Global Comparison of Argo dynamic height with Altimeter sea level anomalies

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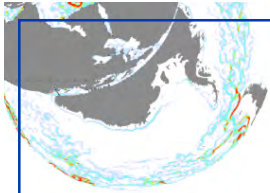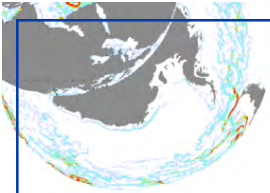**Christine Coatanoan, Pierre-Yves Le Traon**

Ifremer

Objectives and Outline

- As, Sea Level Anomalies (**SLA**) from altimeter measurements and Dynamic Height Anomalies (**DHA**) calculated from in-situ T and S profiles are **complementary** and **strongly correlated** :

  ➔ **To use Satellite altimeter measurements to check the quality of the Argo profiling floats time series**

  ➔ **To study the interannual variability of the sea level : total / steric**

- **Outline :**
  - Argo quality control
    - Data and Method
    - Global consistencies between the two data sets
    - Results for each Argo float time series
  - Sea level variability
    - Data and Method
    - Impact of the sampling of the Argo data set
    - Interannual variability
  - Conclusions and Perspectives

Argo quality control : *Data and Method*

- The main idea is **to compare** co-located :
  - Altimeter **S**ea **L**evel **A**nomalies (**SLA**)
  - and **D**ynamic **H**eight **A**nomalies (**DHA**) from Argo T/S profiles

  for each Argo float time series

- Method :

  DHA = DH – Mean-DH   /   **SLA**

  2 times series co-located in time and space

  SLA : AVISO multi-mission combined products
  DHA : Argo Coriolis-GDAC data base (uploaded as of February 2008)
      DH calculated from T/S profiles using a reference level at **900-m** depth
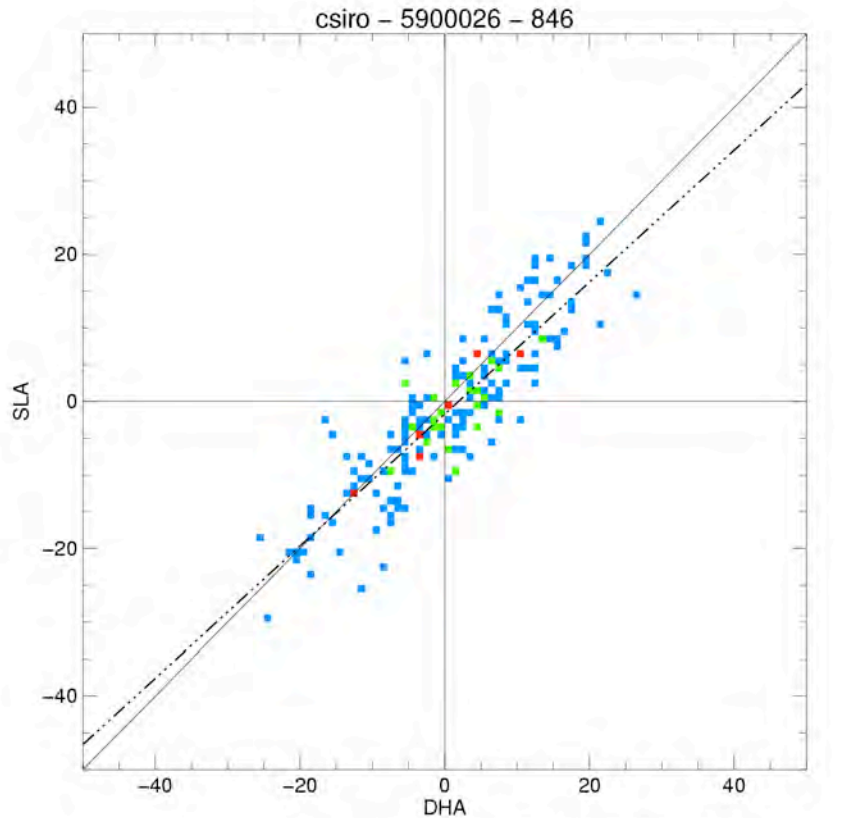   only data with : POSITION_QC = '0', '1', '5'
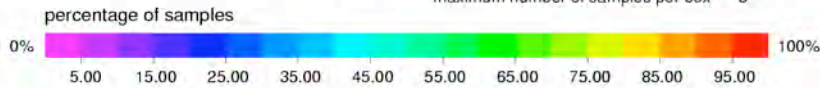   JULD_QC = '0', '1', '5'
                  PRES/TEMP/PSAL_QC = '1' (DATA_MODE='R')
                  PRES_ADJ/TEMP_ADJ/PSAL_ADJ_QC = '1' (DATA_MODE='A'/'D')
  Mean-DH : Levitus annual climatology, contemporaneous Argo climatology (2-steps approach)

csiro – 5900026 – 846

csiro – 5900026 – 846

minimum number of samples per box 1
maximum number of samples per box 3

percentage of samples

0% ▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮ 100%

5.00 15.00 25.00 35.00 45.00 55.00 65.00 75.00 85.00 95.00

Statistics Y–X

mean = −1.86108
rms = 5.27513
rms (%rms(X)) = 27.20221
rms (%rms(Y)) = 26.79463
std = 4.93413

