Use of Argo data in near real time ocean analyses and reanalyses in Mercator Océan systems

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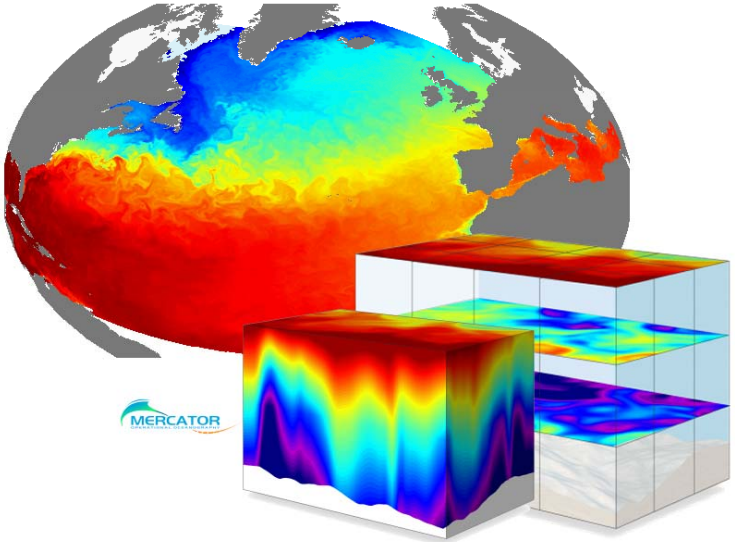

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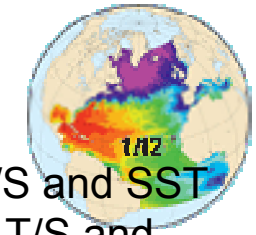
Mercator analysis & reanalysis systems overview

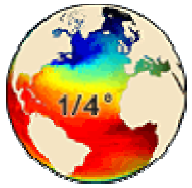
outline

- Mercator analysis / reanalysis systems overview
- Impact of Argo data in GLORYS ¼° Reanalysis
- Argo data Quality Control in Mercator systems
- Temperature and salinity bias correction using Argo data: method et early results
- Conclusions & prospects

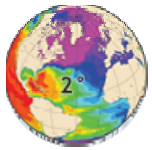
Mercator analysis & reanalysis systems overview



- **Regional eddy resolving** (2002→ now)
  - North Atlantic + Mediterranean : 5-7 km, OPA8, ROOI assimilation of alti. T/S and SST
  - **From April 2008**: **1/12°** (6.5 km at 45°N), **NEMO/LIM, SEEK assim**. of alti, T/S and SST, daily fcst
  - Target: mesoscale upper ocean, downscaling to smaller regional and coastal regions, …
- **Global eddy permitting** (09/2005 → now)
  - ¼°, global, ocean and sea ice
  - **From April 2008**: **¼°, NEMO/LIM, SEEK assim**. of alti, T/S and SST
  - Target: global ocean climate monitoring, biology, sea ice, reanalysis, …
  - Config. used to produce **GLORYS1 reanalysis (2002-2008)**



- **Global low resolution** (05/2004 → now)
  - Today: **2°, OPA8, SEEK assim** of alti, T/S and SST
  - Target: oceanic initial conditions for coupled seasonal prediction, reanalysis



- ***Global eddy resolving (to be operational at the end of MyOcean)***
  - ***NEMO/LIM+SEEK 1/12°***
    - *Has been demonstrated in April 2008*
  - *Target: Global Marine Core Service and downscaling to European regions*
- ***Northeastern Atlantic high resolution (to be operational at the end of MyOcean)***
  - ***NEMO 1/36° +SEEK + Tidal free surface***
  - *Target: IBIROOS Marine Core Service → Boundary data to coastal systems*

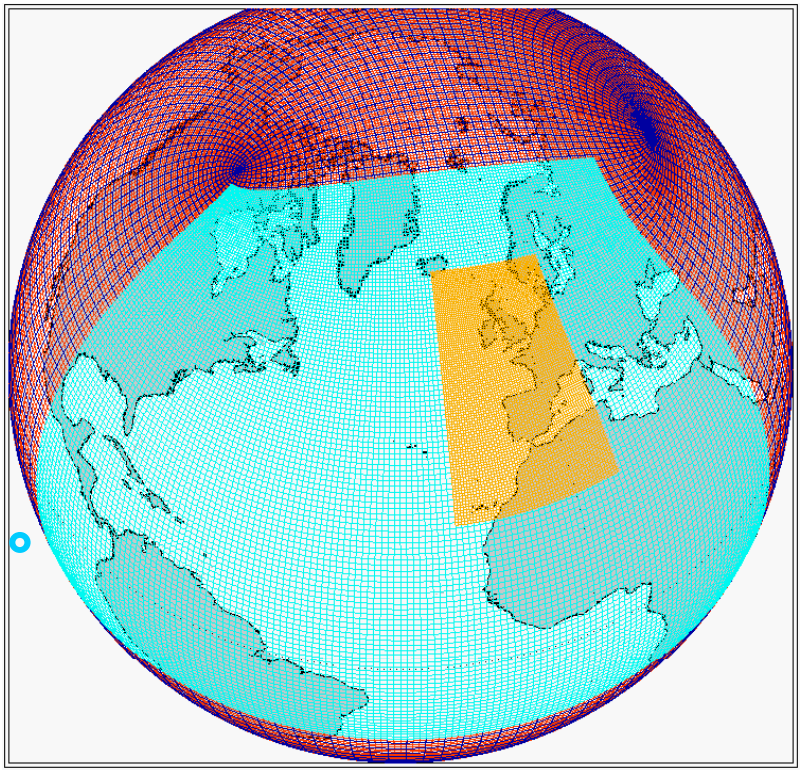
Mercator analysis & reanalysis systems overview

Model:

- Use **NEMO**: OPA ocean model with **ORCA** grids + **LIM2_EVP** sea-ice model
- 50 vertical levels : dz ~1m near surface, 500m near bottom
- **GPCP** rainfall correction
- **ECMWF** operational forcing fields
- bulk formulation: **CLIO** / CORE / ECUME

Different configurations:

Global: 1/12°, ¼°, 2°
Regional North Atl.: 1/12°
IBI : 1/36°



Mercator analysis & reanalysis systems overview

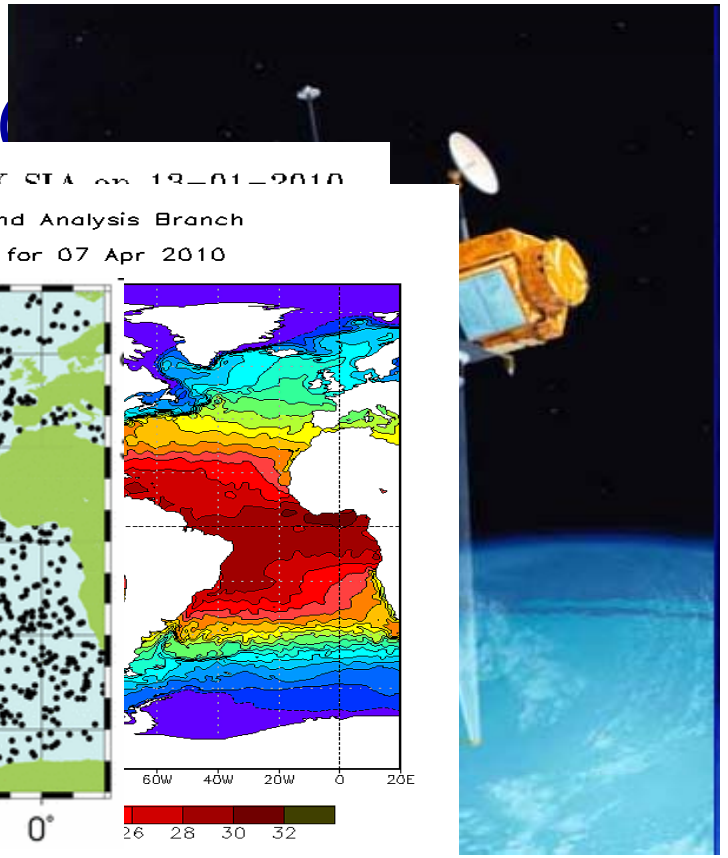
- Data Assimilation Scheme SAM2v1:
  - Based on a multivariate **SEEK filter**
  - State vector: Hbar, T, S,U,V
  - FGAT method to calculate innovation vector

$$K = S_n \left[I + (HS_n)^T R^{-1} (HS_n) \right]^{-1} (HS_n)^T R^{-1}$$

- Forecast error covariances P^f: multivariate 3D anomalies:
  - Sub-space is built from an ensemble of **anomalies** (A) from a free simulation.
    - no truncation
    - localization technique, see Houtekamer and Mitchell (2001) or Oke *et al* (2006).
- Adaptative scheme for the background error variance:
  - We adjust forecast error variance at each assimilation cycle in order to be consistent with innovation statistics
- Incrmental Analysis Update scheme:
  - Efficient way to distribute the correction in time.
  - continuous time solution

Mercator analysis & reanalysis systems overview

- **Assimilated data :**
  - **Along track SLA (SSLATO/DUACS) : Jason-1, Jason-2, Envisat**
  - **NCEP RTG ½° SST,**
  - **in situ temperature & salinity profiles (**
  - **etc..**



Impact of Argo data in GLORYS ¼° Reanalysis

GLORYS French project:

GLobal Ocean ReanalYses and Simulations:
Contribution to MyOcean global ocean reanalyses

