Observation of near surface ocean variability: data synthesis and analysis

F. Gaillard, K. Von Schuckmann

Laboratoire de Physique des Océan

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L. Petit de la Villéon, SISMER, IFREMER

Context and Objectives

- The ocean is part of the climate system, and for that reason T and S need to be monitored in order to detect, describe and quantify the variability.
- Global systems are already operating
  - For surface properties: SST and in a near future SSS (SMOS and Aquarius)
  - For in-situ: ARGO for 0-2000m, GOSUD for near surface
- ISAS (In Situ Analysis System) has been developped by the ARIVO project to produce a synthesis of the temperature and salinity data made available by Coriolis. The fields are used to analyze ***global variability from intraseasonal to interannual time scales***.

We present here

- Results of an analysis based on ARGO (and more), focussing on near surface layers
- Preliminary results on the use of TSG data and our plan for their systematic use

Mesure de la salinité de surface depuis l'espace

Après la température et l'élévation de la surface, c'est à la salinité que vont s'attaquer les satellite. L'ESA annonce le lancement de son satellite SMOS début 2009. La NASA a un projet équivalent pour 2010-2011. Ces mesures devront être calibrées sur des mesures in situ de référence.

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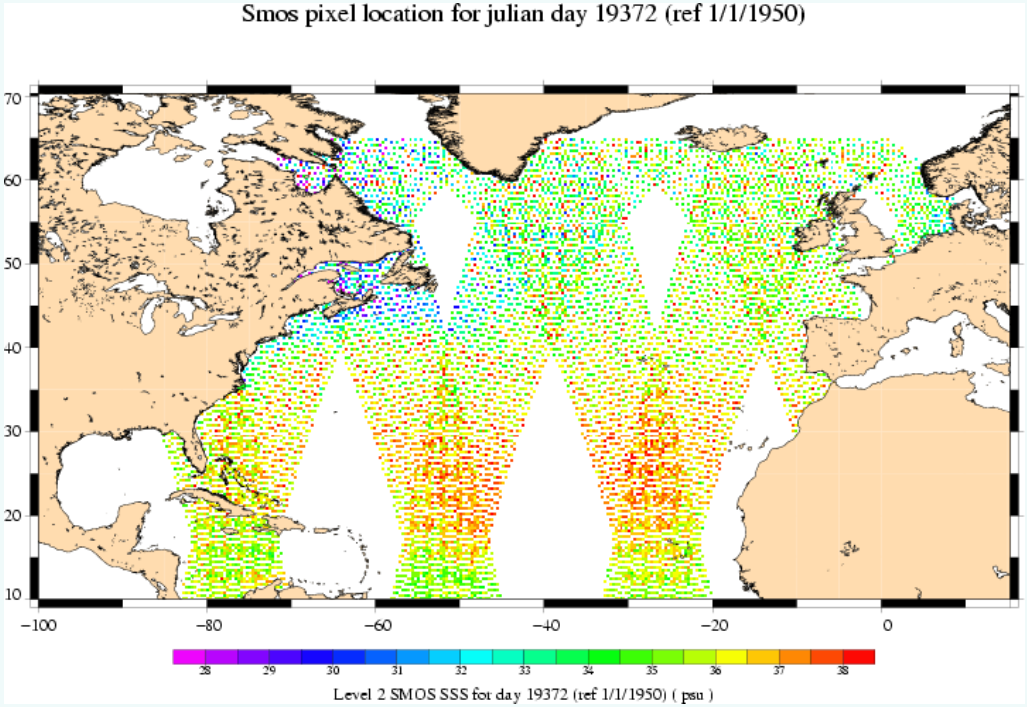


Analysis system: Method

Objective analysis
(Optimal Interpolation)

- yo: data vector (observations)
- xa: state vector (T or S at grid points)
- Pa: covariance matrix of analyzed field
- R: data error covariance matrix
- Co and Cao: covariance matrices of obs-obs and analyzed-obs
- Xf: first guess for x at analyzed points
- Yf: first guess at data point

$$d = y^o - y^f$$

$$x^a = x^f + C_{ao}\left(C_o + R\right)^{-1} d$$

$$P^a = P^f - C_{ao}\left(C_o + R\right)^{-1} C_{ao}^T$$

$$y^o - y^{ao} = R\left(C_o + R\right)^{-1} d$$

Equivalent observation/mapping matrix:

$$H^T = P^{f\,-1} C_{ao}$$

Analysis system: history

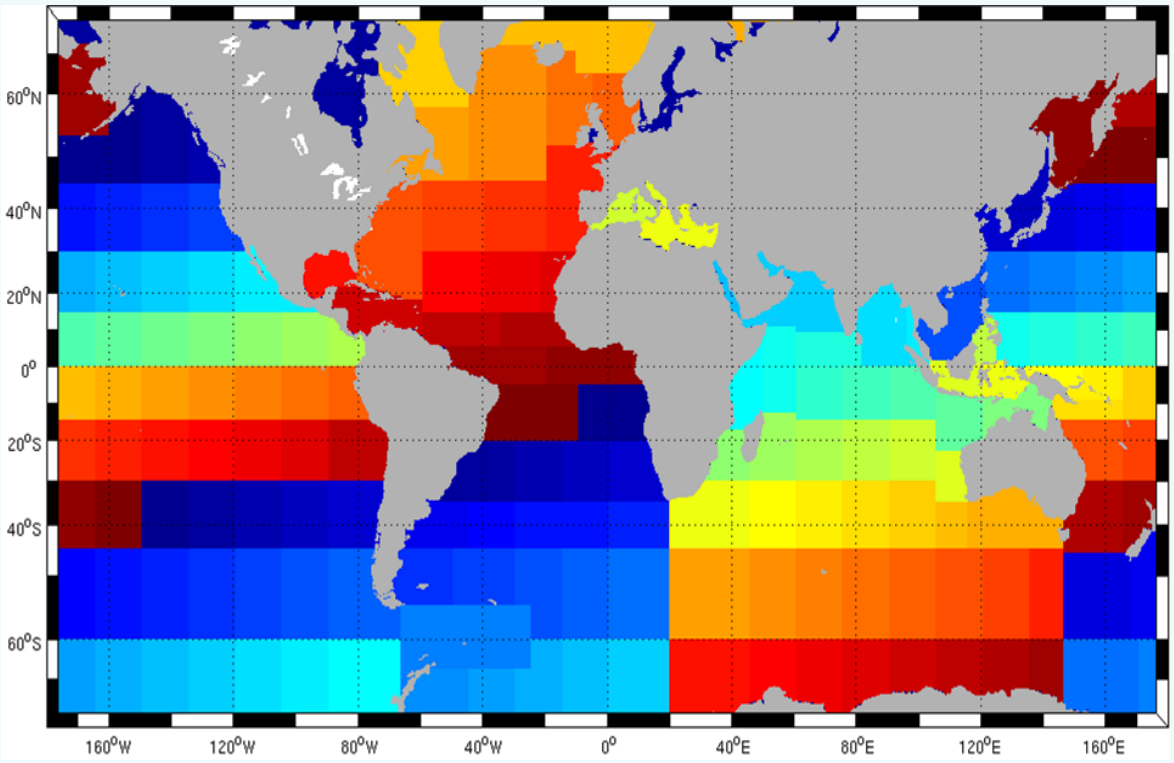
Year/Version Name	Domain/levels	Mode
V1: 1999-2001 V2: 2002-2003	POMME North Atlantic	Operational (LPO) Operational (Coriolis)
V3.1: 2003-2005 V3.3 -3.6: 2005-2008	Atlantic Global	Operational (Coriolis),
V4.1: 2008	Global	Research: data validation, Climatology, Interannual variability

