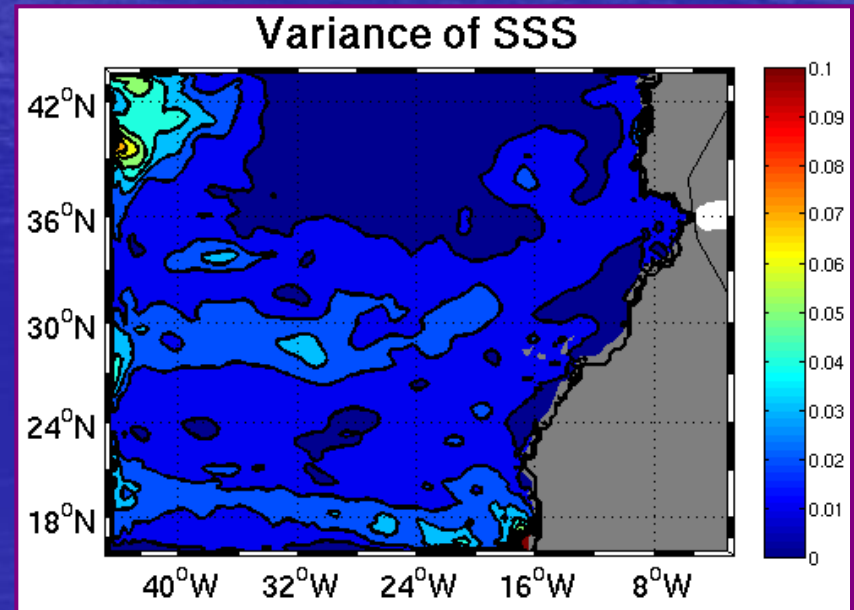
2. NEMO-OPA : Variability (variance) (1/2)