Statistics Y,X

samples = 197
covar = 89.66322
r = 0.88094

Linear regression

type: least squares y=f(x)

y = ax + b
a = 0.89717734
b = −1.71680028

Statistics X

mean = 1.42132
rms = 10.09749
std = 9.99696

Statistics Y

mean = −0.44162
rms = 10.19082
std = 10.18125

Legend

— Linear regression
—— y=x

CLS
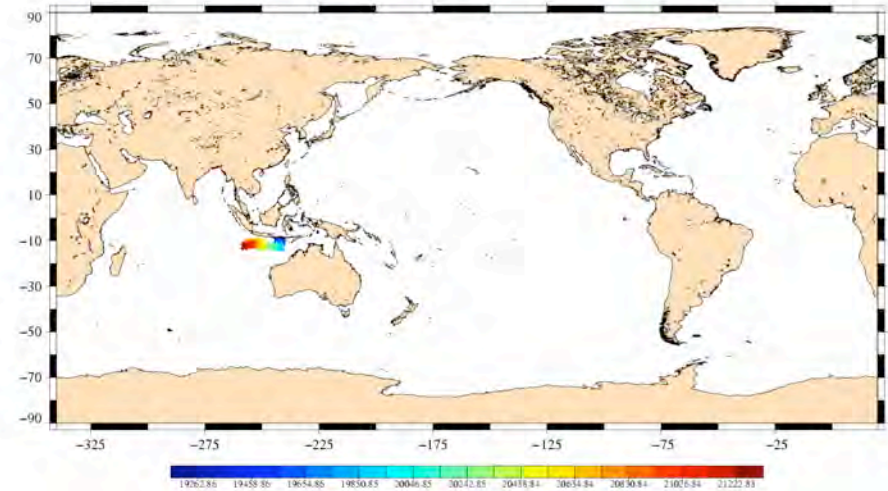
csiro – 5900026 – 846

➔ **Very good consistencies between the two time series**
➔ **Impact of the delayed-mode and real-time adjustment**
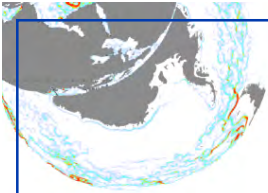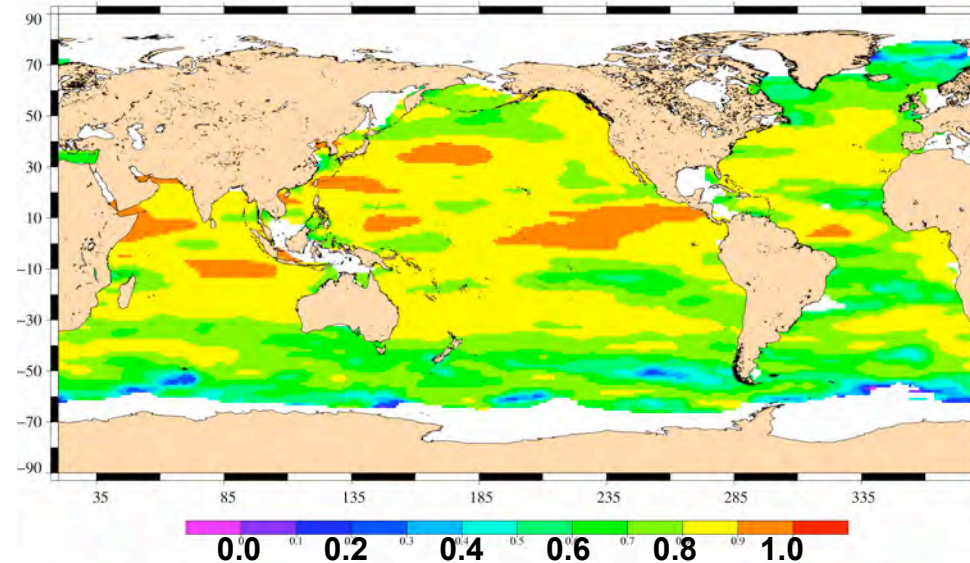
Argo quality control : *Method*

- Method :

    DHA = DH – Mean-DH   /   **SLA**

- Differences between DHA and SLA can arises from :
    - Differences in the physical content of the two data sets
    - Problems in SLA (assumed to be perfect for the study)
    - Problems in the Mean-DH / Inconsistencies between Mean-DH and DH
    - **Problems in DH** (i.e. the Argo data set)

- In order to minimize the problems in the Mean-DH, we have used a 2-steps approach :
    - 1st : Mean-DH = Levitus annual climatology, comparisons, questionable Argo floats separated
    - 2st : calculation of an Argo Mean-DH – consistent with the Argo period
        comparisons on the all data sets

- In order to take into account the differences in the physical content of the two data sets, mean representative statistics of these differences have first been computed
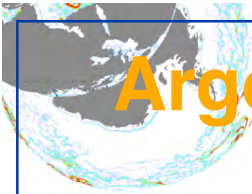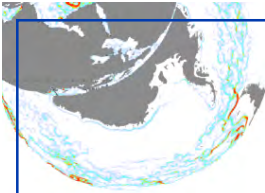
Argo quality control : *Mean representative statistics*

- Computed using the same data set – questionable floats separated
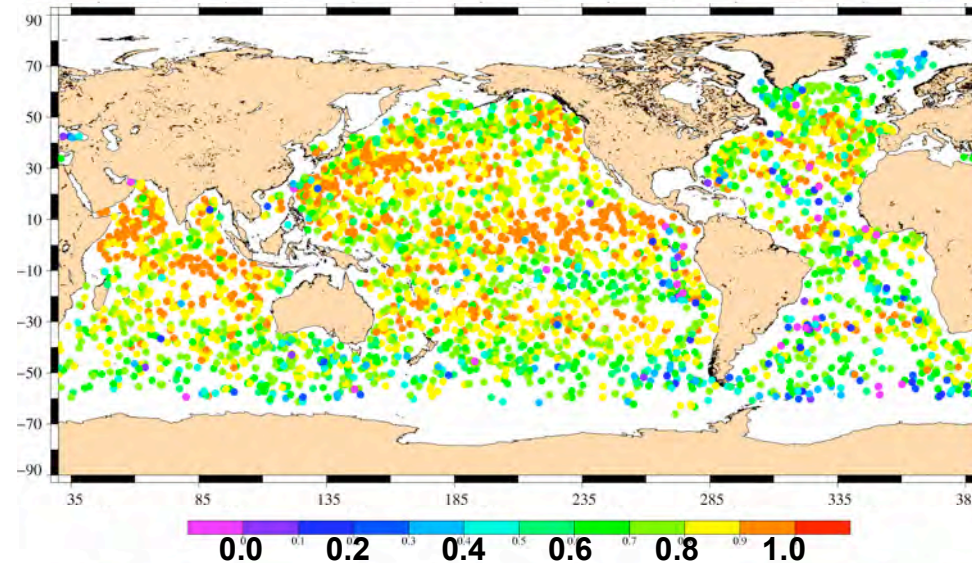- Correlation coefficient (DHA/SLA) :