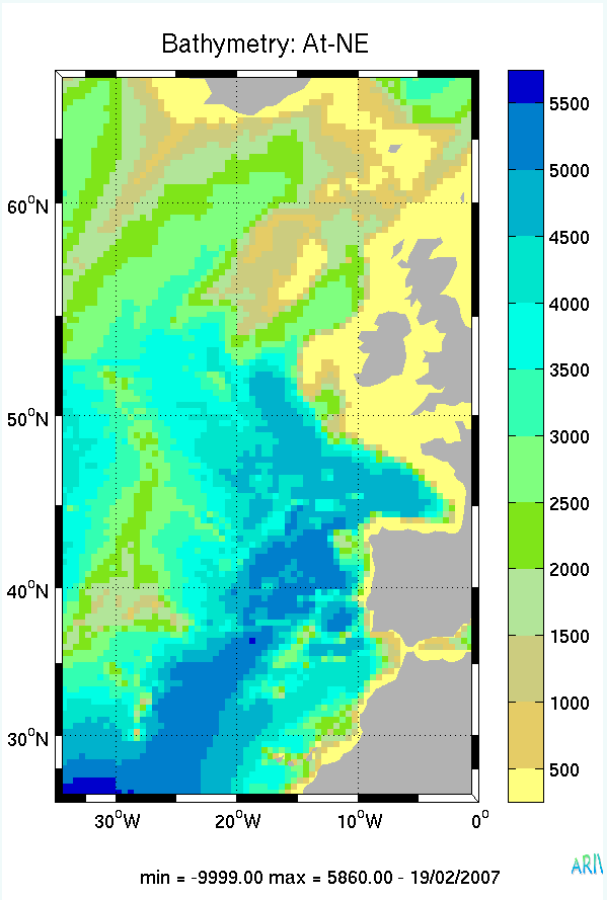
ISAS-V4: organisation

STD	Climatology and spike check Interpolate on standard levels Super-obs (averaging high frequency data)	matlab
PreOA	Gather data for each area Prepare NetCDF files (data and field)	matlab
OA	Analyse anomaly relative to reference in each area Save residuals	F95 Caparmor
PostOA	Gather areas and compute total field (reference + anomaly) to produce final files	matlab

In Situ Analysis System : ISAS-V4

- 151 std-level: [[0 3] [5:5:100] [110:10:800] [820:20:2000]]
- 1/2° Mercator limits:



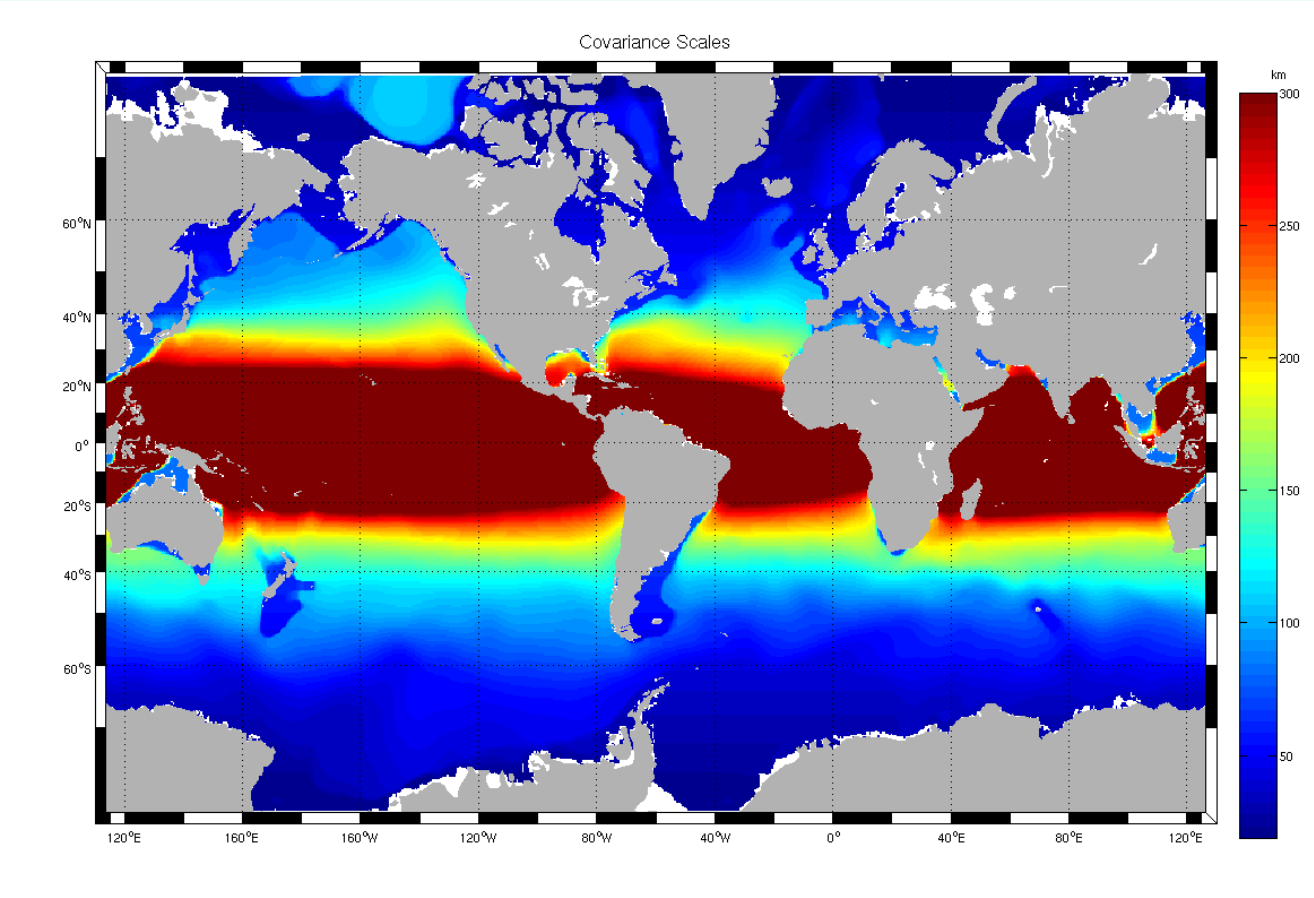


Covariances scales

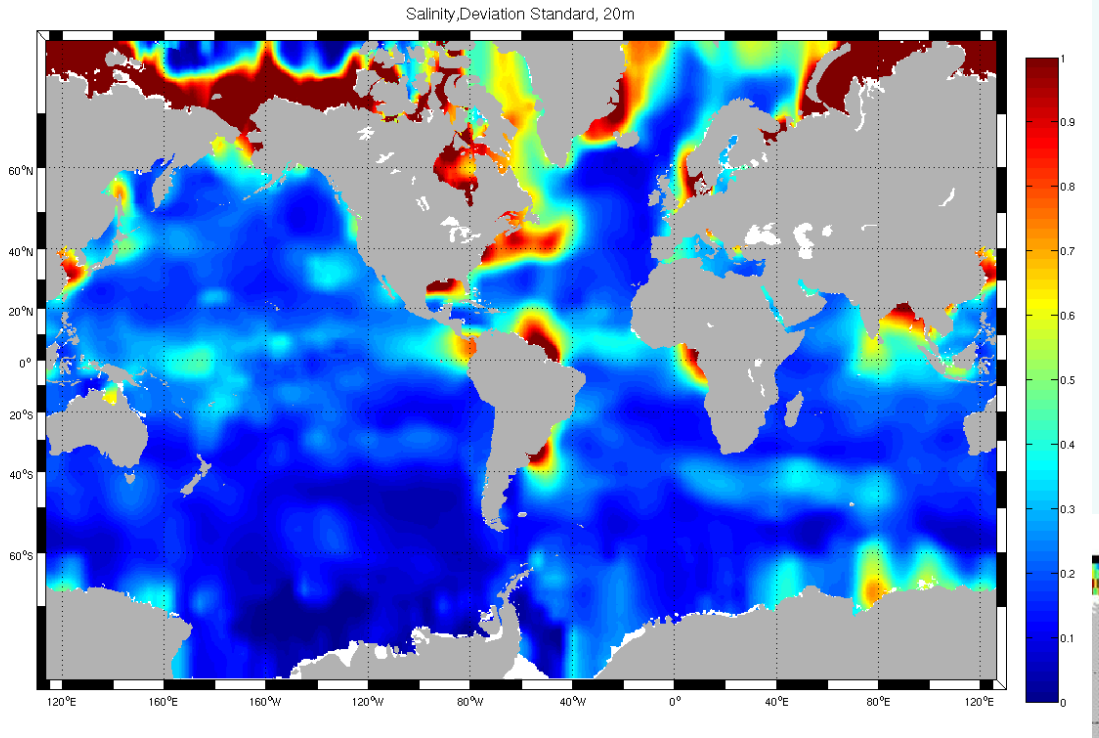
$$C_o = C_o(dx_o, dy_o, dt_o) = \sum_i \sigma_i^2 \, e^{-\left[\frac{dx_o^2}{2L_x{}_i^2} + \frac{dy_o^2}{2L_y{}_i^2} + \frac{dt_o^2}{2L_t{}_i^2}\right]},$$