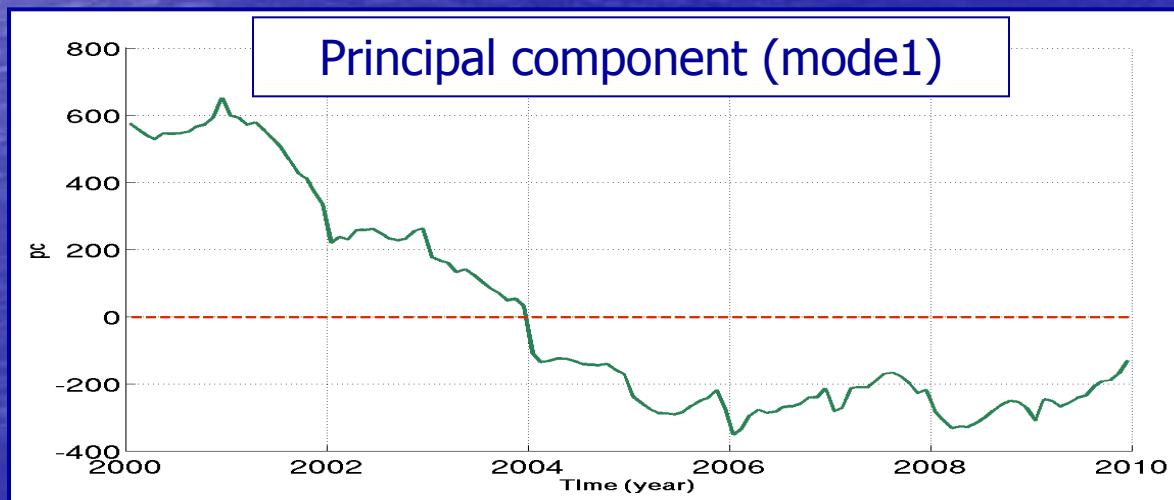
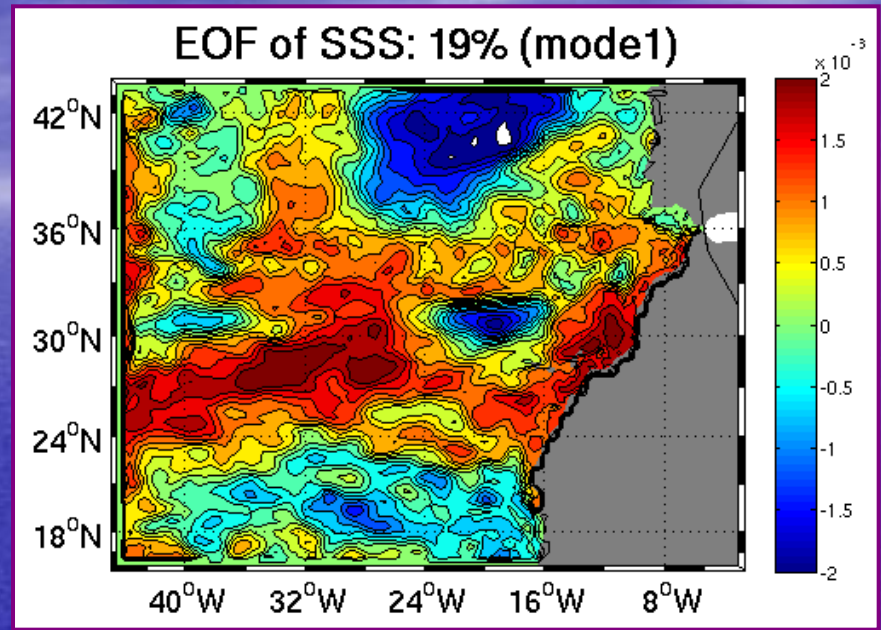
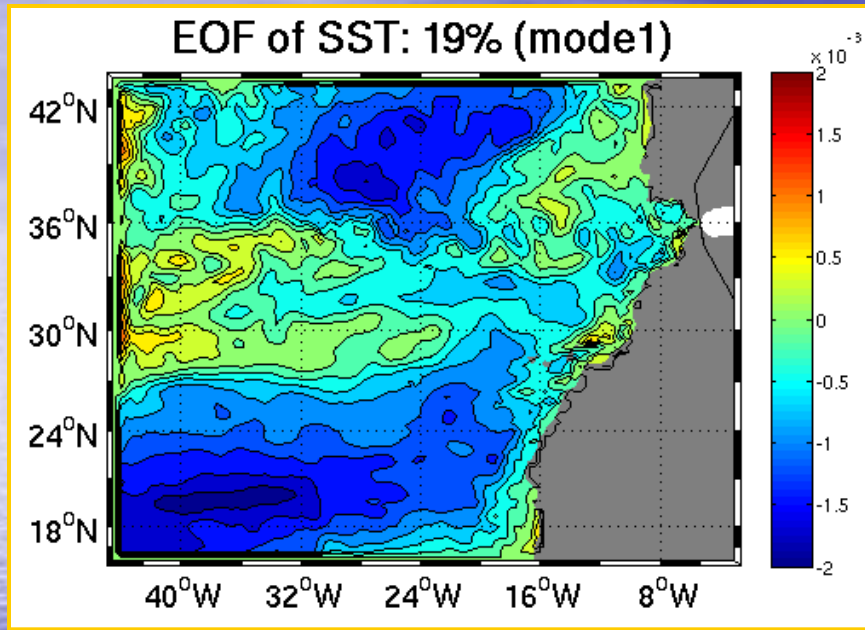
Region of low variability in the South

Region of higher variability in the North (seasonal cycle)