0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0

- Rms of the differences (SLA-DHA) as % of SLA variance :
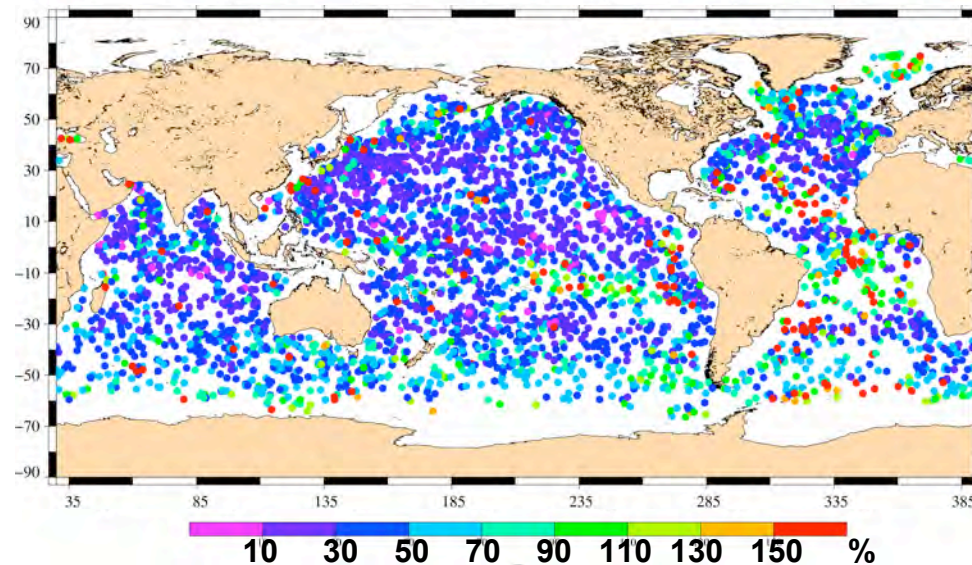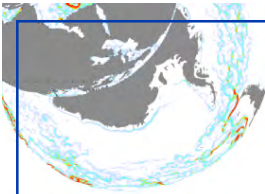

10 30 50 70 90 110 130 150 %
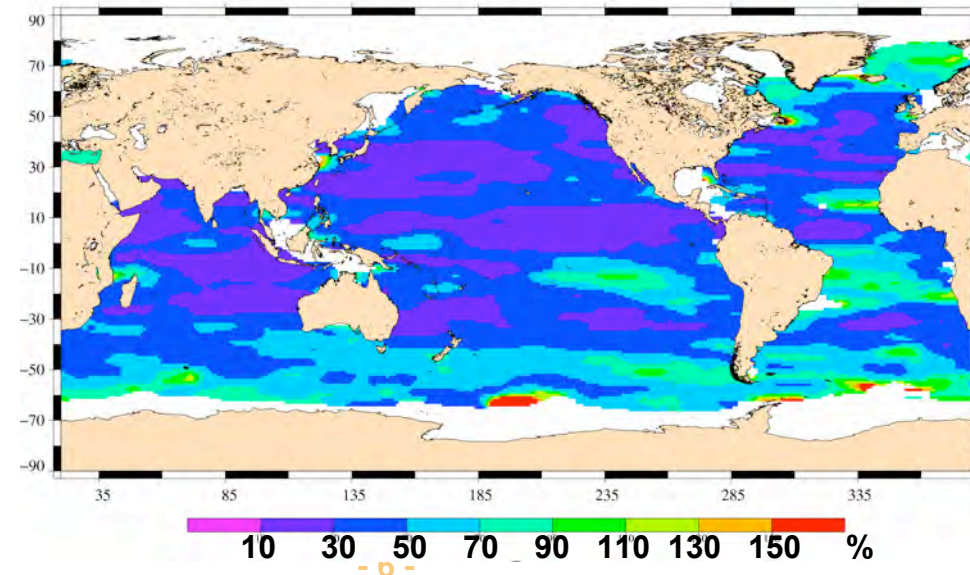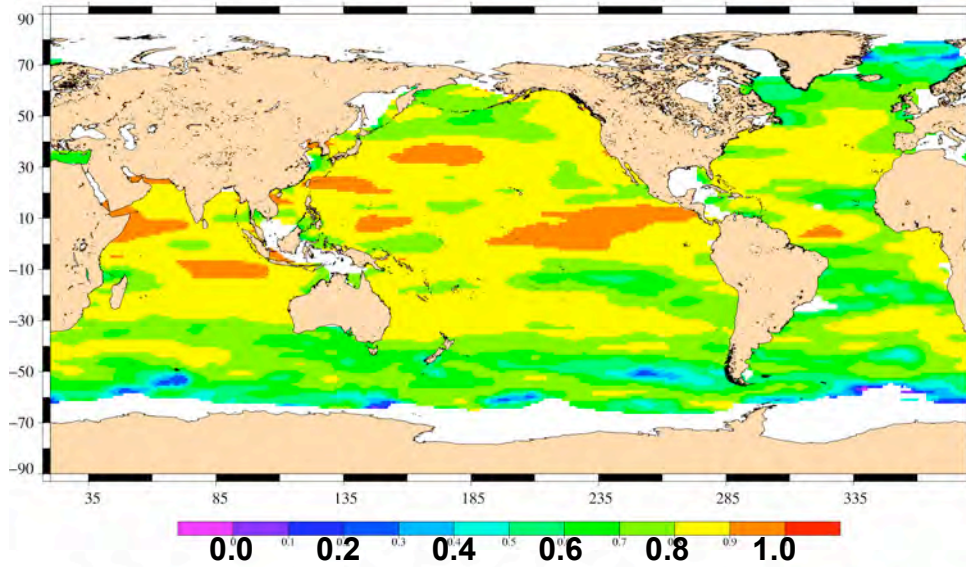
Argo quality control : *Global results*

- One point represents a time series at its mean position (~ 4100 floats)
- Correlation coefficient (DHA/SLA) :