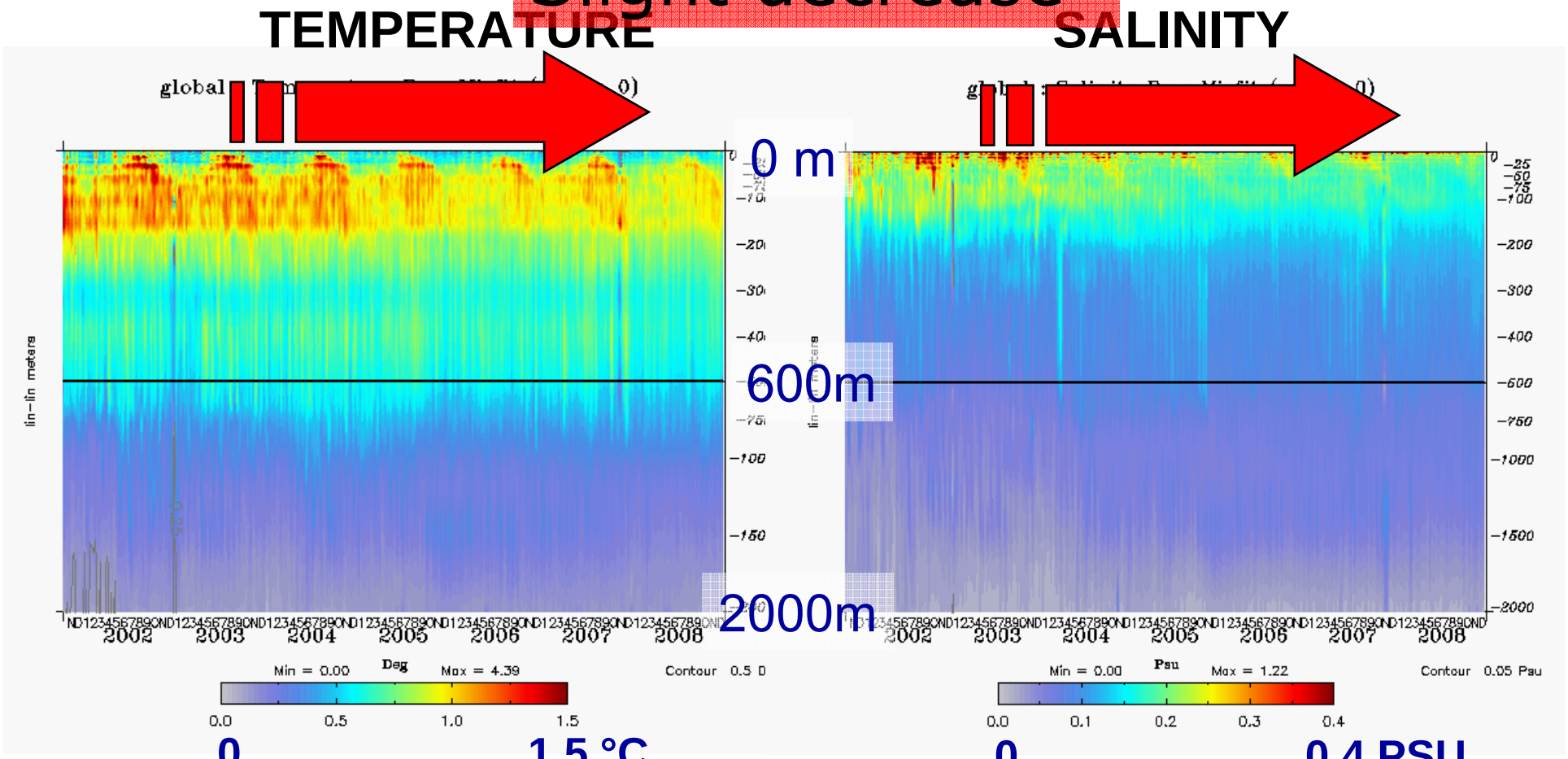
Multi year reanalyses at ¼° resolution covering different periods:

'Argo era':	2002-2008 : GLORYS1V1, produced in 2009
'Altimetric era' :	1992-2009: GLORYS2V1 → end 2010

Data assimilation verification: In situ T, S

Innovation RMS:

Slight decrease



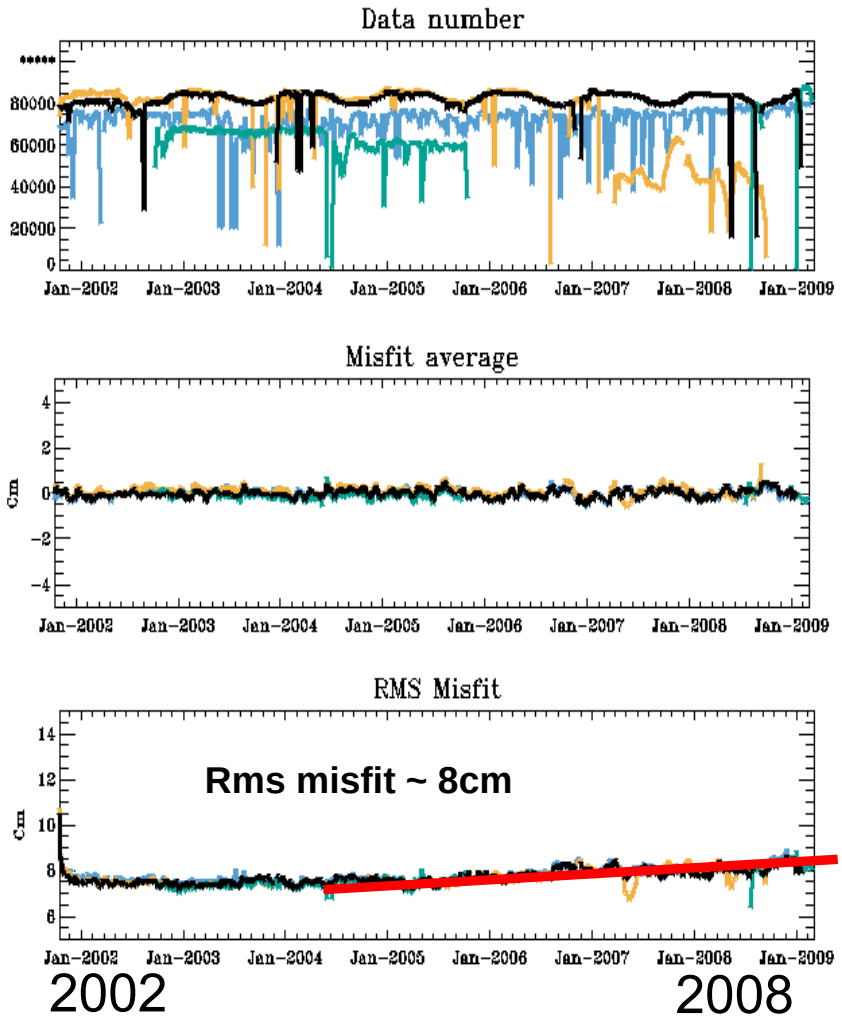
0 1.5 °C

0 0.4 PSU

Data assimilation verification: Altimetry

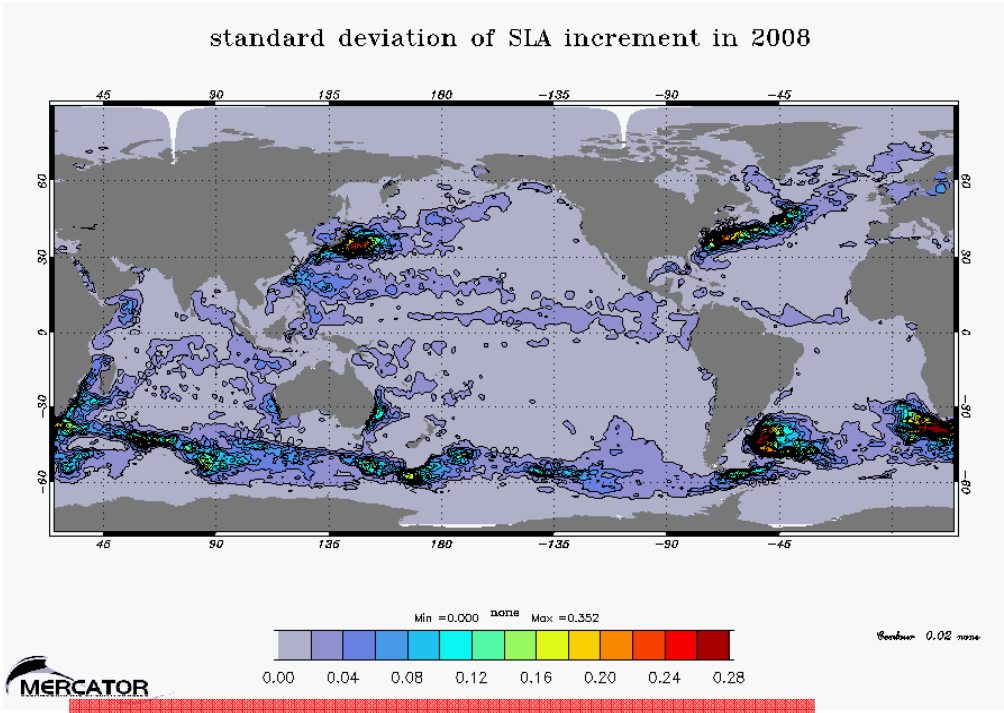
GLOBAL

(Black : JASON, Blue : ENVISAT, Orange : GFO, Green : TPN)