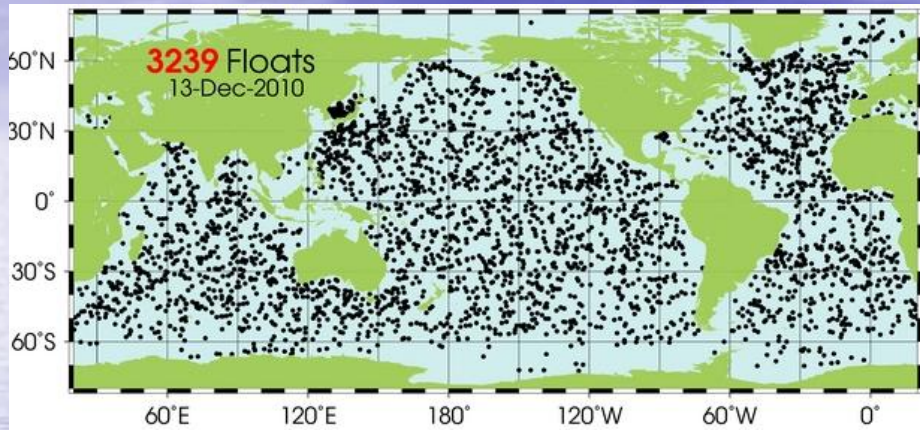
SSS variance < 0.01



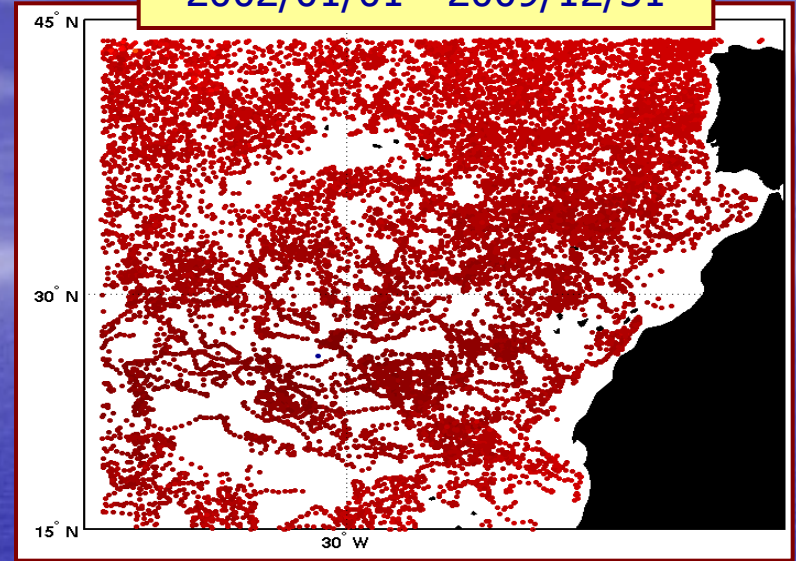
2. NEMO-OPA : Variability (SST,SSS EOFs) (2/2)



3. ARGO data



Cumulated ARGO floats
2002/01/01 - 2009/12/31



Coriolis database
24 047 ARGO profiles



Pre-process and selection

- 1- Not in the "Grey list" (a list of known wrong ARGO)
- 2- Good QC for T, S and P
- 3- Departure from Levitus < 5°C for T ; < 2psu for S

14 438 ARGO profiles

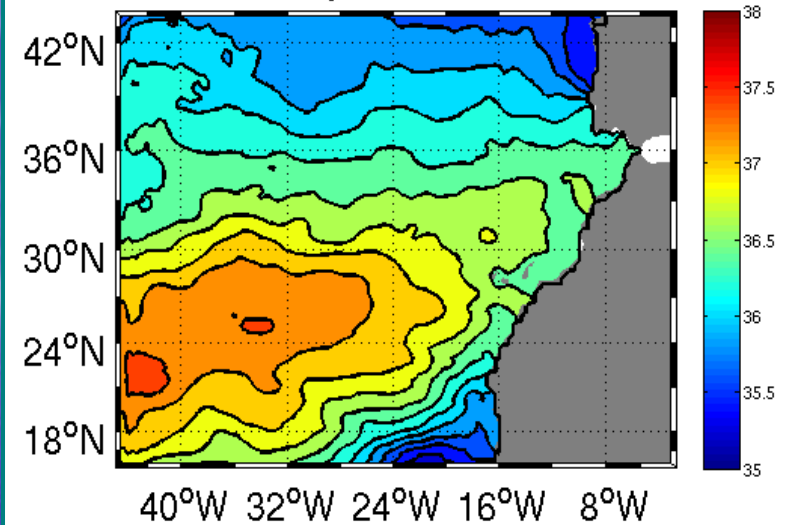
A large purple arrow pointing downwards, indicating the final selection of 14,438 ARGO profiles.