0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0

→ Questionable floats can already be extracted by comparing to the neighbours

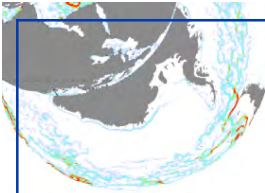- Rms of the differences (SLA-DHA) as % of SLA variance :

10 30 50 70 90 110 130 150 %

Argo quality control : *Global results*

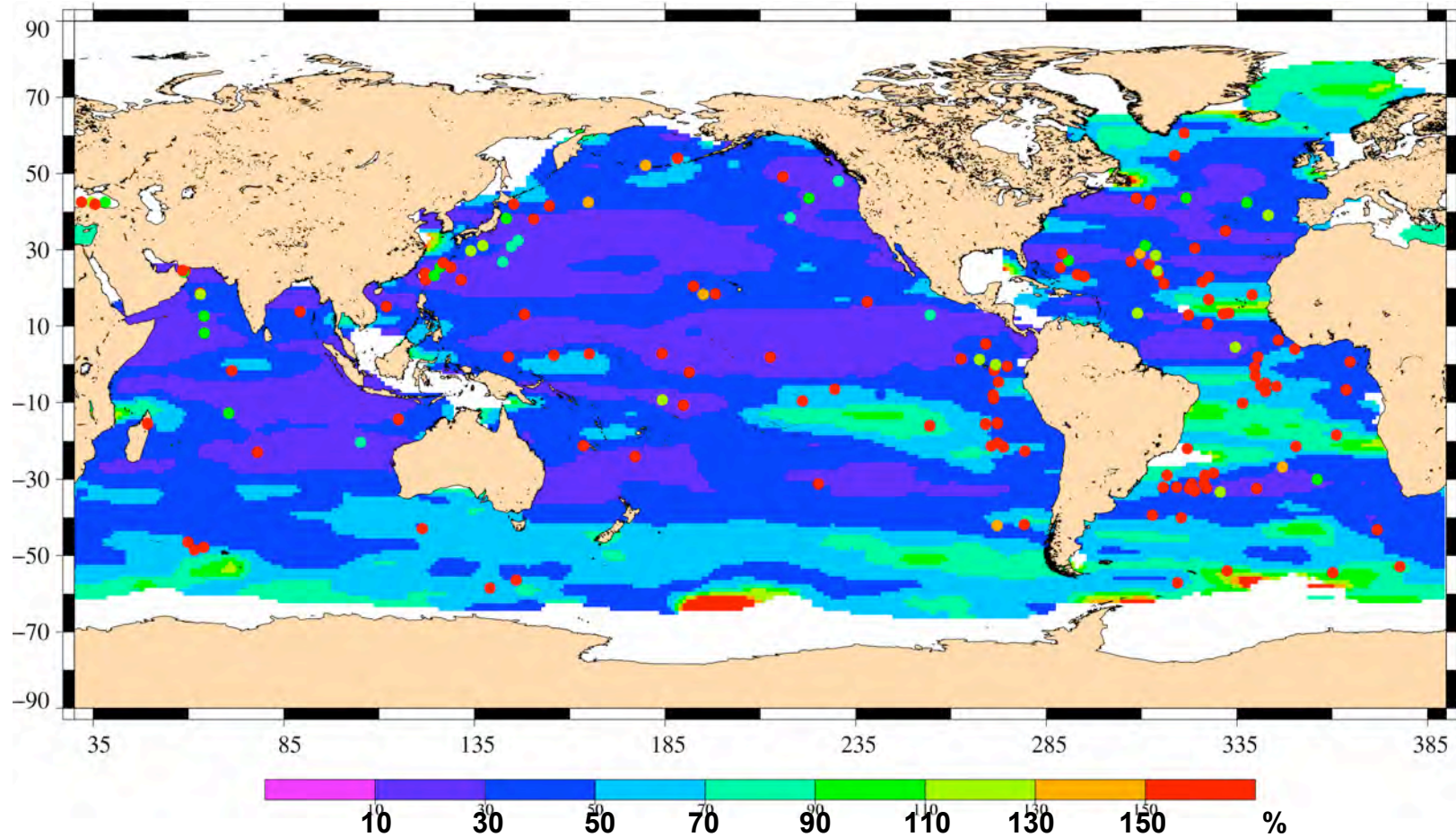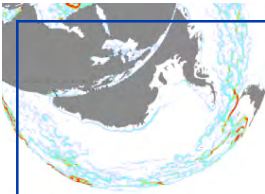- Comparisons with the mean representative statistics :
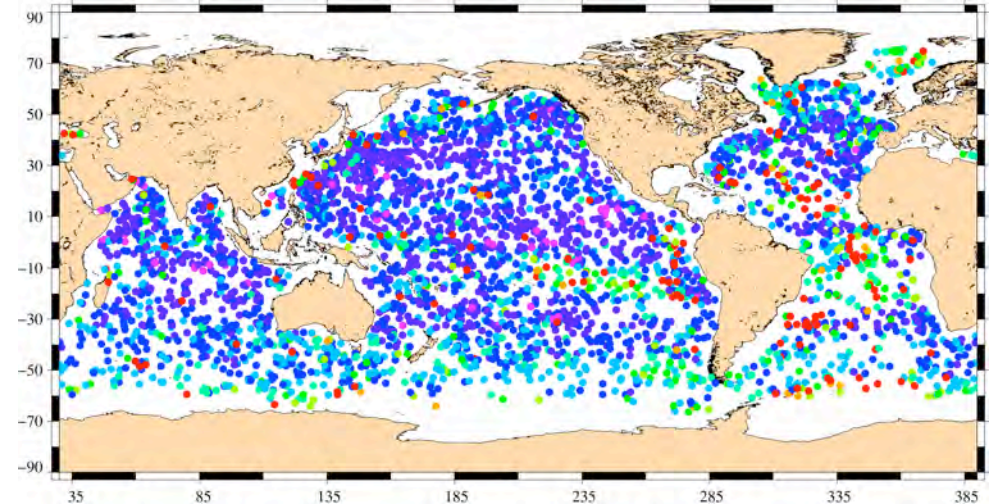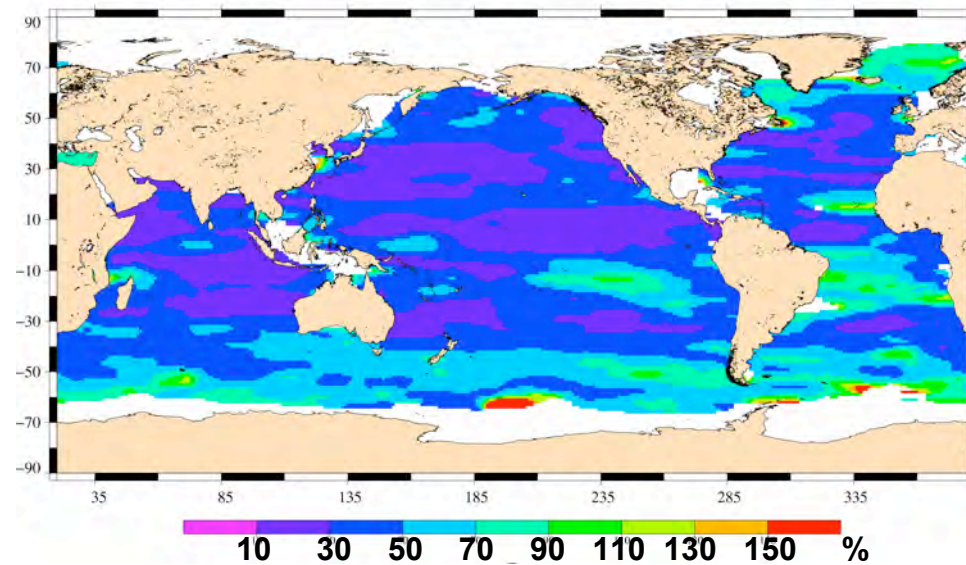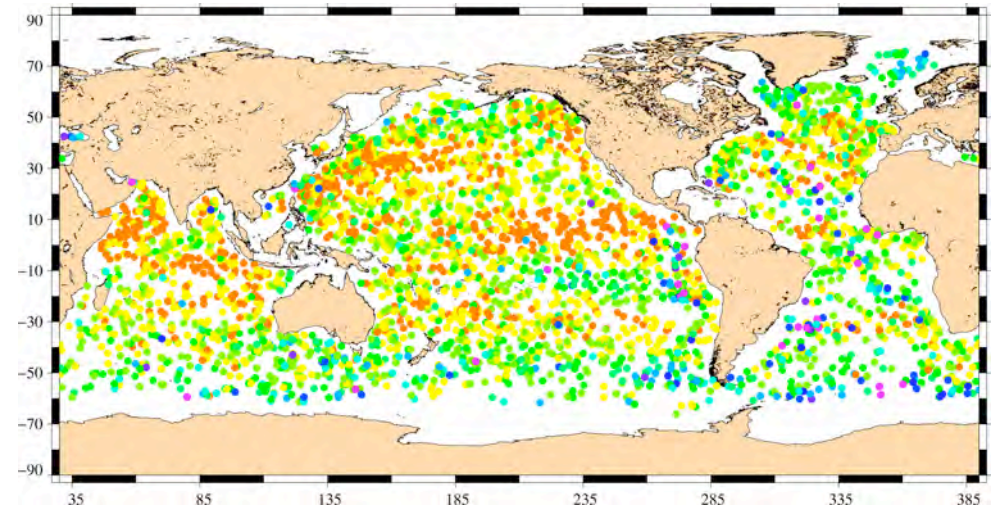
Argo quality control : *Global results*