2002 2008

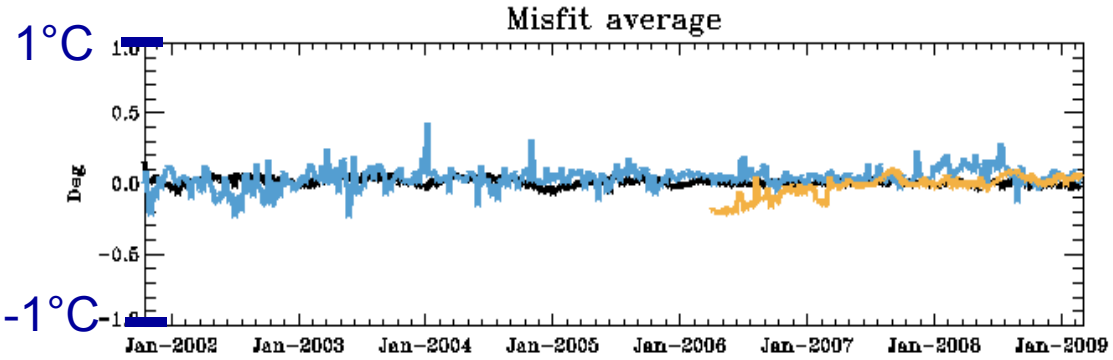
SLA incr. std dev

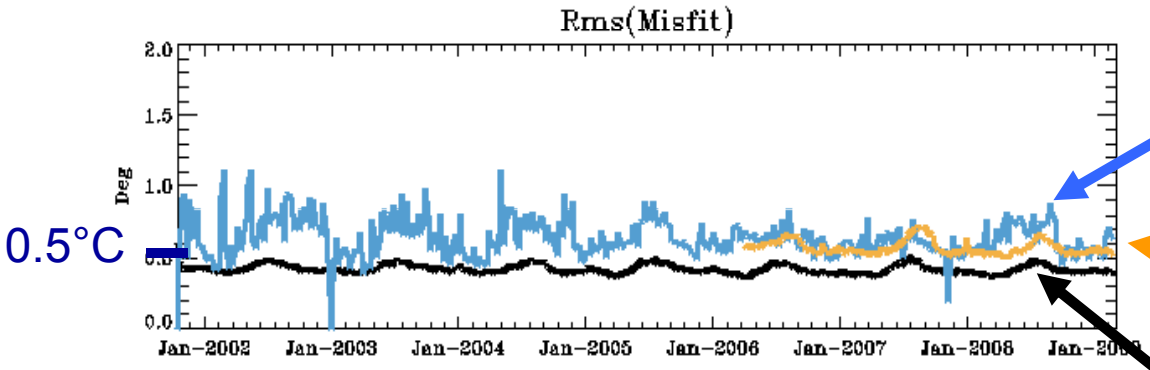


Slight increase

Data assimilation and verification: SST

Global



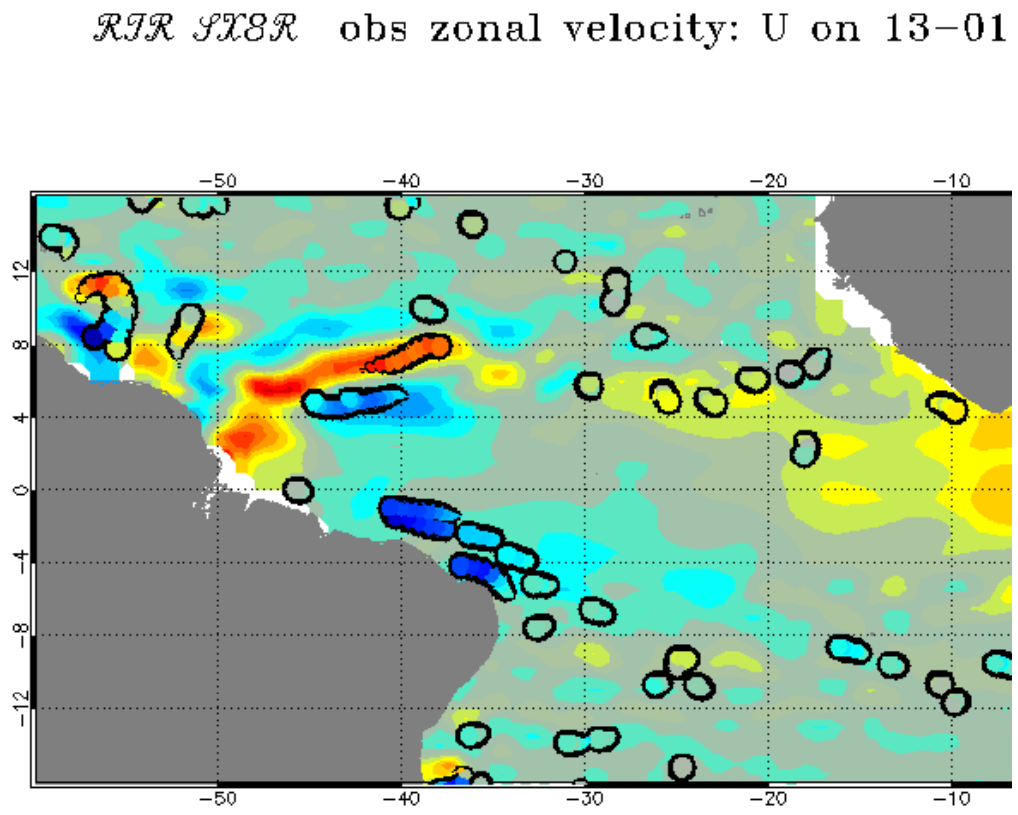


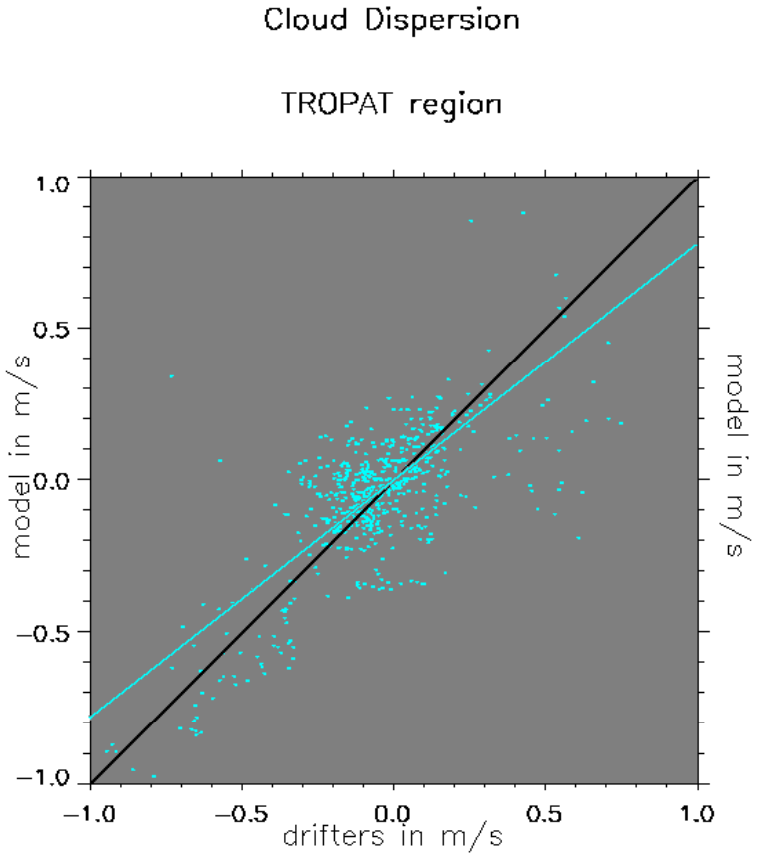
In situ data from Argo near surface

OSTIA SST
used for verification.

Assimilated RTG NCEP SST

Comparison with independent observations : surface velocity from SVP buoys

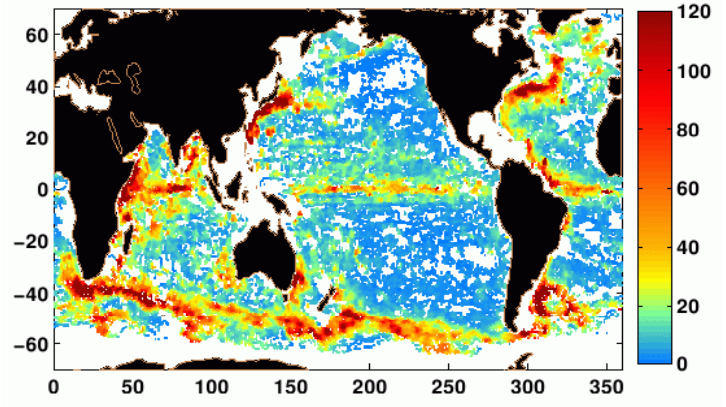




Verification with independent observations

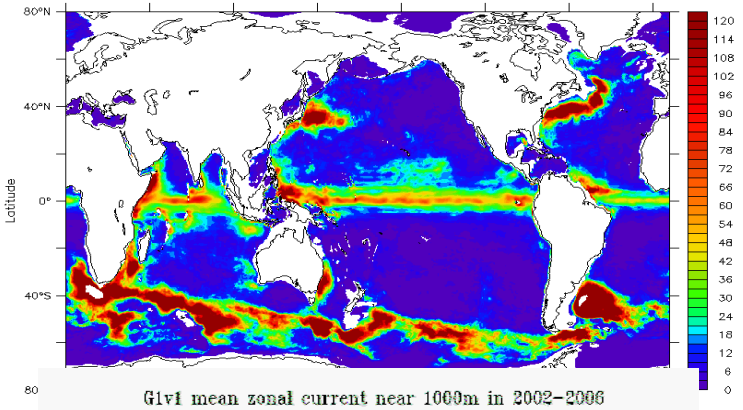
Circulation at 1000m depth (from Argo floats)

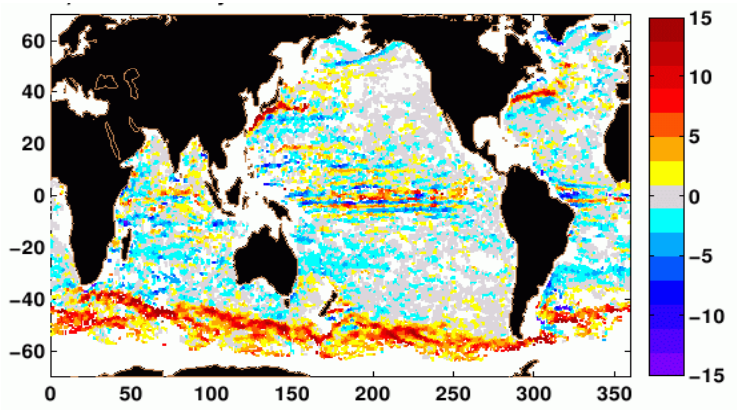
Cabanes et al. 2008, Argo Floats



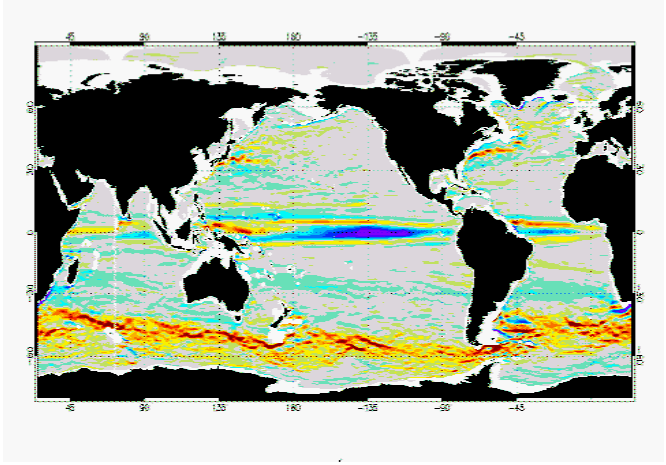
EKE

GLORYS1





MEAN U



Argo data Quality Control in Mercator systems

Argo data Quality Control in Mercator systems

Quality Control :

Thanks to appropriate tests it is possible to detect suspicious data.