i = 1; Lx=Ly=300km; Lt = 21 days

i = 2; Lx=Ly=2*resol<4*Rossby radius)<300km; Lt = 21 days



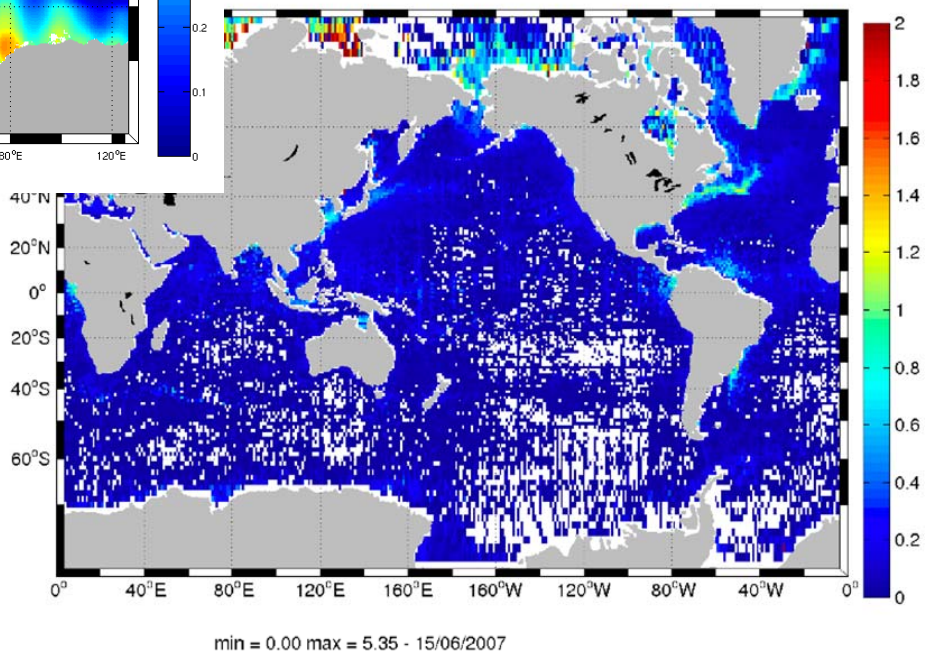
A priori variance



signal noise

$Var_{tot} = var_{LS} + var_{ms} + var_{ur} + var_{me}$

WOA - Variance



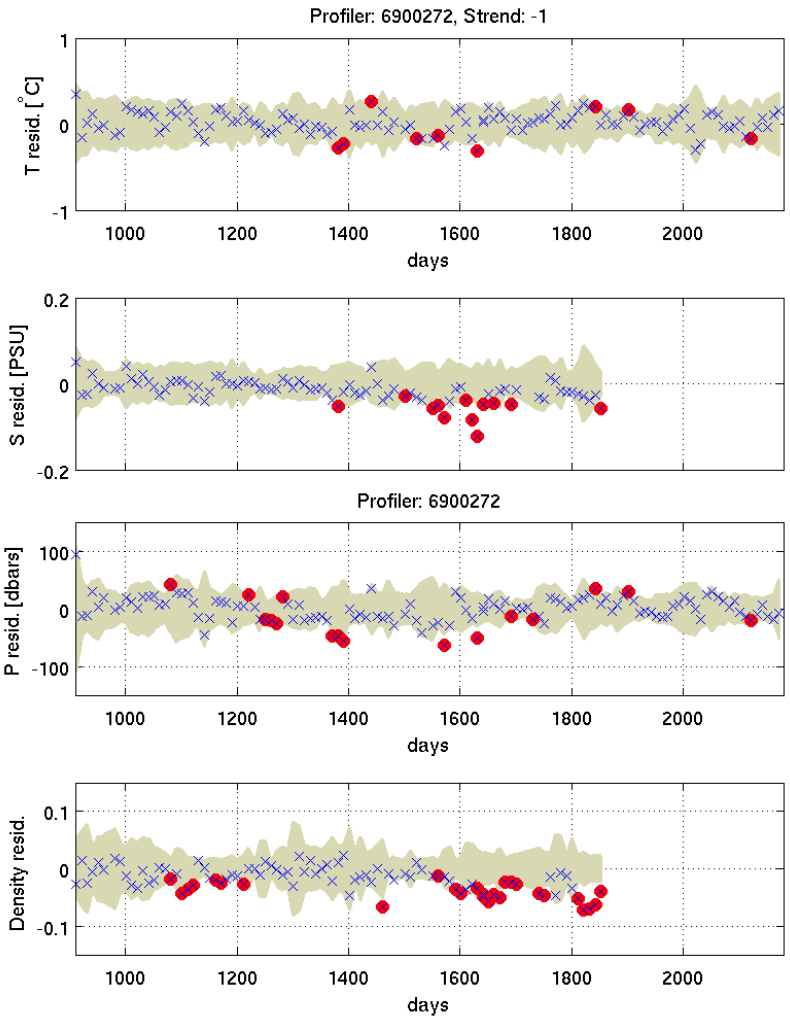
- $Var_{tot:\ deduced}$ from 2002-2006 database $(S_{obs} - S_{clim\text{-}month})$
- Var_{me}: from instrument type
- Ratio var_{ms}/var_{ls} and var_{ur}/var_{ls} specified

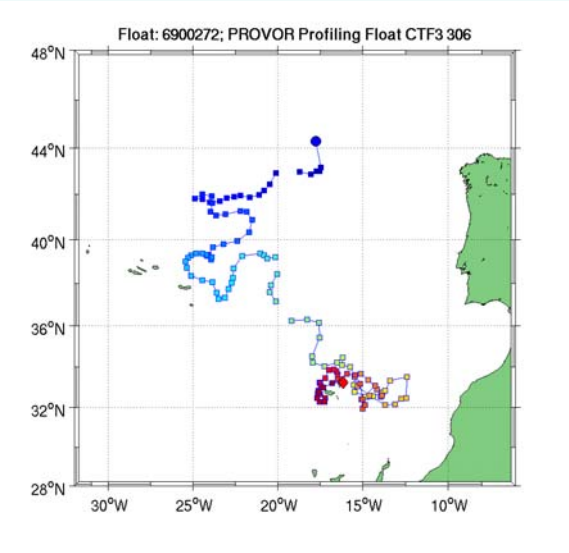
Data validation

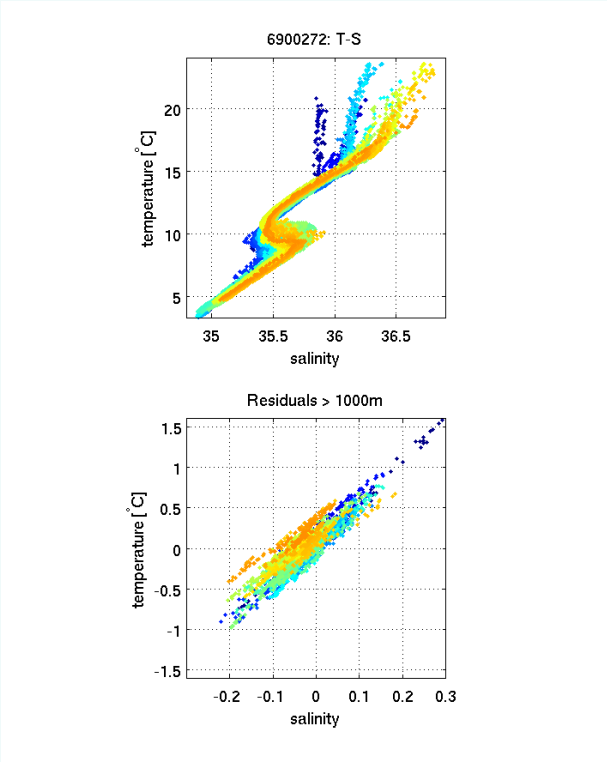
- Analysis of residuals:
  - $y_o - y_a = R\,(C_o + R)^{-1} d$
- Applied to ARGO floats:

Data validation

- Detecting Salinity drift

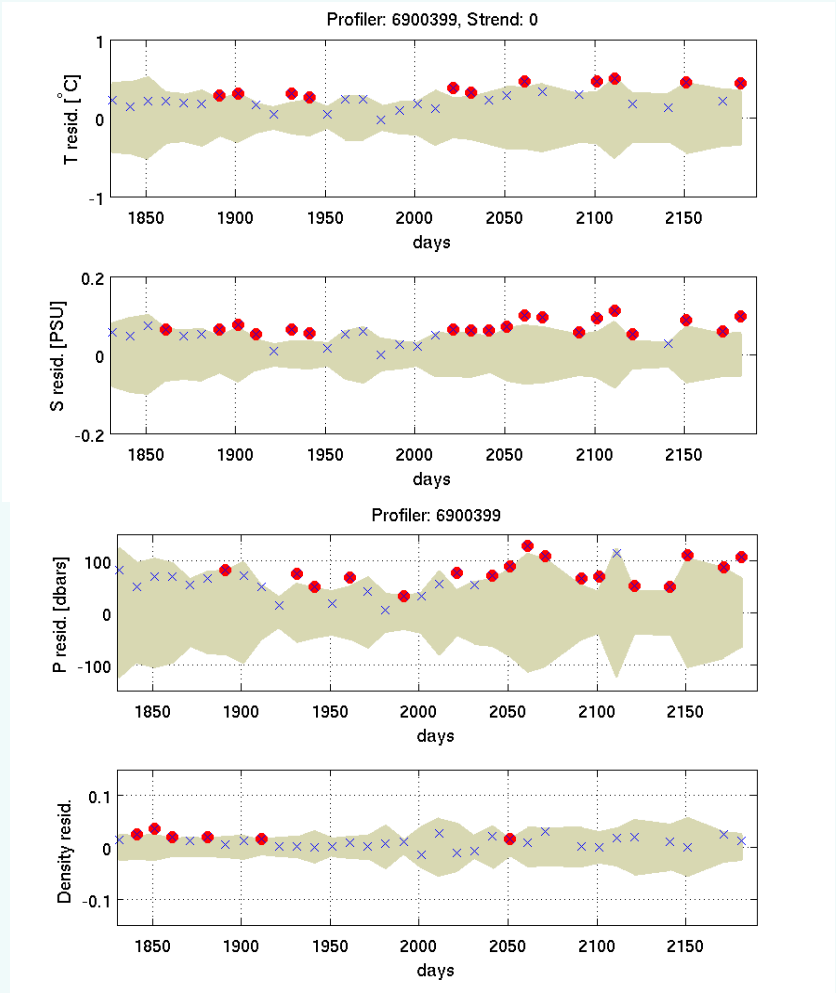


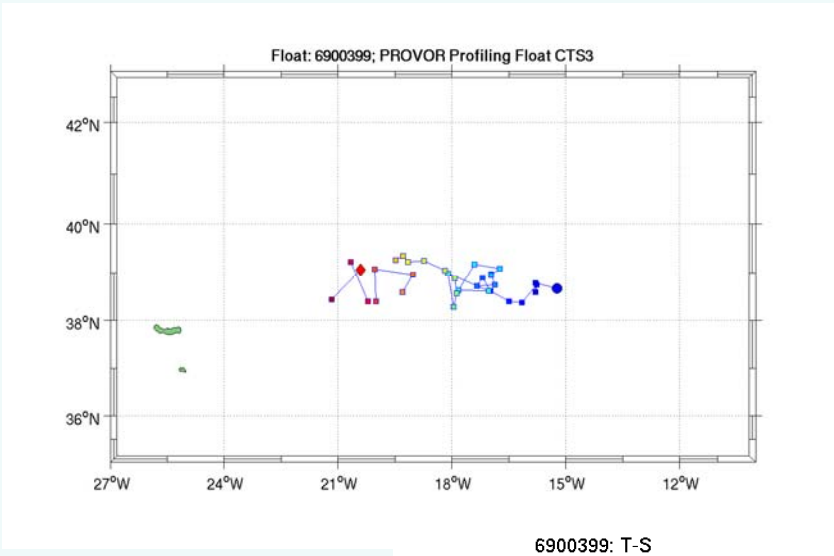


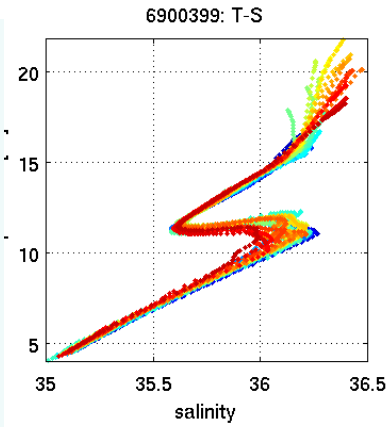


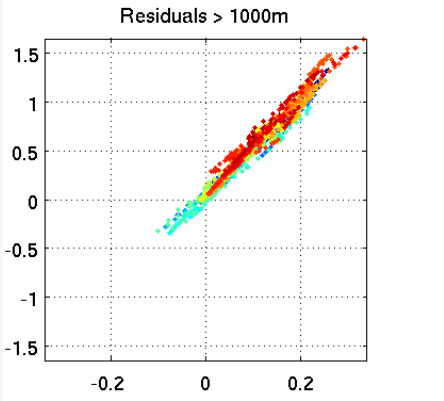
Data validation

- Meddy



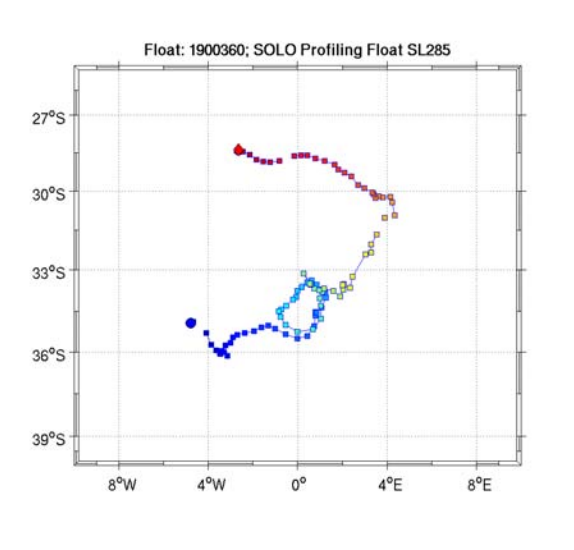


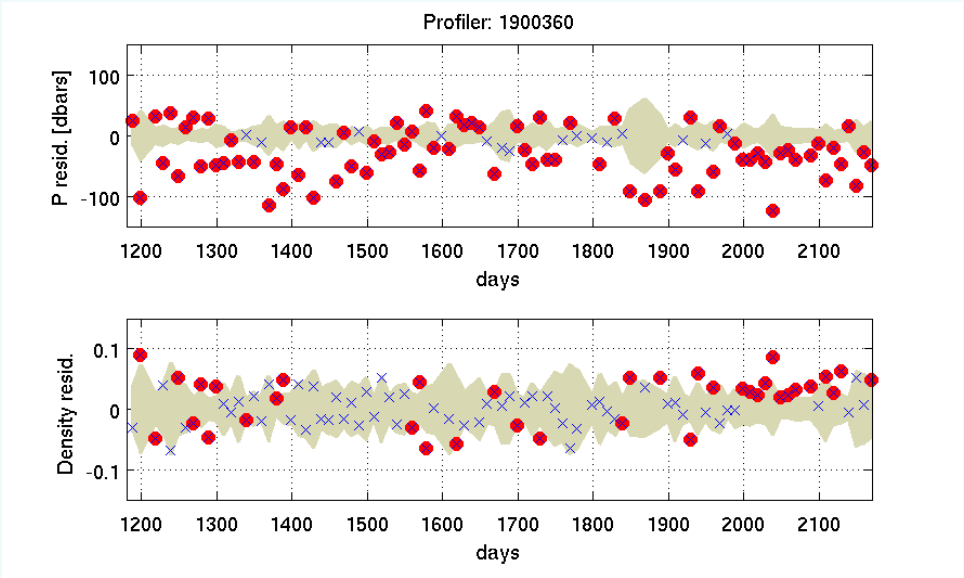


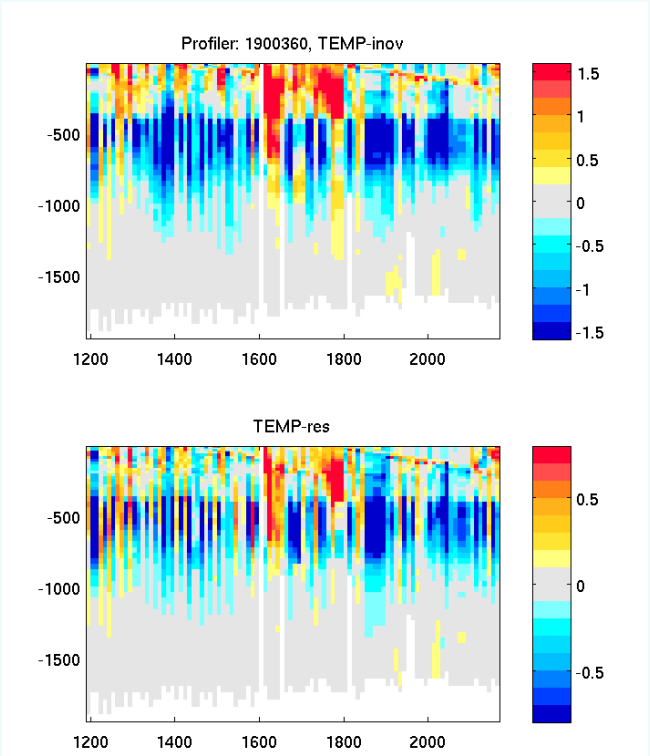


Data validation

- Pressure sensor problem