- Comparisons with the mean representative statistics
 ➔ extraction of 111 anomalous floats
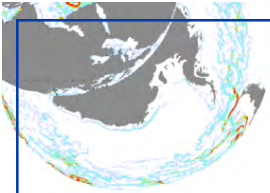
Argo quality control : *Global results*

- ftp://ftp.ifremer.fr/ifremer/argo/etc/argo-ast9-item13-AltimeterComparison

- List of floats to be checked :

| DAC	WMO	INST-TYPE	TYPE OF ANOM
kma	2900434	846	spikes
meds	4900116	846	offset
meds	51886	831	offset
meds	51887	831	offset
incois	2900783	846	offset
coriolis	1900651	846	spike
coriolis	5900198	842	?
coriolis	6900399	841	offset
coriolis	69039	842	drift
bodc	1900141	842	spike
bodc	1900454	842	spikes

…………
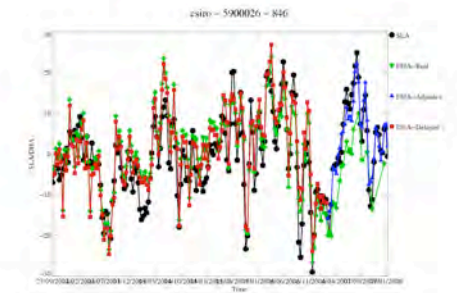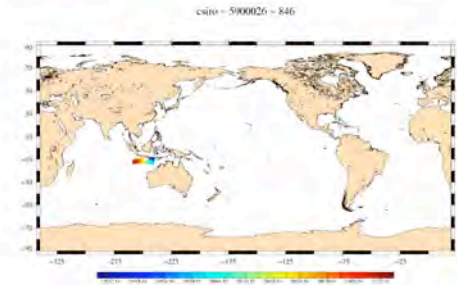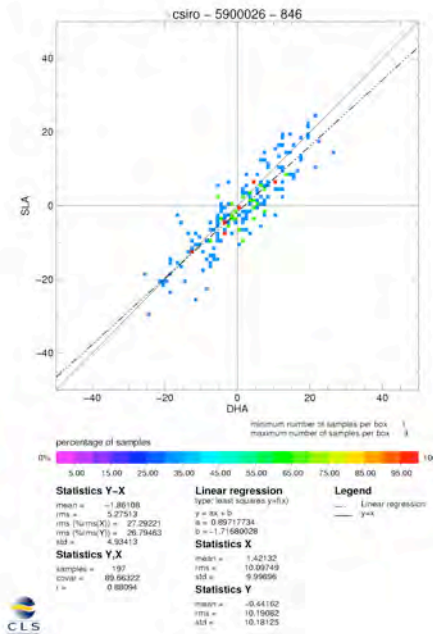
- The AIC monthly report for May