- "gross" error detection
- background quality control :
  obs. is rejected if $(y-H(x))$ exceeds $n*(\sigma^o+\sigma^b)$
- detection of spikes
- detection of systematic biases
- detection of suspicious falling rate of XBTs
- etc …

The objective is twofold:

→ improve the quality of the ocea analyses / forecasts

→ provide observation blacklist to GDACs

Argo data Quality Control in Mercator systems

(y-H(x)) is normally distributed : $\mathcal{N}$ $(0, \sigma^o + \sigma^b)$

Using GLORYS1V1 reanalysis (2002-2008), it is possible to have a good estimation of $\sigma^o + \sigma^b$

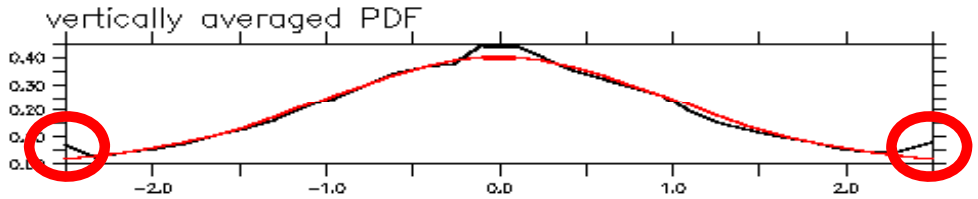
This is possible only because :

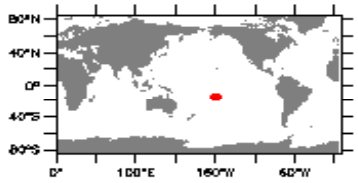
- Argo has a good global ocean sampling

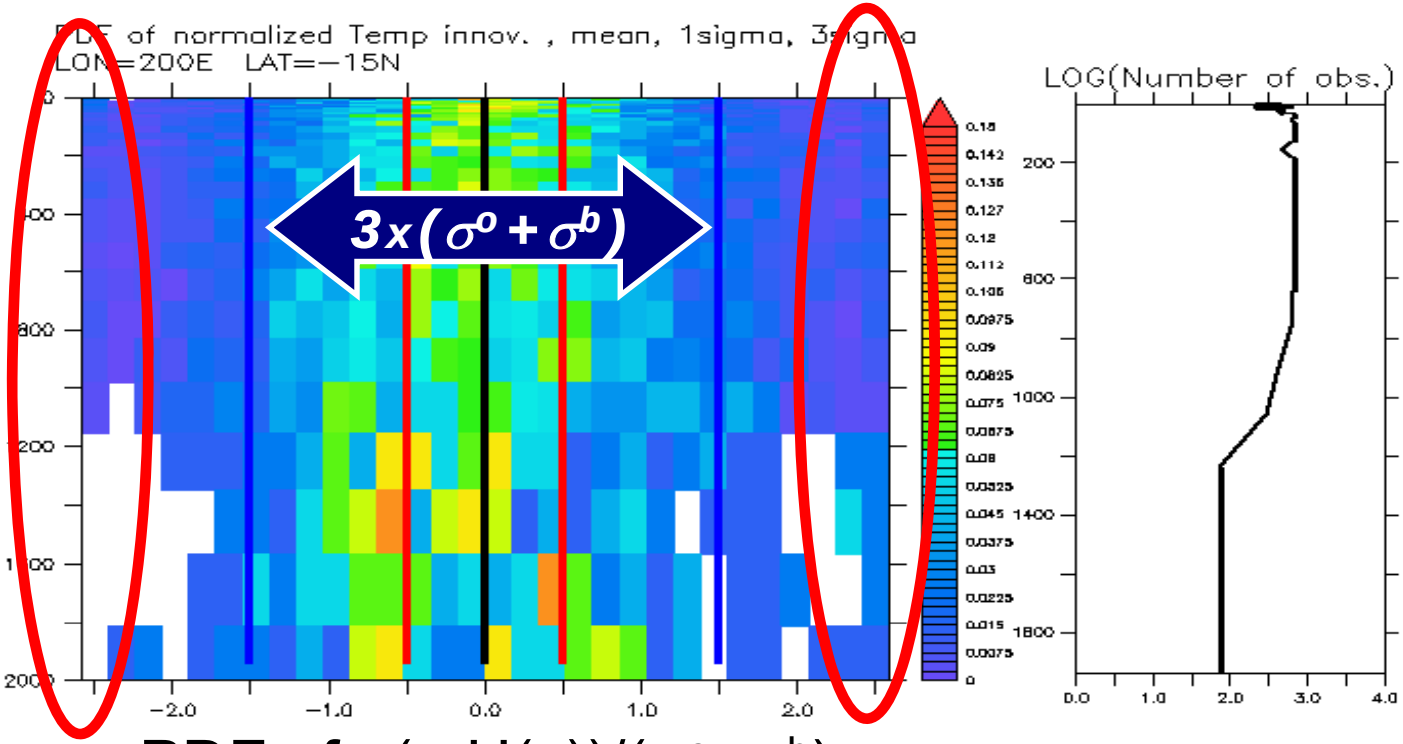
- Argo provides a sufficient large large number of observations

Argo data Quality Control in Mercator systems

(y-H(x)) is normally distributed : $\mathcal{N}(0, \sigma^o + \sigma^b)$

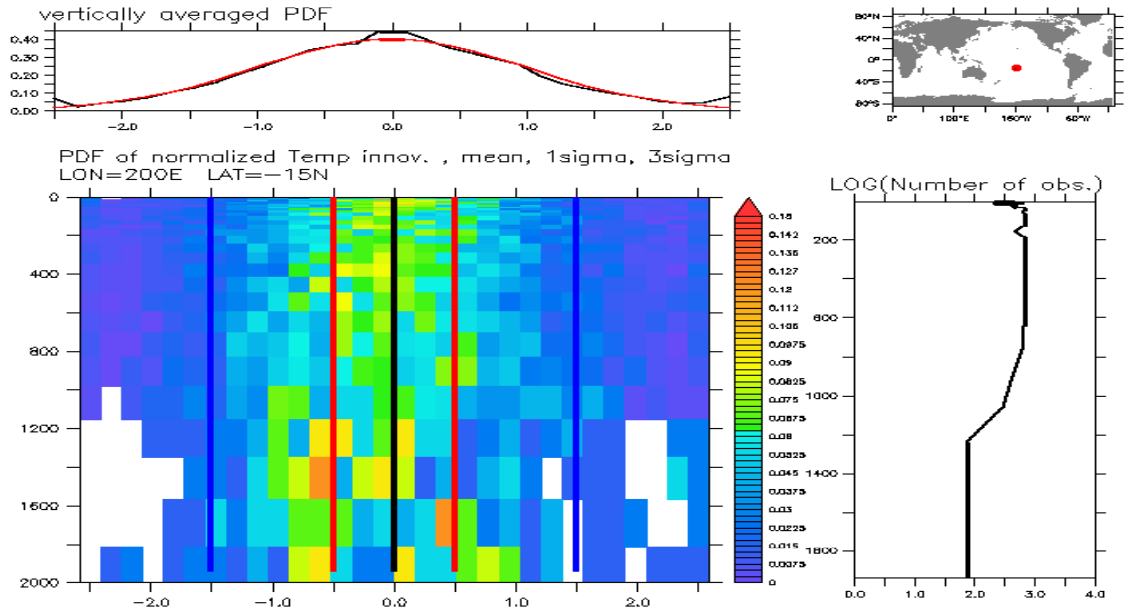






PDF of (y-H(x))/(σ^o+σ^b)

Argo data Quality Control in Mercator systems



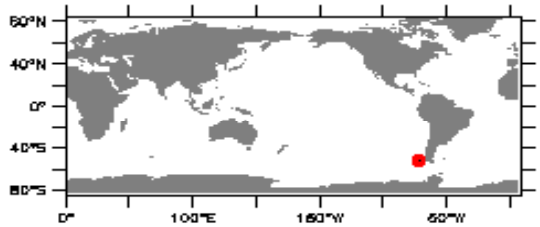
PDF of $(y-H(x))/(\sigma^o+\sigma^b)$

- background quality control :
  obs. is rejected if ***(y-H(x))*** exceeds ***$n*(\sigma^o+\sigma^b)$, $n \sim 3.4$***