3. ARGO data: EOF fitting

3D-Interpolation onto NEMO grid by multivariate EOF fitting:

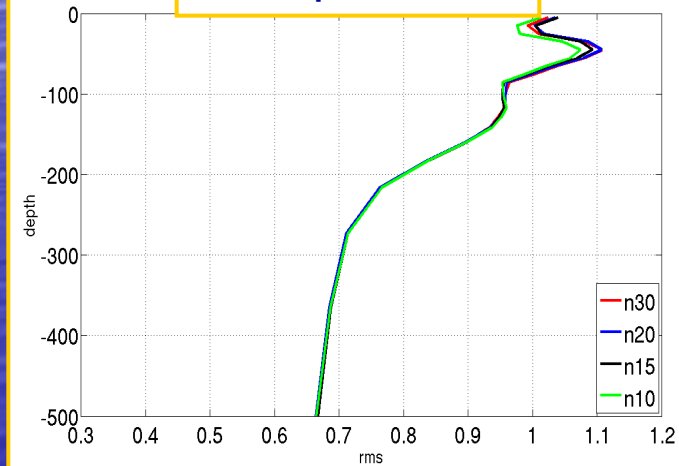
- 10 EOFs, which represent 61% of the total variability.
- Monthly field

SSS ARGO interpolated nEOF=10, Jan02

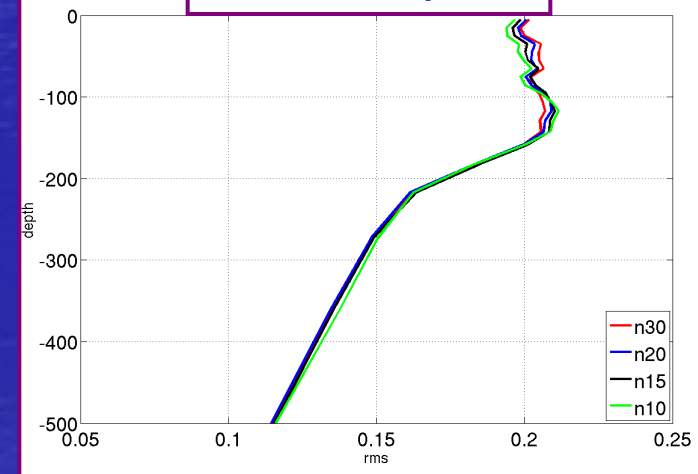


CROSS-VALIDATION: RMS (Argo original – Argo interpolated), as a function of depth and number of EOFs.

Temperature



Salinity



4. Nudging Method

$$\frac{dx}{dt} = \text{Physics} + \mu (x^0 - x)$$

Observations

Prognostic variable **T, S, U, V.**

Relaxation coefficient (s^{-1})

The diagram shows the equation $\frac{dx}{dt} = \text{Physics} + \mu (x^0 - x)$ in a light blue box. A red circle highlights $\frac{dx}{dt}$, with an arrow pointing to a yellow box labeled 'Prognostic variable **T, S, U, V.**'. A red circle highlights μ , with an arrow pointing to a purple box labeled 'Relaxation coefficient (s^{-1})'. A red circle highlights x^0 , with an arrow pointing to a red box labeled 'Observations'. A red circle highlights x , with an arrow pointing to the same red box labeled 'Observations'.

- Relaxation term is added into the equation of evolution of a **prognostic variable** (in our case, T and S).
- The nudging term tends to reduce exponentially the distance of the model towards the observations.