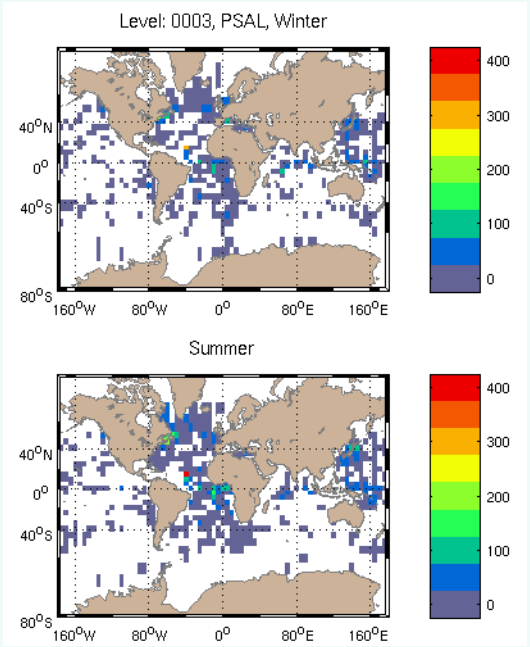


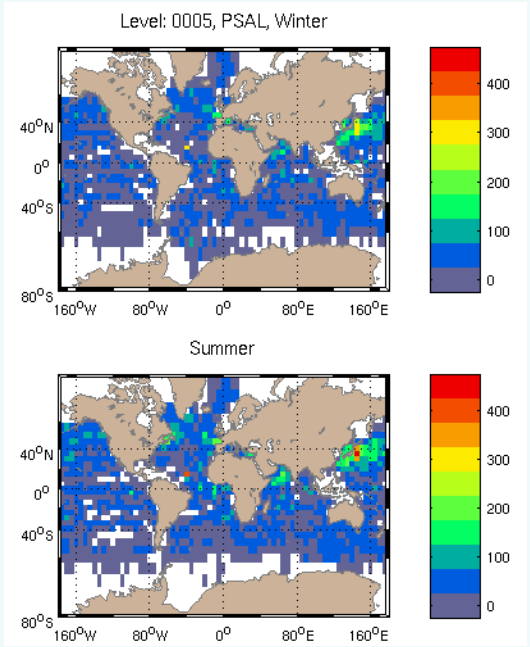


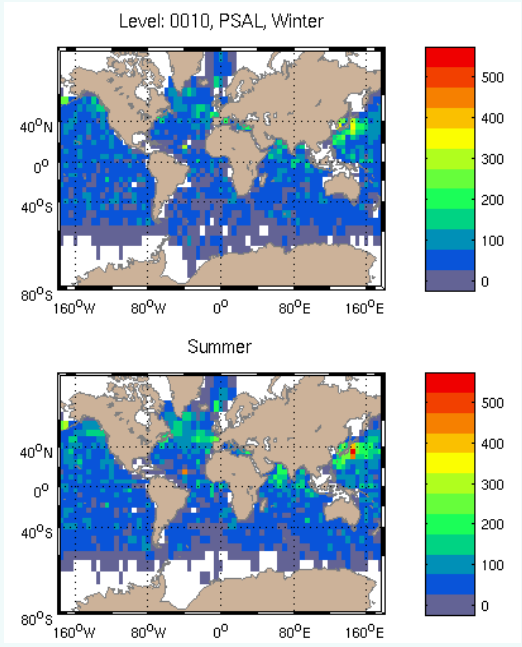


ARRAGL04: Re-analysis 2002-2007

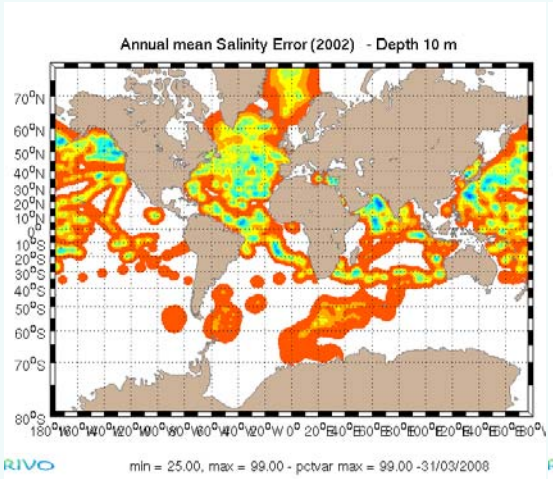
- Data count (no TSG) :
- Number of data in 5° squares by season over the period 2003-2007
  - Very few data at 3 m
  - Maximum at 10 m
  - Introducing TSG should improve significantly 3 and 5 m coverage