- Dacs should check the suspicious floats they are managing together with their delayed mode operators and Pis and provide appropriate corrections if needed – provide feedback on the method
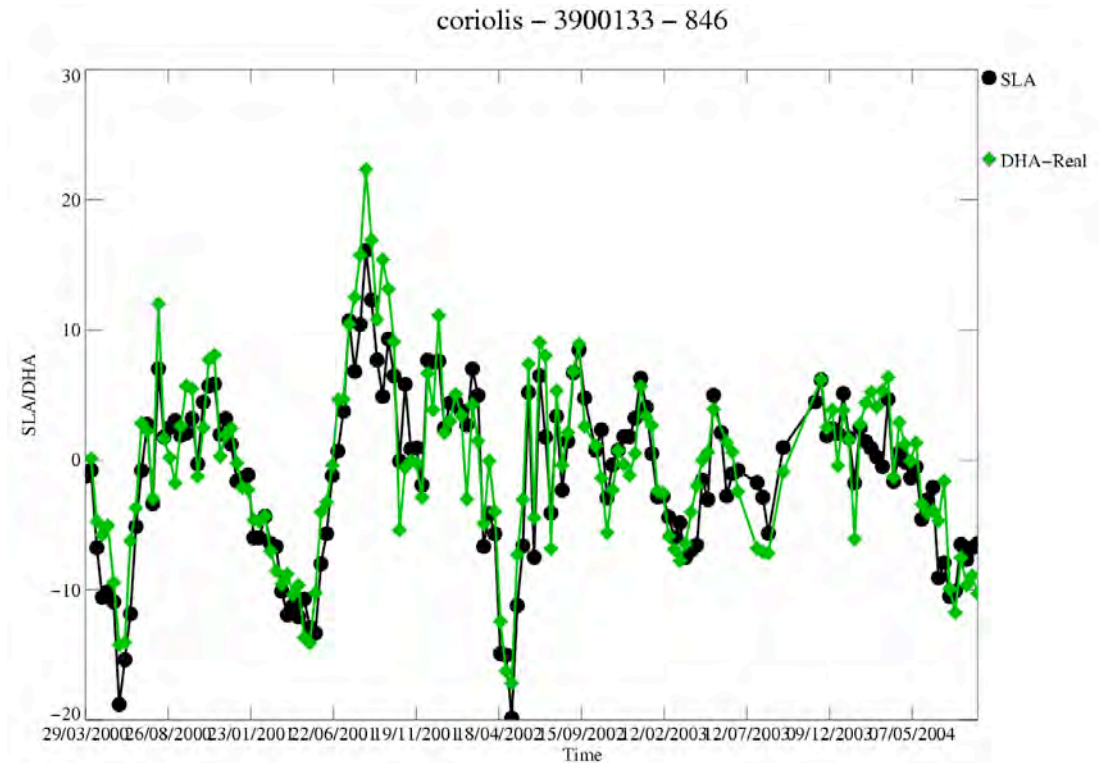
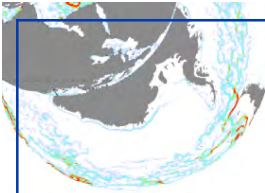# Argo quality control : *Very good consistency*

- The majority of floats !

coriolis – 3900133 – 846
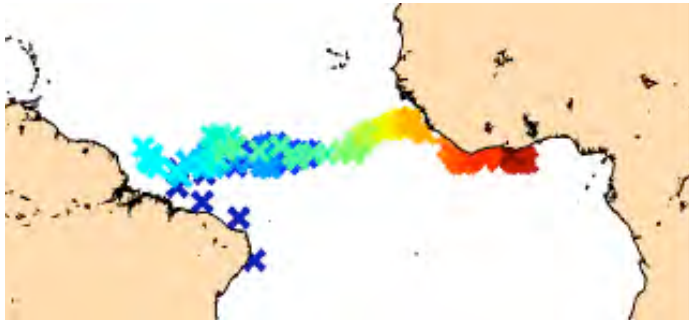
Float : 3900133

r : 0.91

rms-diff : 20.44 %

mean-diff : -0.73 cm

samples : 147
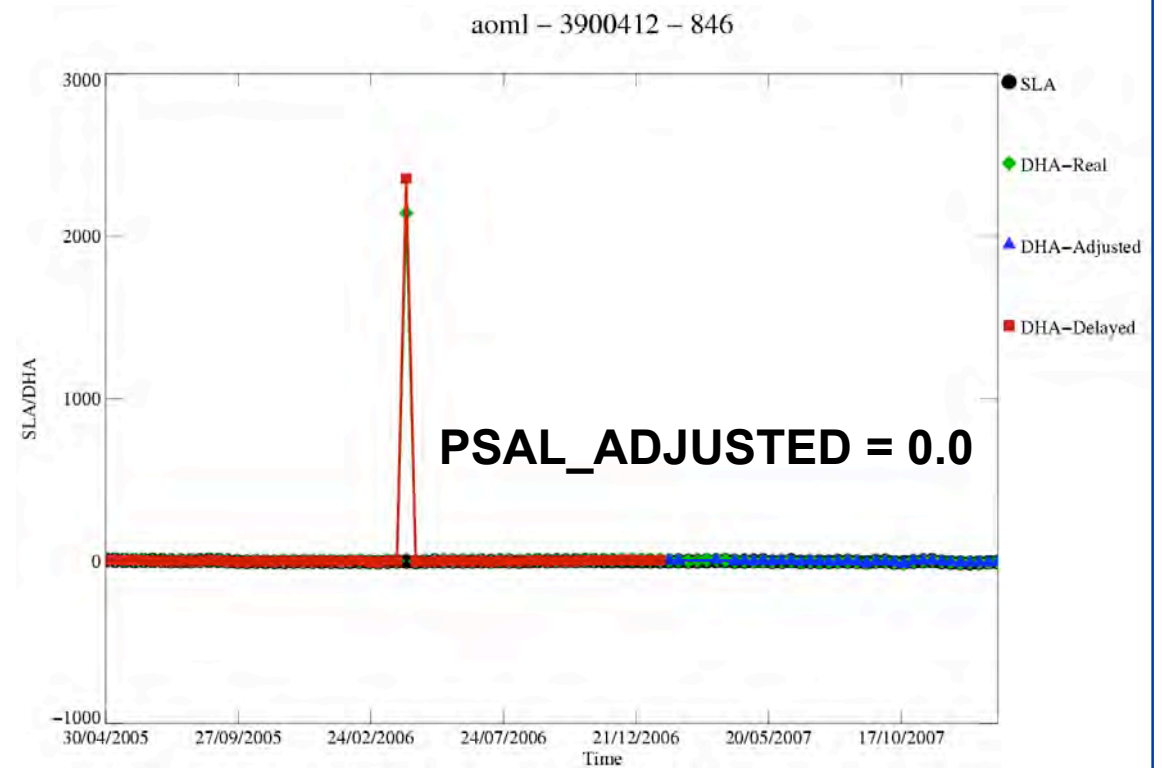
Argo quality control : *Representative anomalies*