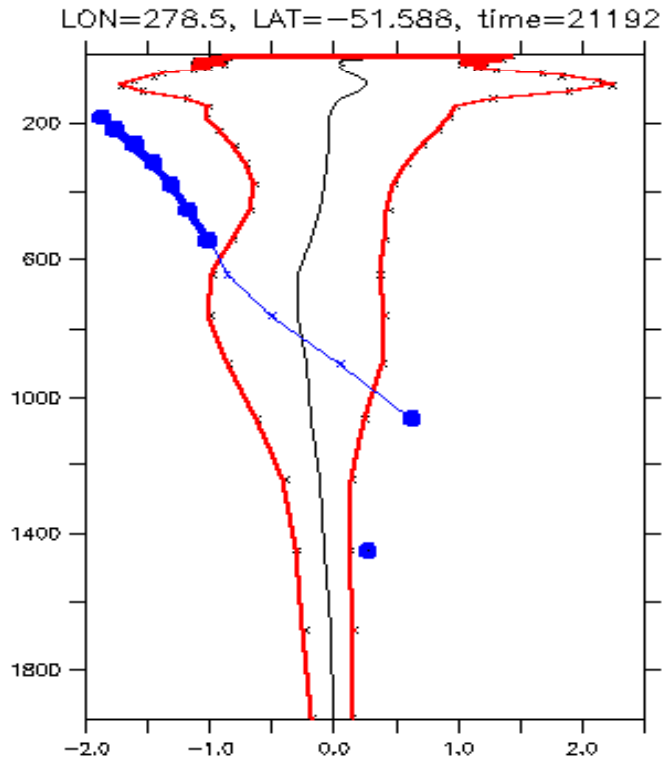
→ an efficient background quality control can be done

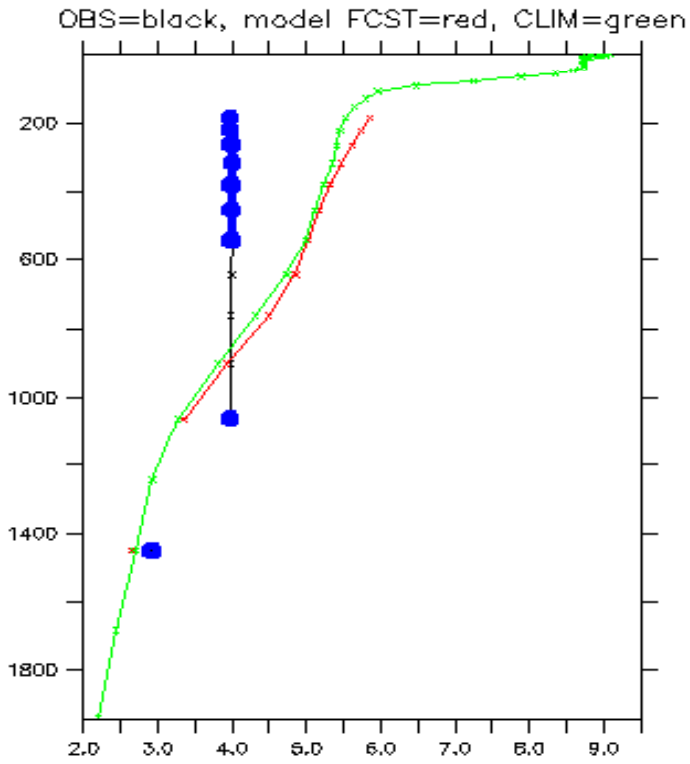
Argo data Quality Control in Mercator systems

Example of
gross error detection:



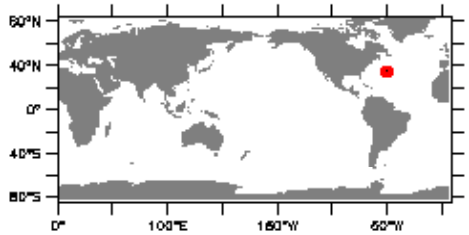
Temperature



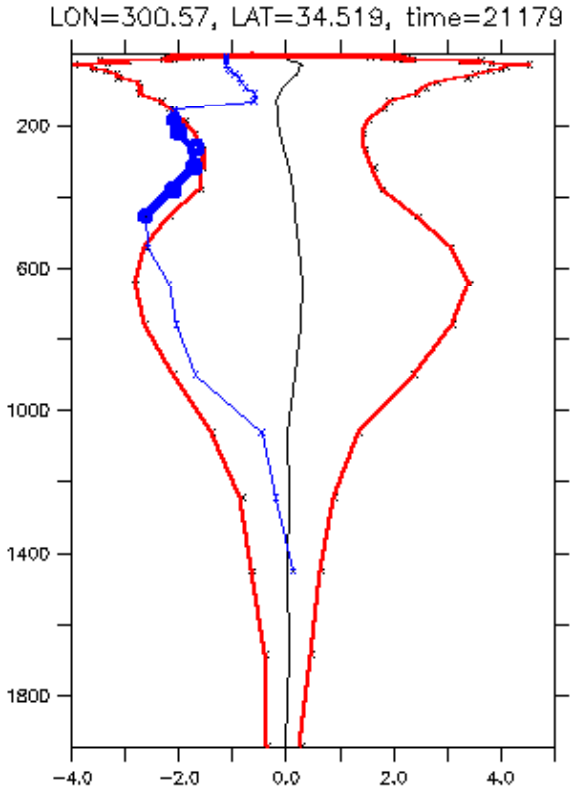


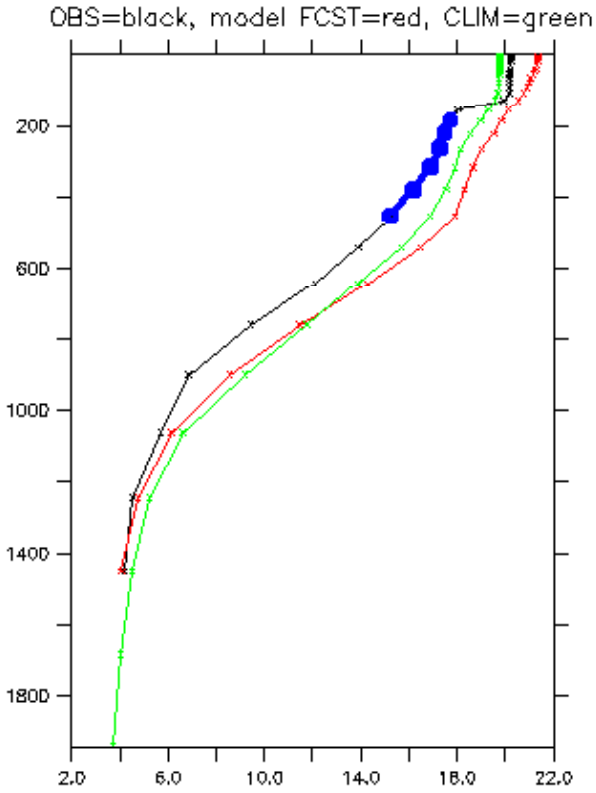
Argo data Quality Control in Mercator systems

Example of
pressure drift in Argo:



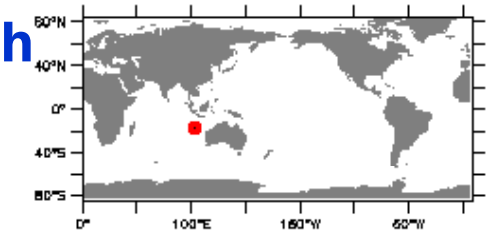
Temperature



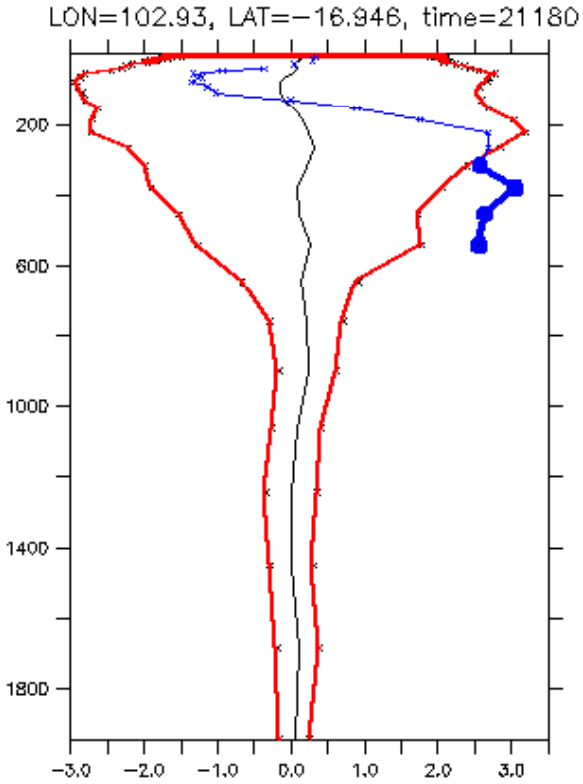


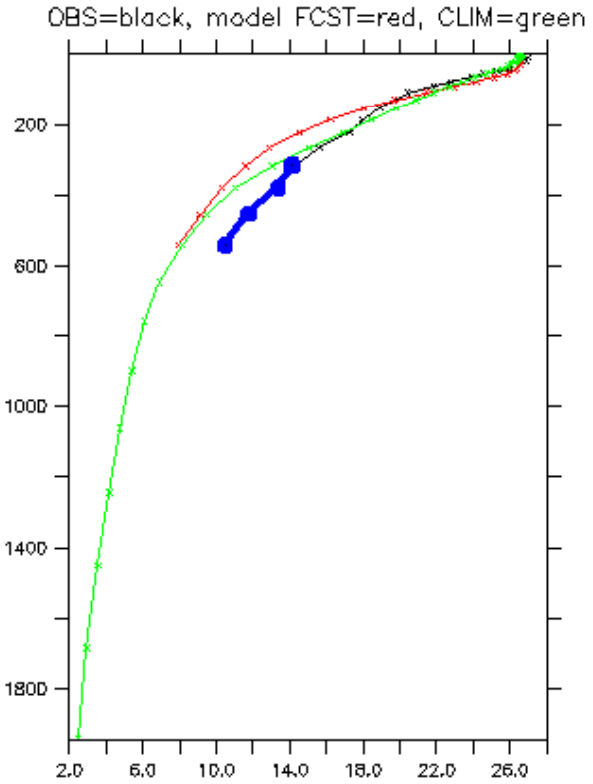
Argo data Quality Control in Mercator systems