4. Nudging: coefficient

- Reynolds SST data

Adjusted manually

$$\mu = 10^{-5} \text{ s}^{-1} (\approx 1 \text{ day}^{-1})$$

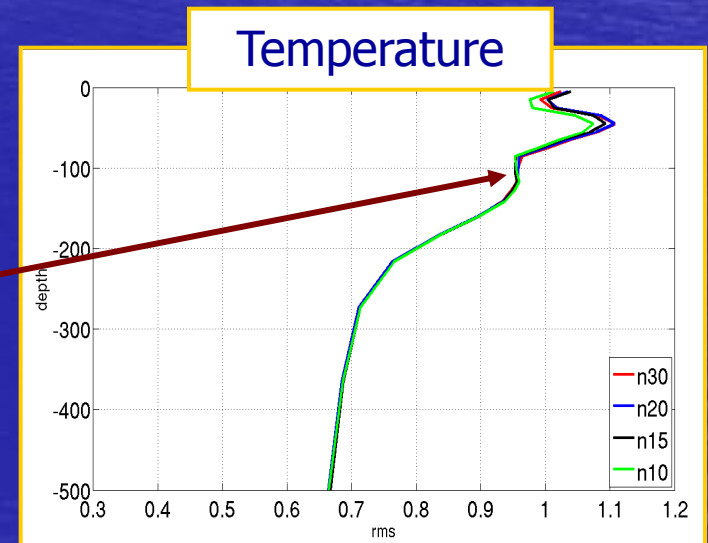
- 3D fields of T and S (ARGO data)

we use the relationship relating the nudging coefficient with the expected error of the observation:

$$\mu(z) = \frac{1}{\Delta t} * \frac{C^2}{C^2 + \text{rms}(z)^2} \text{ s}^{-1}$$

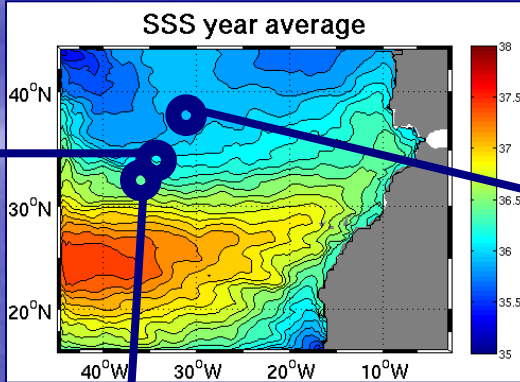
$$C^2 = 6.42478 \times 10^{-4} \text{ when } \mu = 10^{-6} \text{ s}^{-1} (\approx 10 \text{ days}^{-1})$$

Ref: J. BALLABRERA (PhD thesis, 1998)