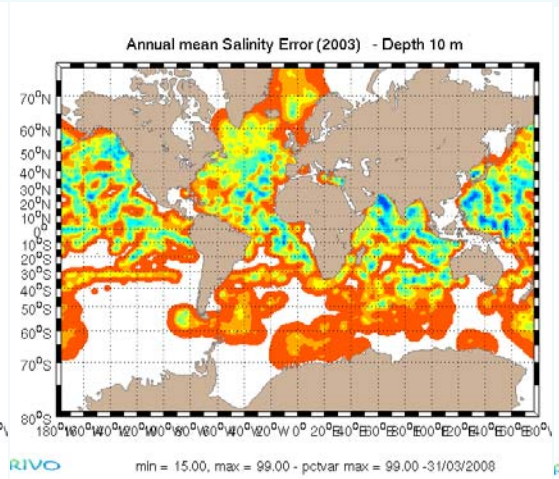


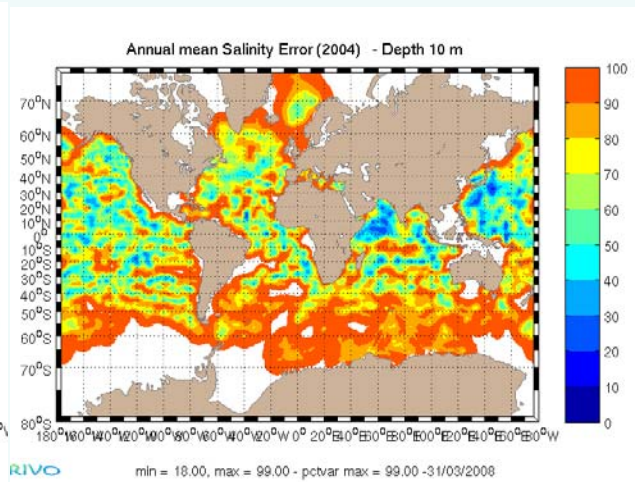


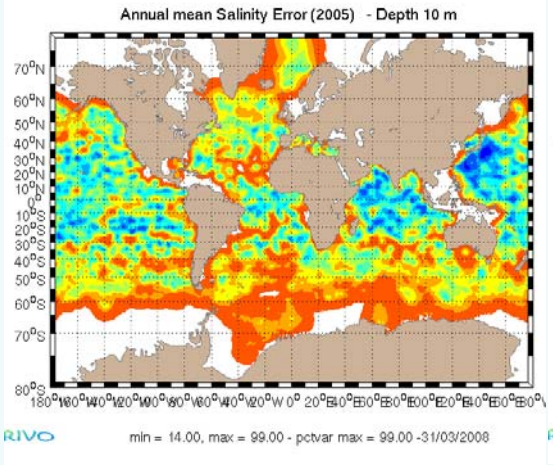


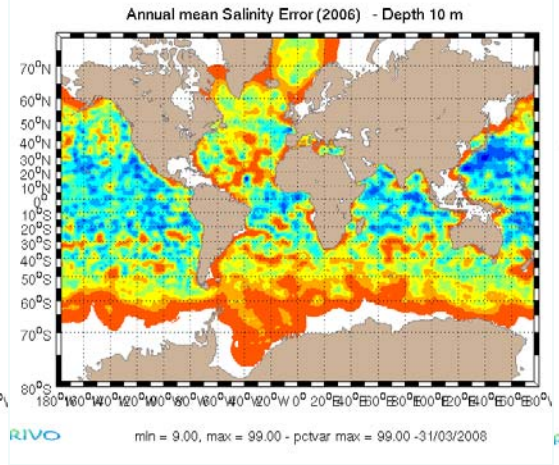
Error map at 10 m

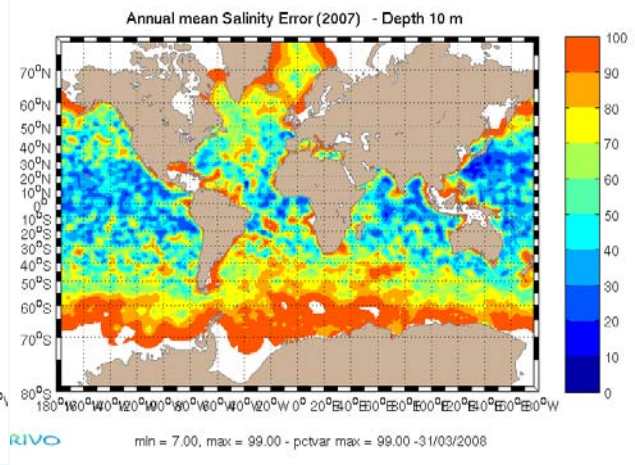




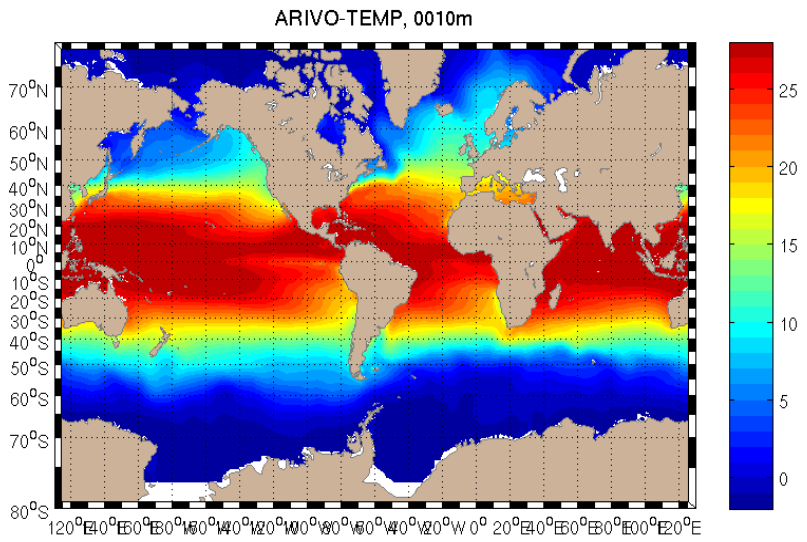


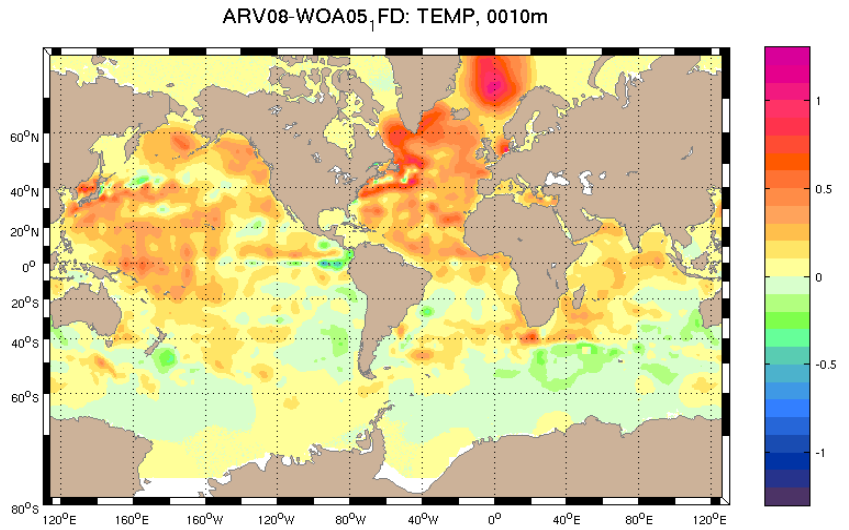


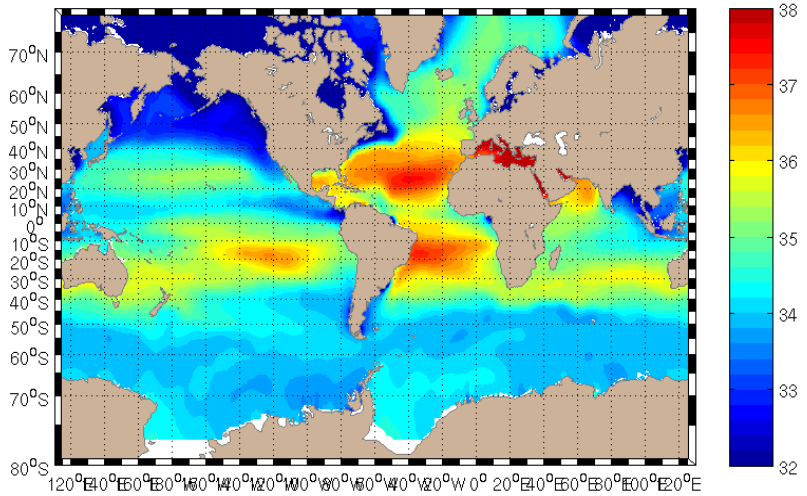


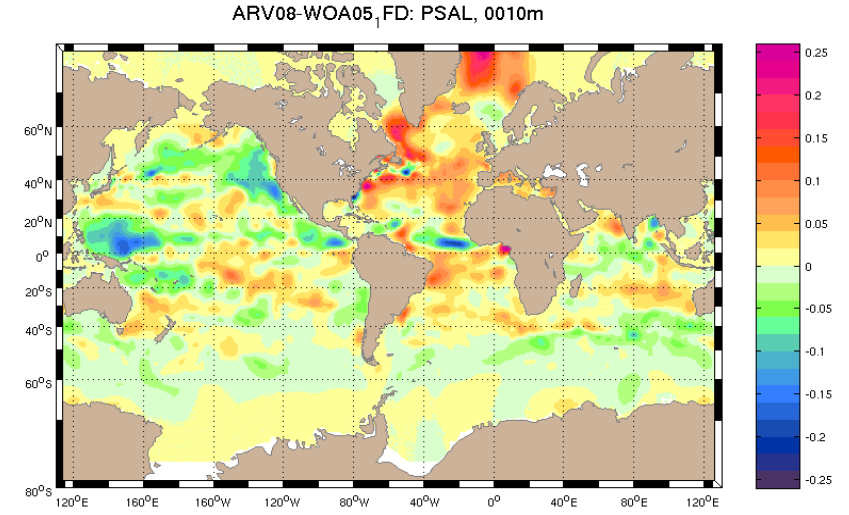


Mean 2002-2007/WOA05:

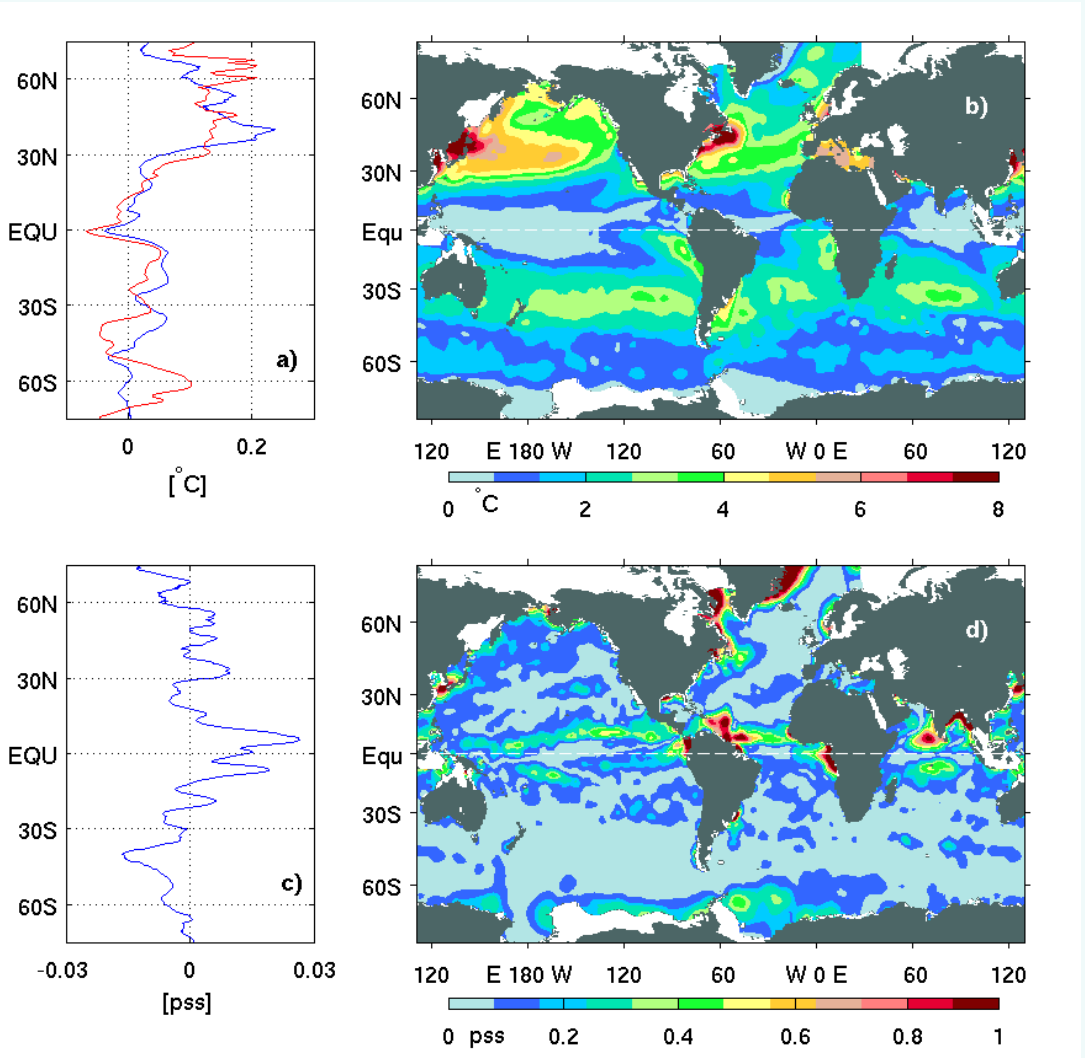








Amplitude of annual cycle☐

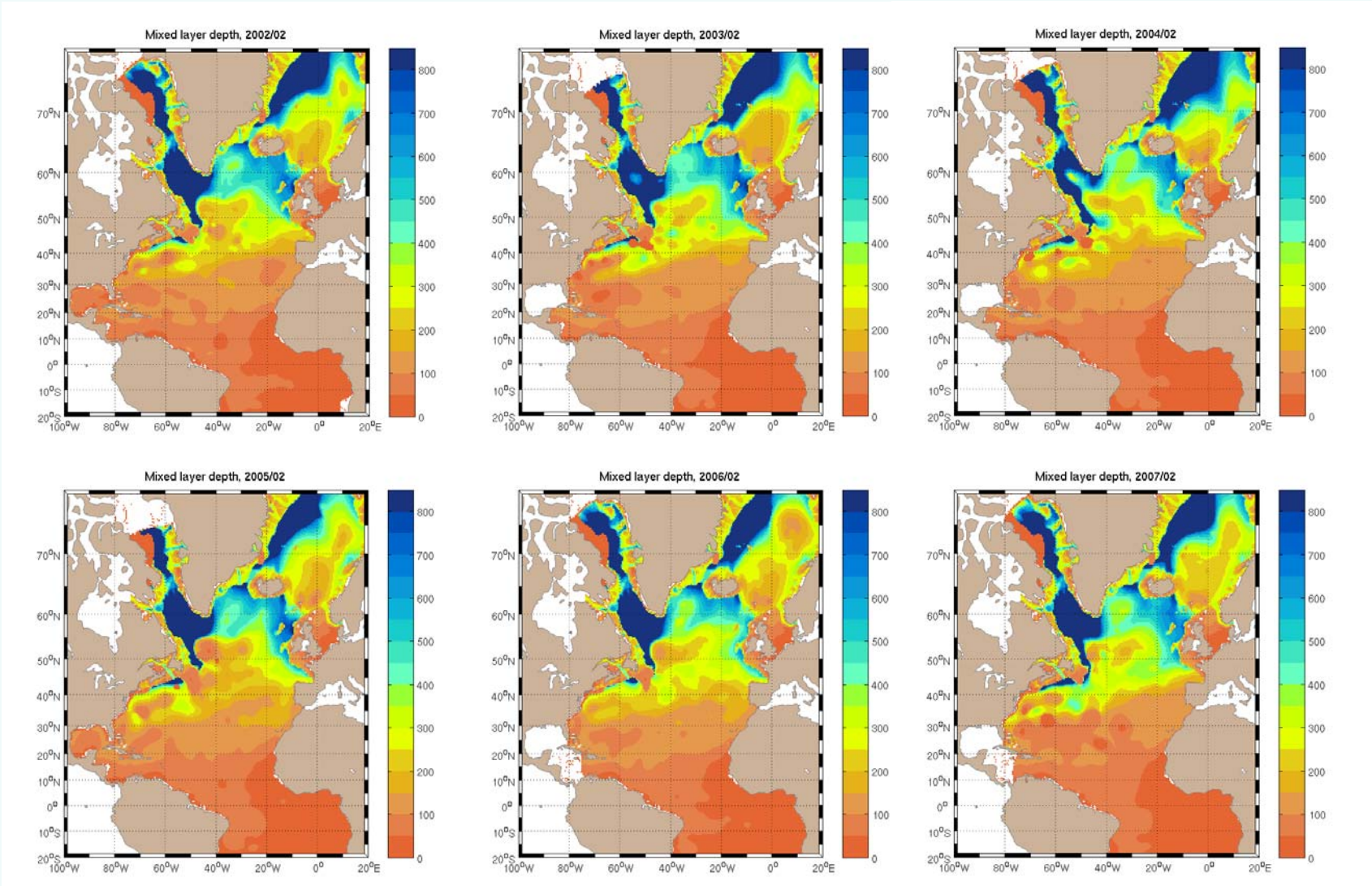


(K. Von Schuckmann, LPO)

The first annual harmonic, reprensenting the seasonal cycle has been extracted from the monthly series (left panel). The amplitude of the temperature annual cycle is stronger on the western side of the basins of the northern hemisphere. It is minimum along the equator. The salinity cycle is totally different. It is stronger in the tropical band and in the vicinity of large rivers outflows. It is also intensified in the areas influenced by ice formation. The imprints of the strong current system (mainly on the western boundaries) is also detected.