- Spike

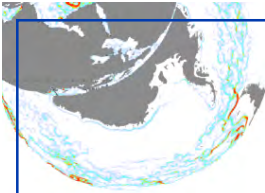Float : 3900412
r : 0.83
rms-diff : 45.96 %
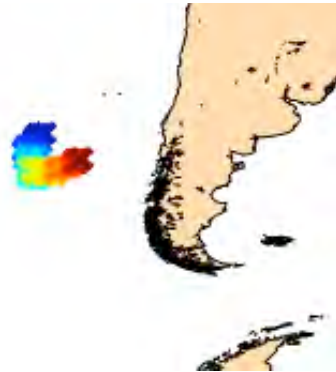mean-diff : -0.70 cm
samples : 95

aoml − 3900412 − 846

PSAL_ADJUSTED = 0.0

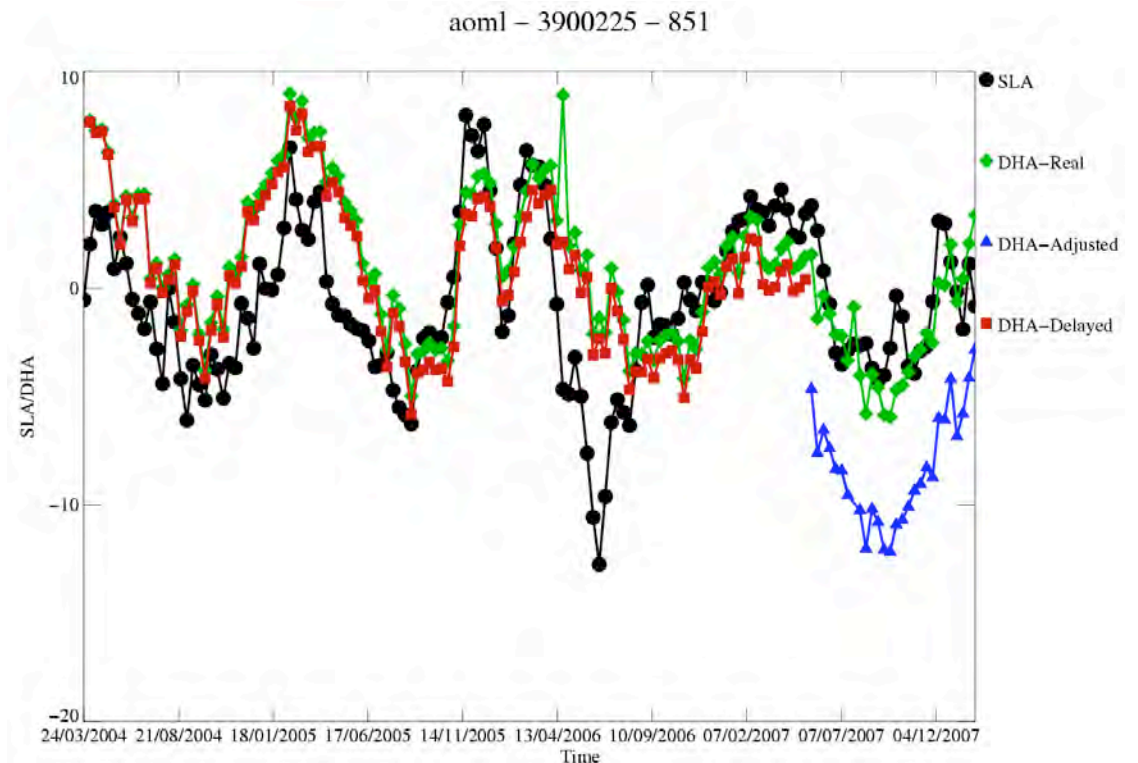➔ **Delayed-mode values to be qualified**

Argo quality control : *Representative anomalies*
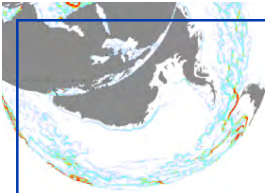
- Problem in the Adjusted time series :
  - Delayed-mode value : S-offset = 0.015
  - Real-time adjusted value : S-offset = 0.092