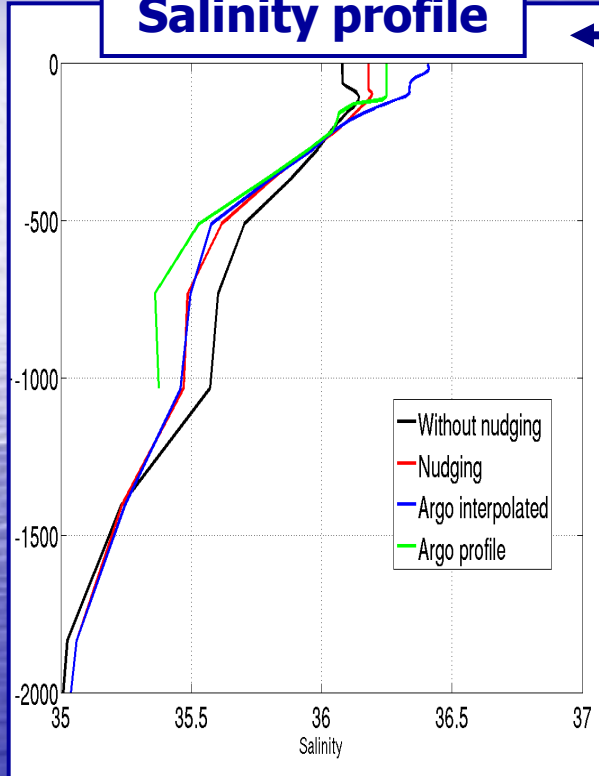


4. Nudging $SST(x,y) + T(x,y,z) + S(x,y,z)$

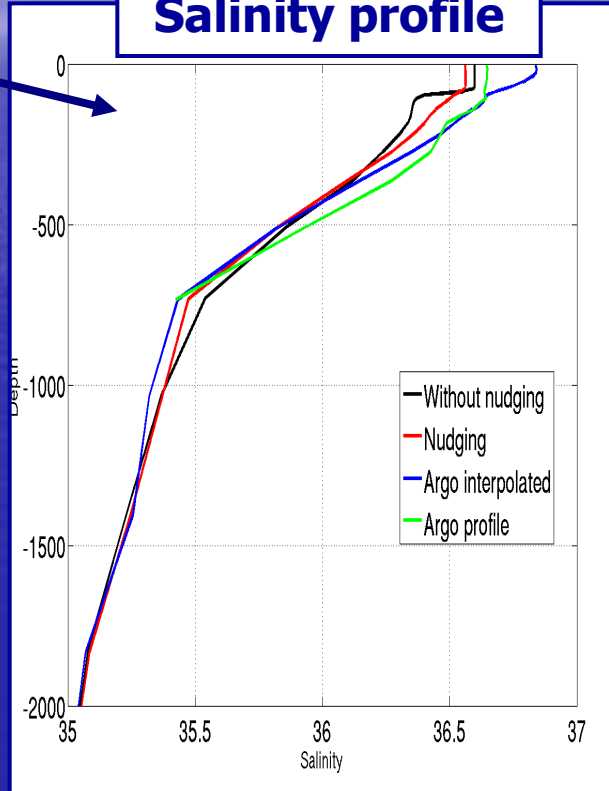
28 of January 2002



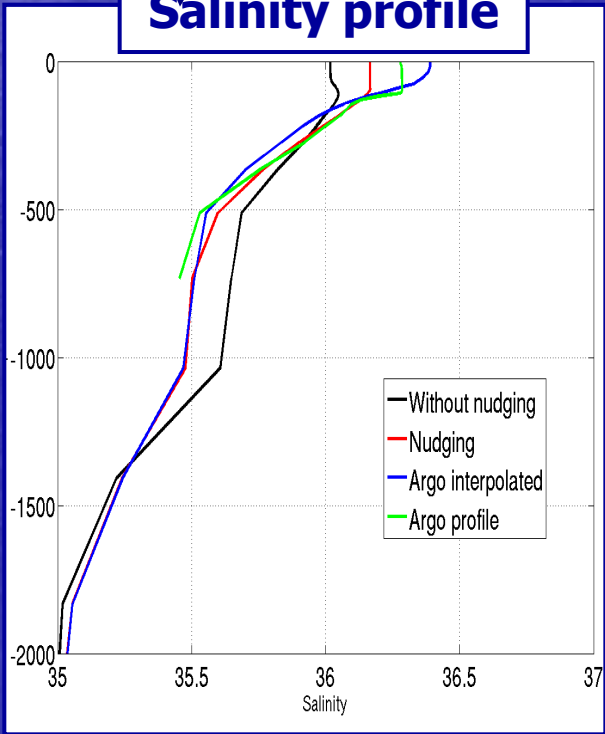
Salinity profile



Salinity profile

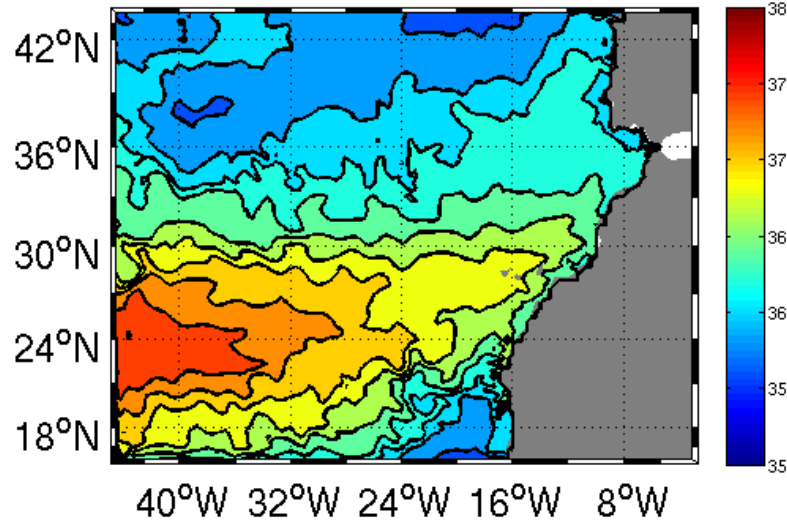


Salinity profile

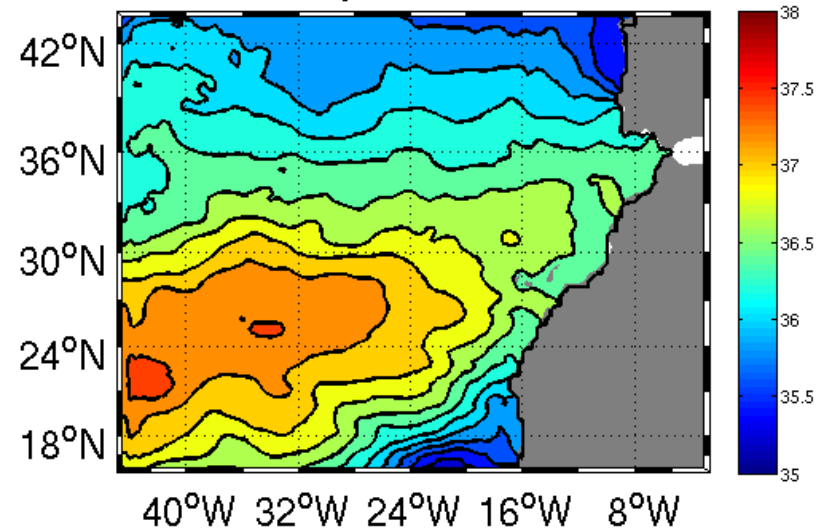


28 of January 2002

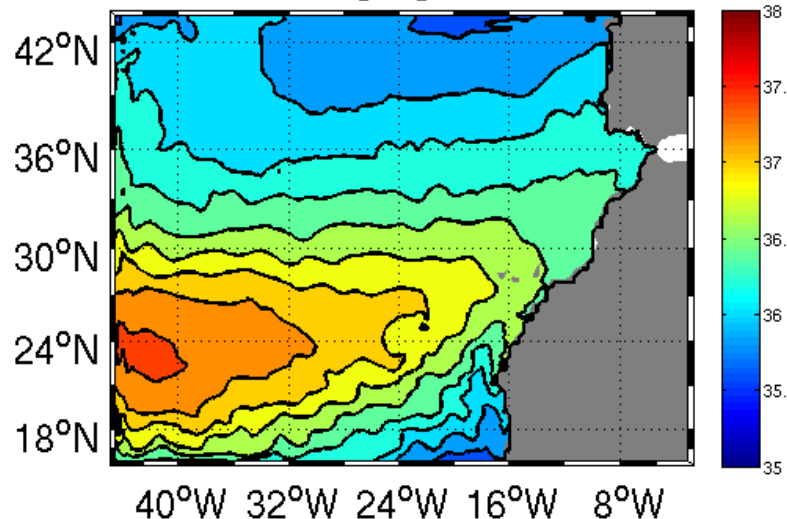
SSS model, 28 Jan02



SSS ARGO interpolated nEOF=10, Jan02



SSS Nudging, 28 Jan02



- Reduction of fresh water extension at 36°N.
- Weaker salty tongue.
- Inside the domain, variability comes from observations.
- At boundaries, variability comes from model (open boundary data).

Nudging validated

5. Perspectives ...

- Investigate added value of assimilation of SSS from:
 - ARGO data (new product from OA)
 - SMOS data
- Use other methods of data assimilation, as the Ensemble Kalman Filter (EnKF)

The background is a smooth blue gradient. On the left side, there is a bright, glowing area that resembles a sun reflecting on water, with a white-to-yellow glow that fades into the blue. The overall effect is serene and clean.

Thank you !!!