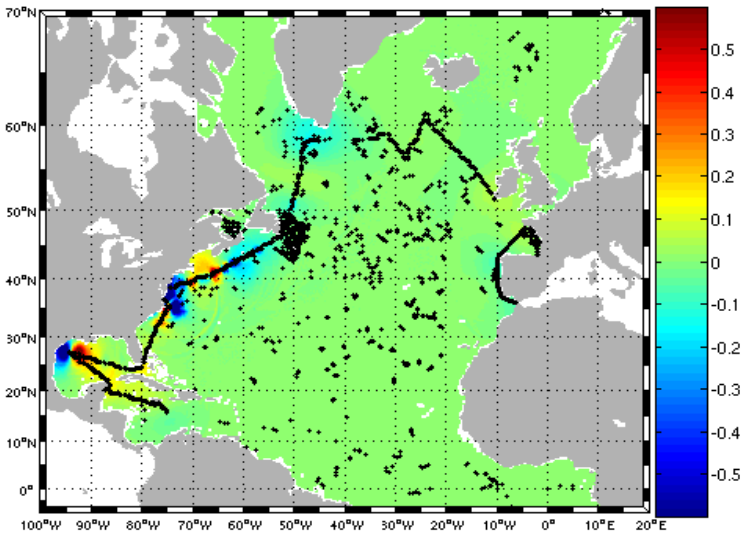
The zonal average of the seasonal cycle amplitude change, relative to the reference WOA-05 cycle is shown on the left panel for both parameters (blue curves). The change in cycle amplitude is compared to a similar quantity derived from satellite temperature data (red curve). The reference period for the satellite data being different, the curves cannot be compared exactly, but the agreement is convincing. The amplitude of the temperature seasonal cycle has increased by nearly 0.2°C in the north hemisphere. Changes in the salinity cycle are strongest in the tropical band.

Interannual variability: Mixed layer depth in february

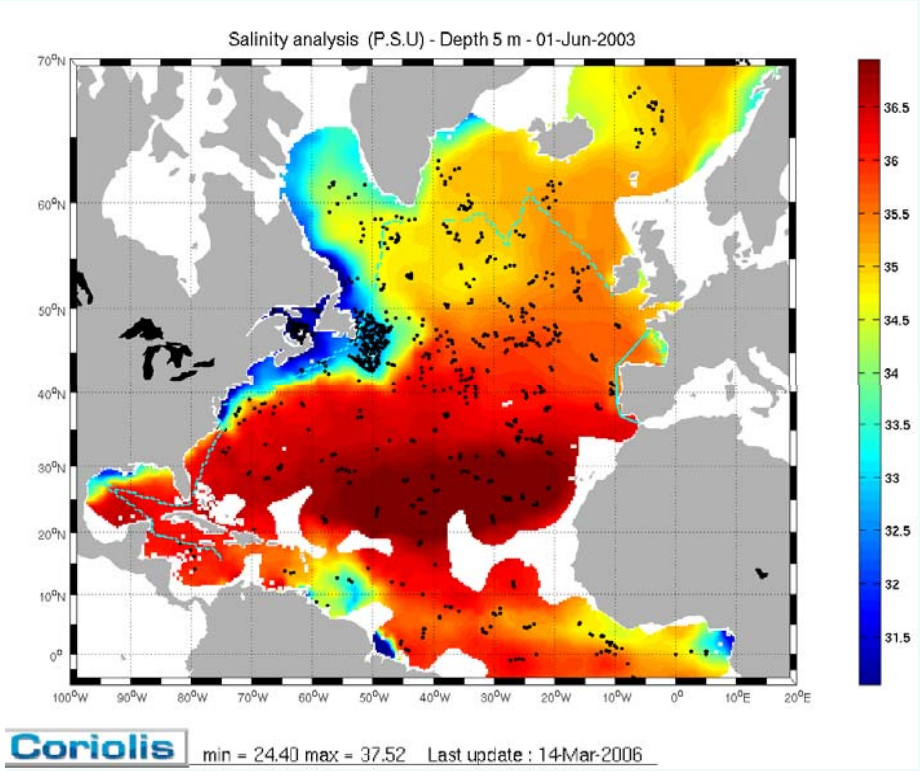


Introducing TSG data in ISAS-V3 (D. Mathias, 2006)

- Configuration: -version 3.02
  - L_T: 20 day
  - W_{LS}=1 ; W_{MS} = 2 ; W_{US}=3
  - Analysis level: 5 m
  - Data averaged over 5 km square and 24 h



Modification introduced by the TSG data

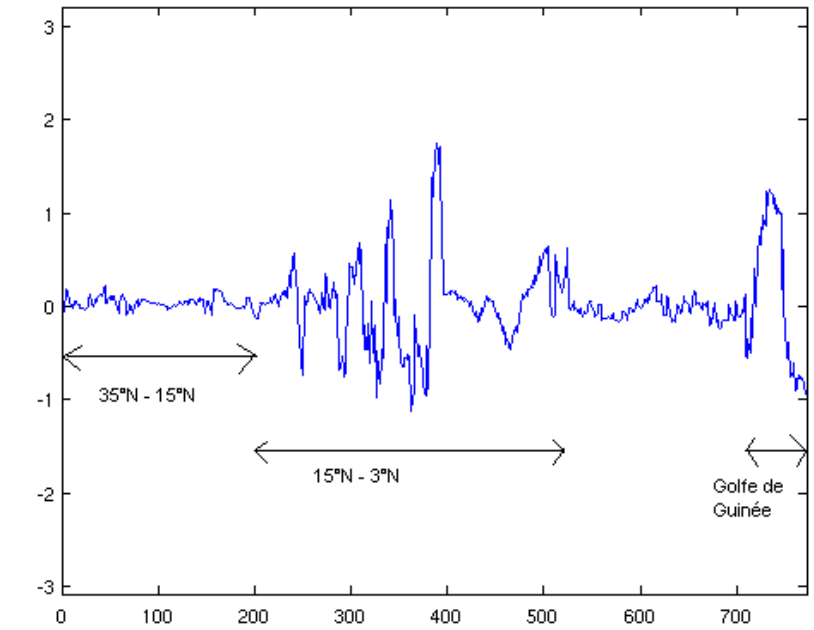


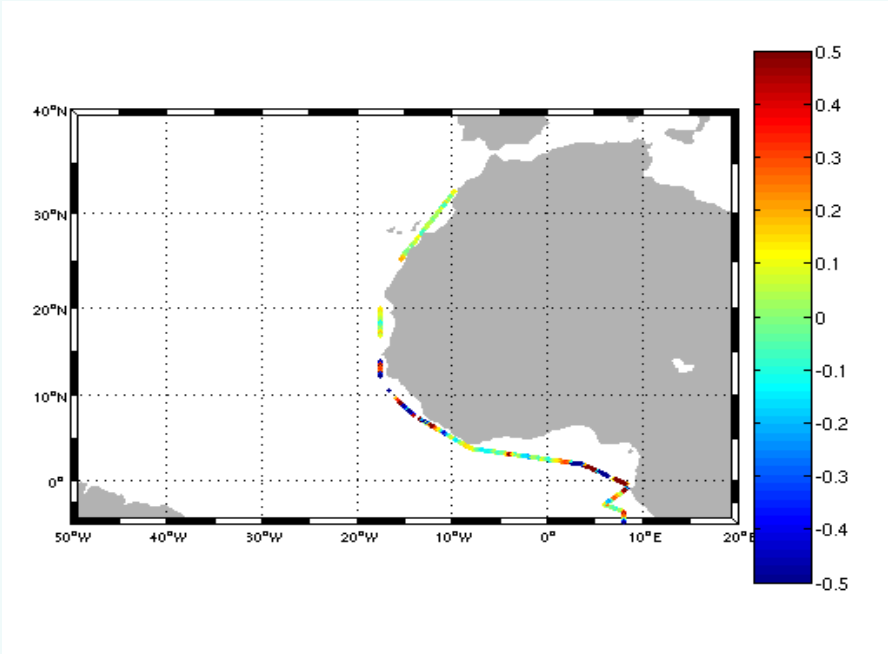
Salinity map at 5 m using ARGO + TSG data

Using residuals to detect biases and errors:

Atalante cruise, december 2003

Time series of residual show no significant bias





- 2 areas with explained high values (Senegal-Liberia and Gulf of Guinea)
- Away from these areas the median residual is 0.05 PSS

☐Introducing TSG data in ISAS

- Plans for V4 (oct. 2008-march 2009)
- Start on 2002-2005 ‘clean dataset’, NetCDF format
- Modify STD to accept DM-Netcdf files
- Produce ‘0, 3, 5, 10 m’ analysis of the North-Atlantic (2002-2005)
- Validate
- Extend to global ocean 2002-2007 with available datasets
- Perform residual analysis to detect biases and errors
- Produce analysis with validated data
- Compare to Reynolds and satellite products