Unrealistic innovation at depth



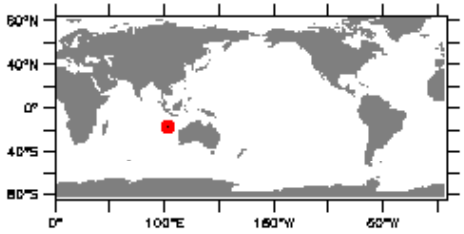
Temperature



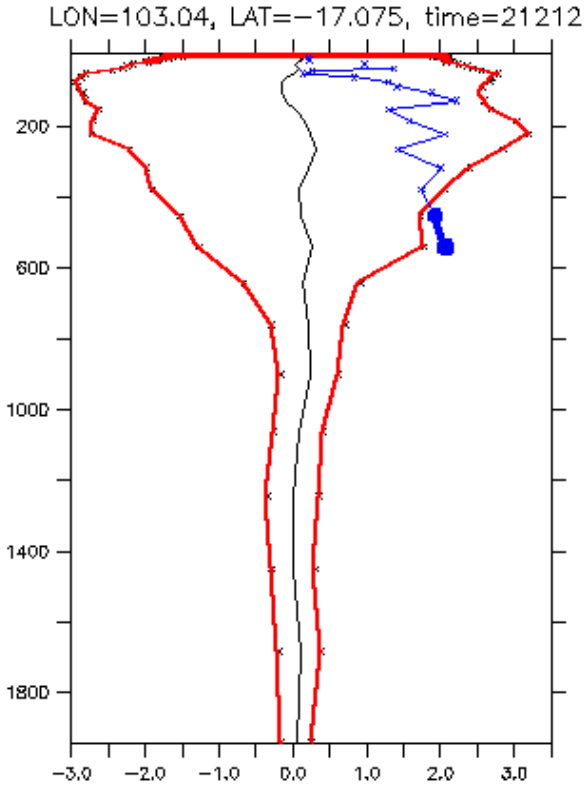


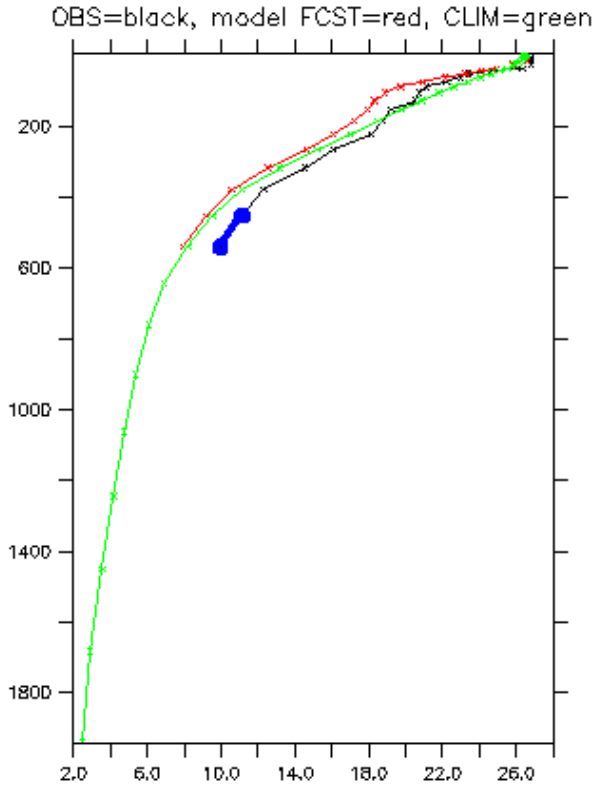
Argo data Quality Control in Mercator systems

Same Argo float,
32 days afterwards



Temperature

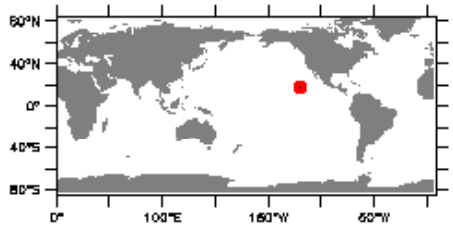


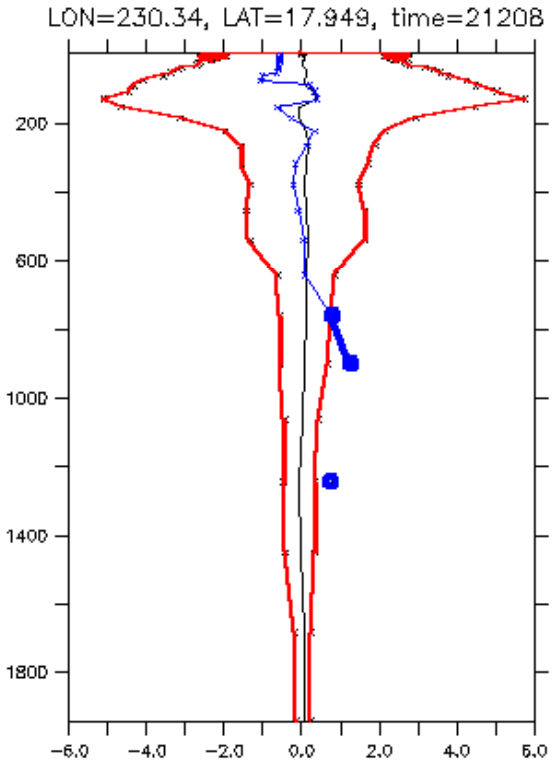


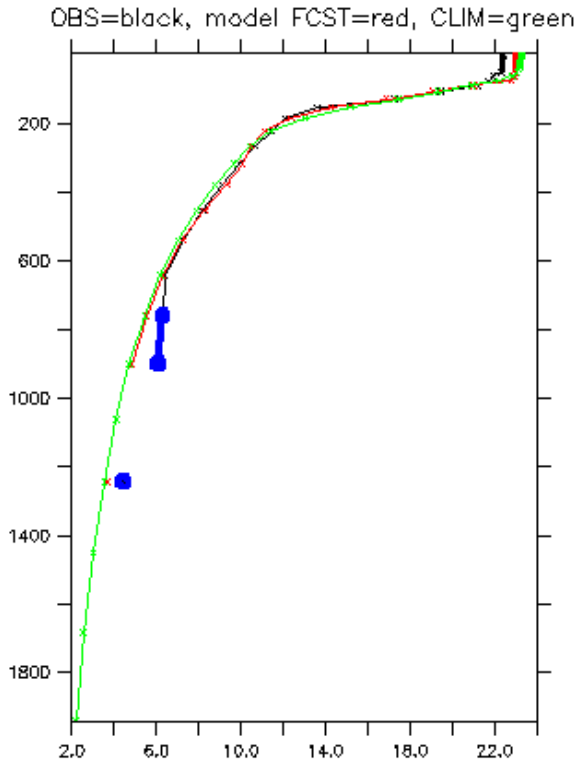
Argo data Quality Control in Mercator systems

Error at depth

Temperature







Temperature and salinity bias correction using Argo

Temperature and salinity bias correction using Argo

→ Due to Argo network good spatial coverage, it is possible to perform bias correction for Temperature and Salinity.

Bias method correction:

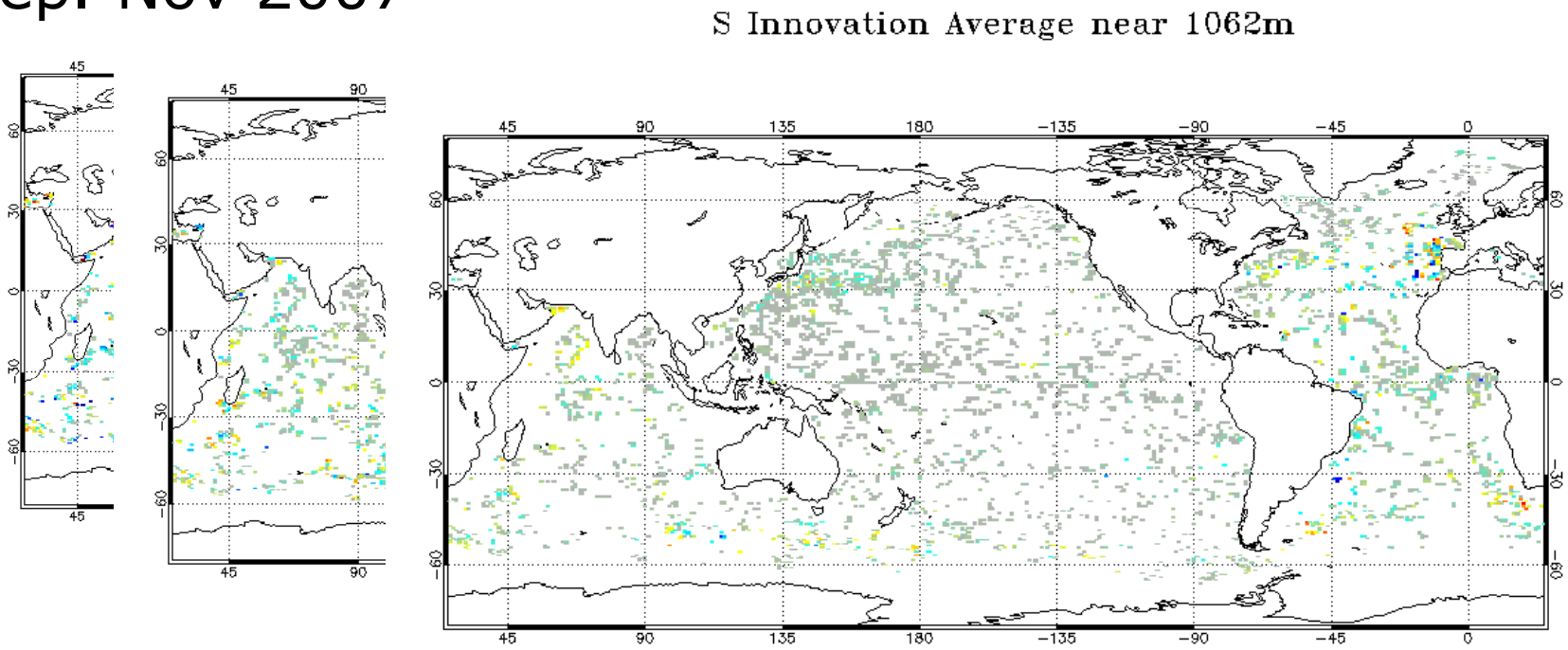
1. Collection of innovations (T&S) over the past 3 months
2. Analysis of the bias (3DVAR method, flow dependent)
3. Model correction using a Incremental Analysis Update method

Temperature and salinity bias correction using Argo

Bias correction method :

Step 1. Collection of innovations (T&S) over the past 3 months

Sep.-Nov 2007



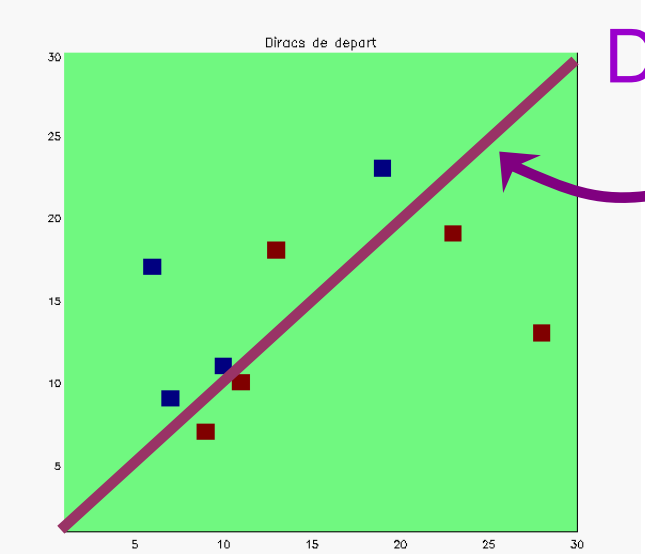
Temperature and salinity bias correction using Argo

Bias correction method :

Step 2. Analysis of the bias (3DVAR method)

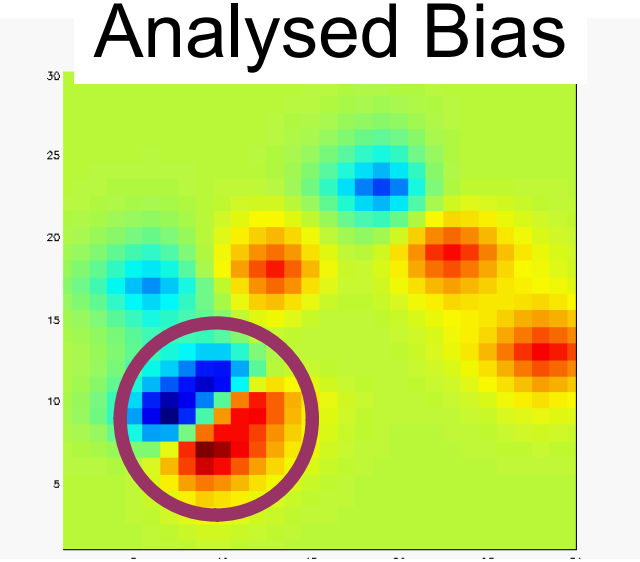
$$J(x) = \tfrac{1}{2} < x - x_g , \mathbf{B}^{-1}(x - x_g) > + \tfrac{1}{2} < y_d - \mathbf{H}\, x , \mathbf{R}^{-1}(y_d - \mathbf{H}\, x) >$$

B is flow dependent, large scale:
Correlation scale are small near density fronts.



Density front

Analysed Bias



Temperature and salinity bias correction using Argo

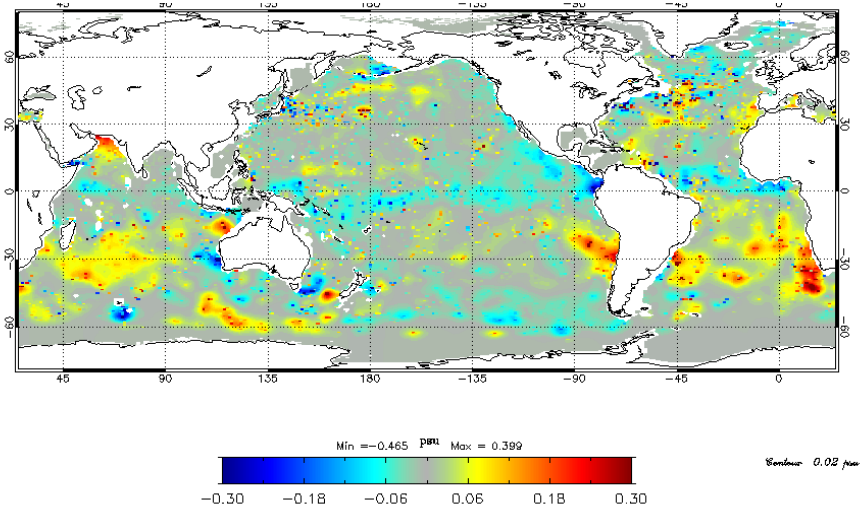
Bias correction method :

Step 3. Model correction using a Incremental Analysis Update (IAU) method

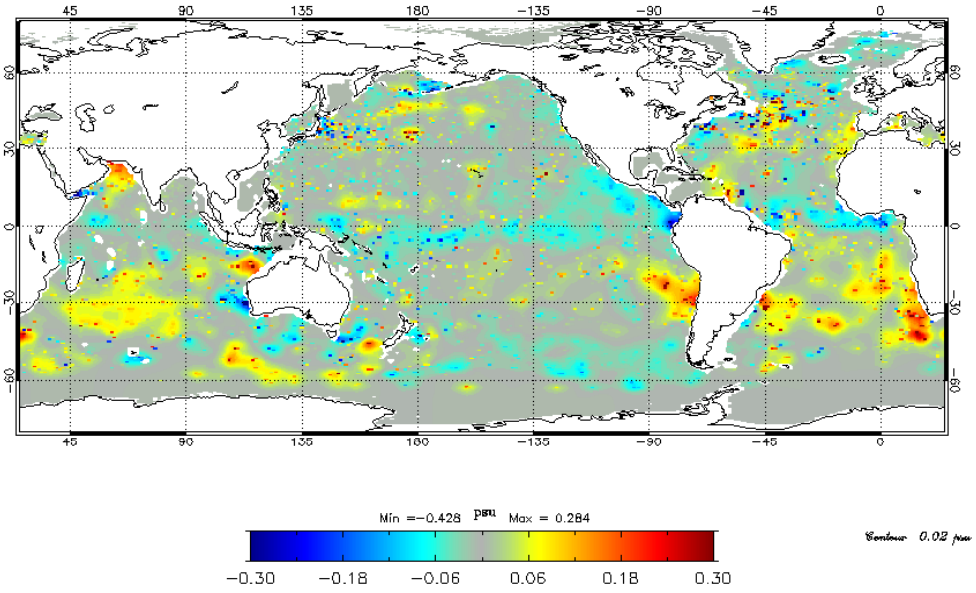
A tendency term is introduced in the model equations (for T & S):

$$\partial X/\partial t = M(t) + BIAS/\tau \quad w$$

Initial Bias, Salinity 800m

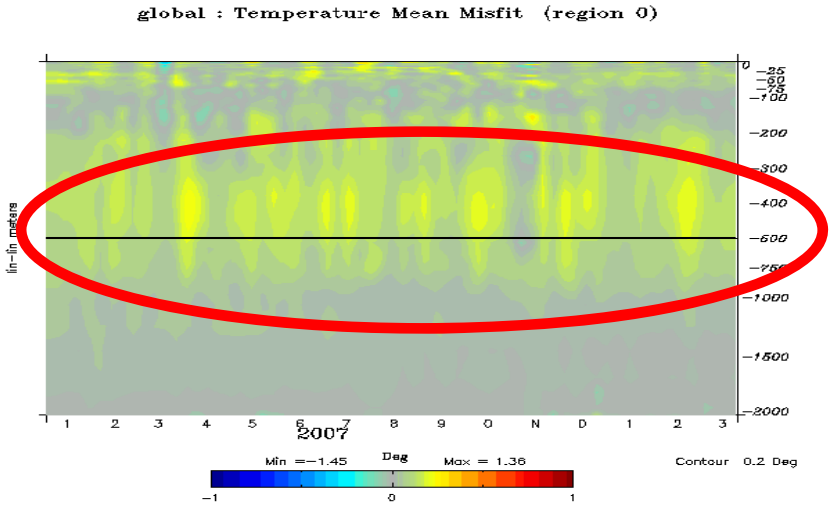


16 month-long run with Bias corr.

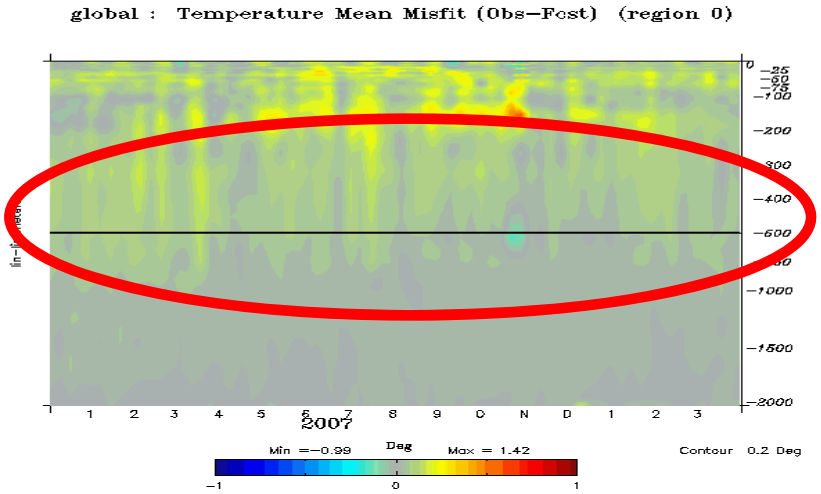


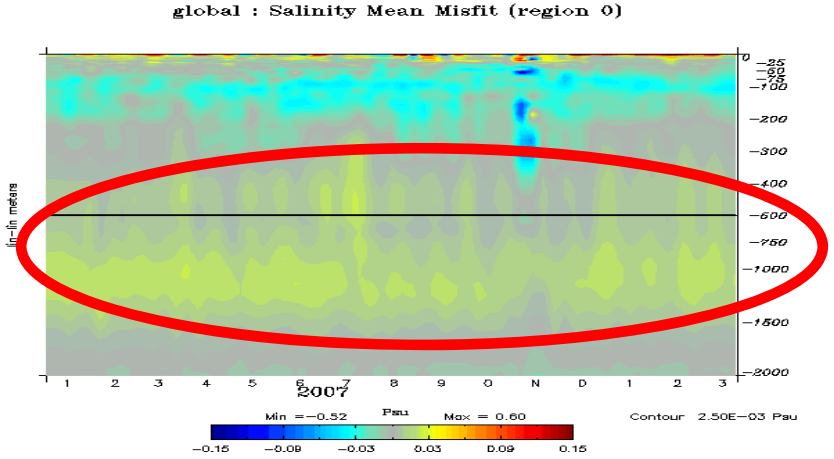
Temperature and salinity bias correction using Argo

Mean misfit

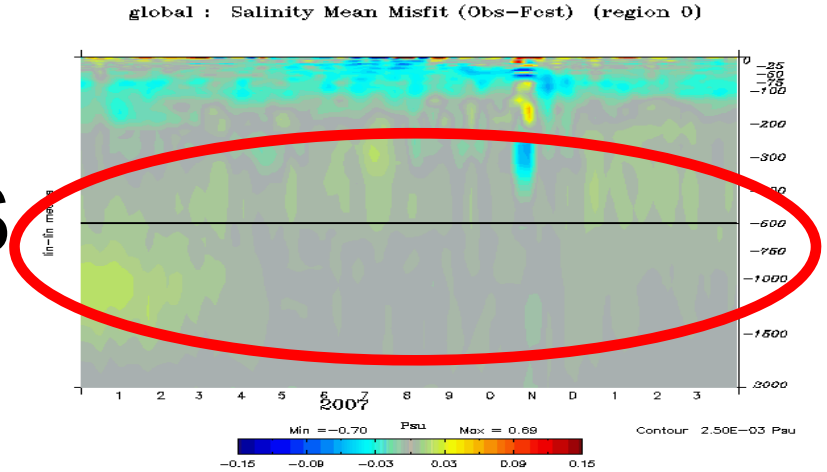


T





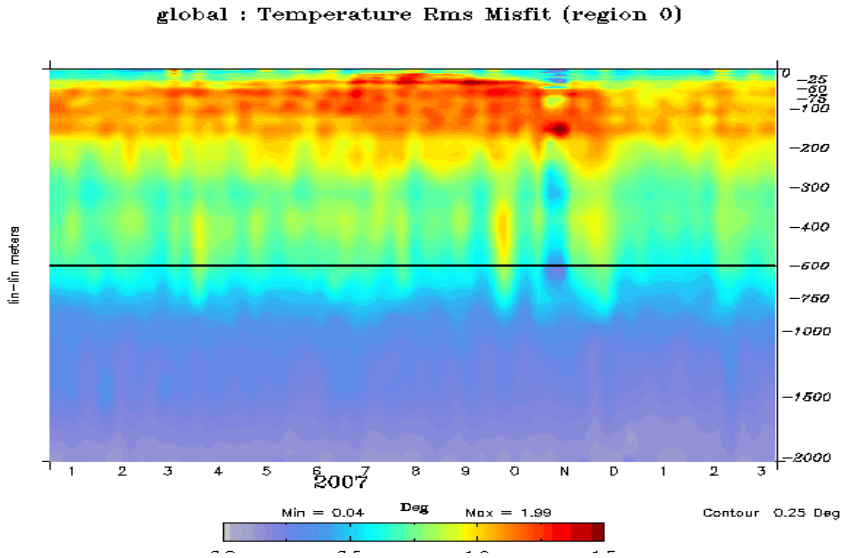
S

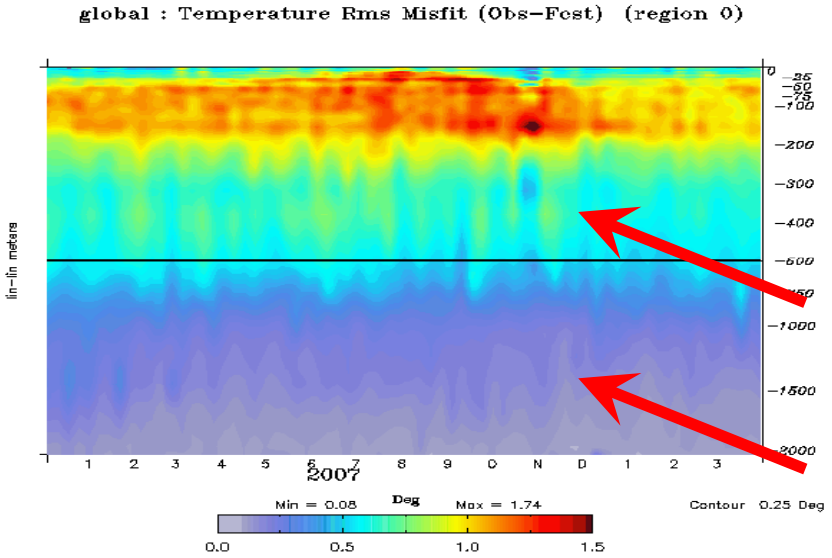


No bias correction

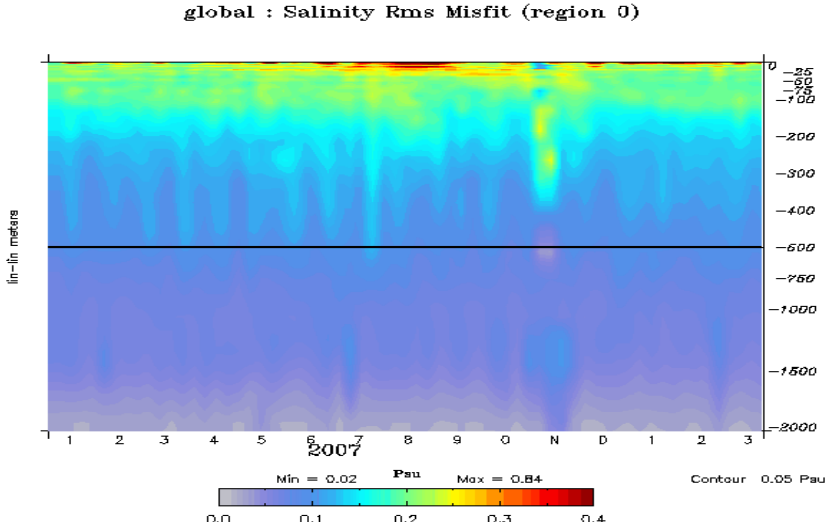
With bias correction

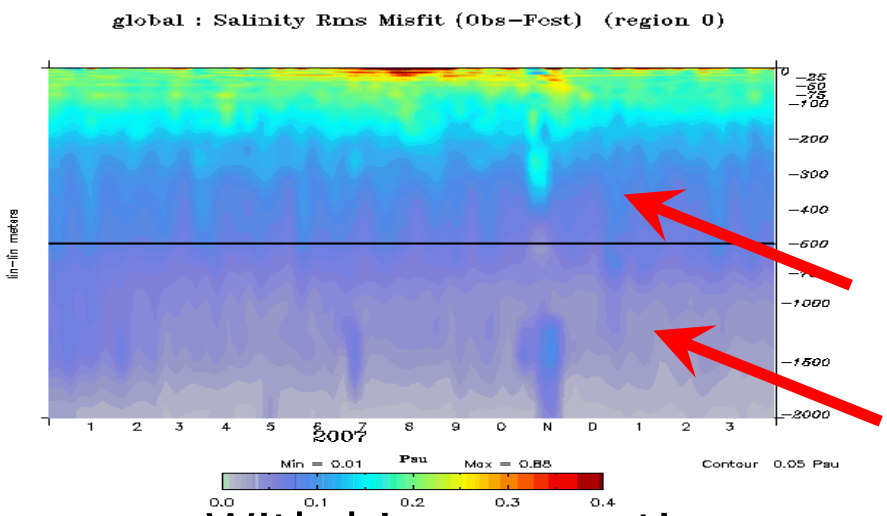
Temperature and salinity bias correction using Argo





T





S

No bias correction

With bias correction

Conclusions & prospects

Argo network is useful for:

- **Data assimilation**: constrain T & S in in the (re)analyses ocean systems, complementary to other observations
- **virtuous circle between OF centres and GDACs** : Mercator ocean forecasting center will contribute to improve the QC of Argo data:
  → data blacklist will provided to MyOcean in situ TAC
- **Unique Argo data coverage**: we are able to perform efficient bias correction
- **other observations expected from Argo ?** :
  - measurements below 2000m depth
  - subsurface velocity estimated with Argo data
  - near surface high precision temperature measurement