Float : 3900225

r : 0.45

rms-diff : 142.75 %

mean-diff : 0.20 cm

samples : 147

➔**Adjusted values in real-time to be qualified**

Argo quality control : *Representative anomalies*
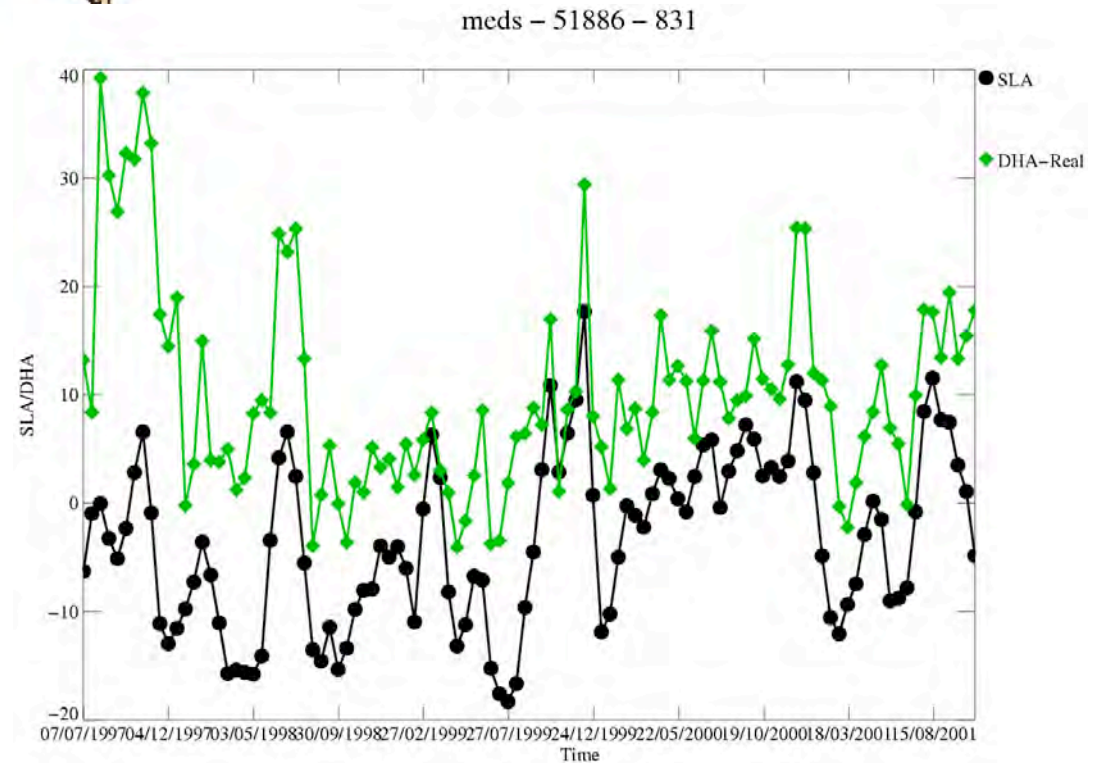
- Systematic bias of 13 cm:
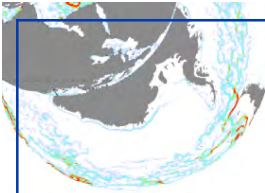

Float : 51886

r : 0.57

rms-diff : 334.00 %

mean-diff : -13.28 cm
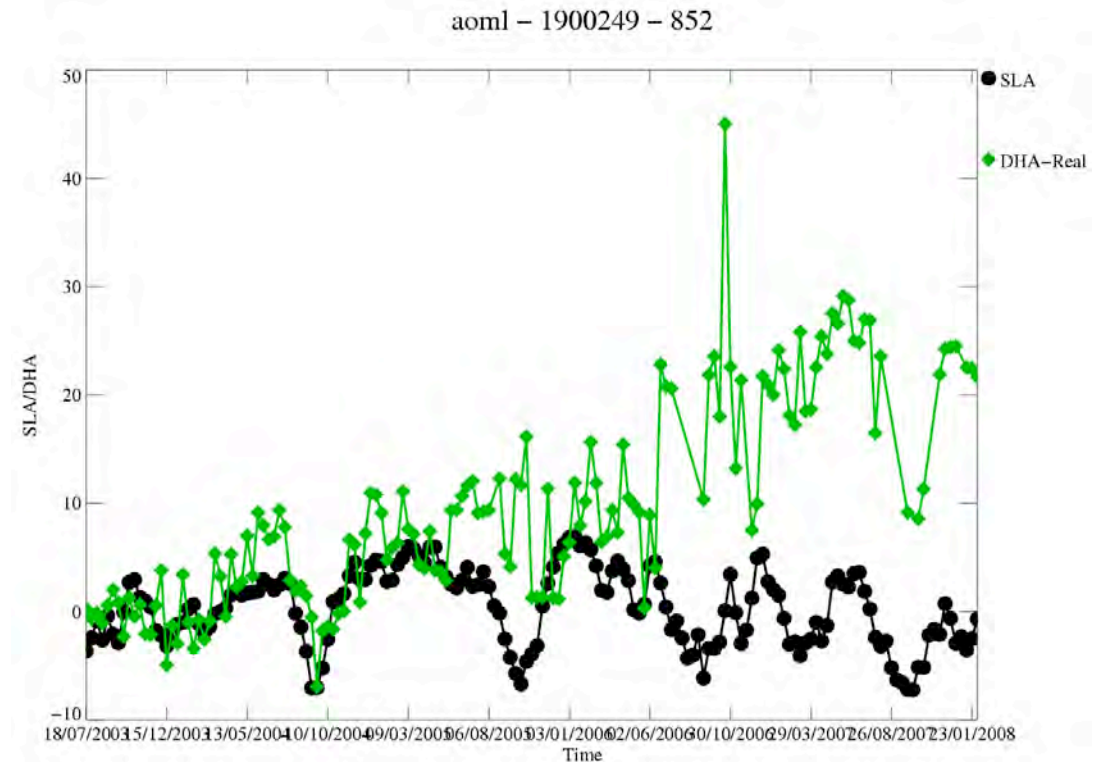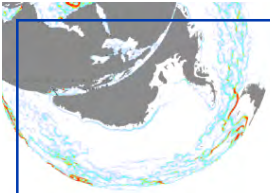
samples : 106

Argo quality control : *Representative anomalies*

- Progressive drift of the salinity/pressure sensors :

Float : 1900249

r : 0.00

rms-diff : 1538.0 %

mean-diff : -8.98 cm

samples : 152

Sea level variability : *Data and Method*

- The objective is to study the **interannual variability** of the sea level :
  total / steric

  - Altimeter data : AVISO multi-mission combined products (1/3° grid – weekly)
    - ➔ total sea level variability
  - Argo data : same data set – suspicious floats have been separated – DHA (900 m / Argo mean dynamic height)
    - ➔ steric sea level variability [0-900] m

- Method :

  - Argo data being discrete measurements in time and in space, steric sea level maps are constructed using an optimal interpolation method : 1/3° grid – monthly
    - mapping method very similar to the one used to compute the AVISO products but with specific parameter

  - The monthly maps (total/steric) are globally averaged to produce time series of total / steric sea level

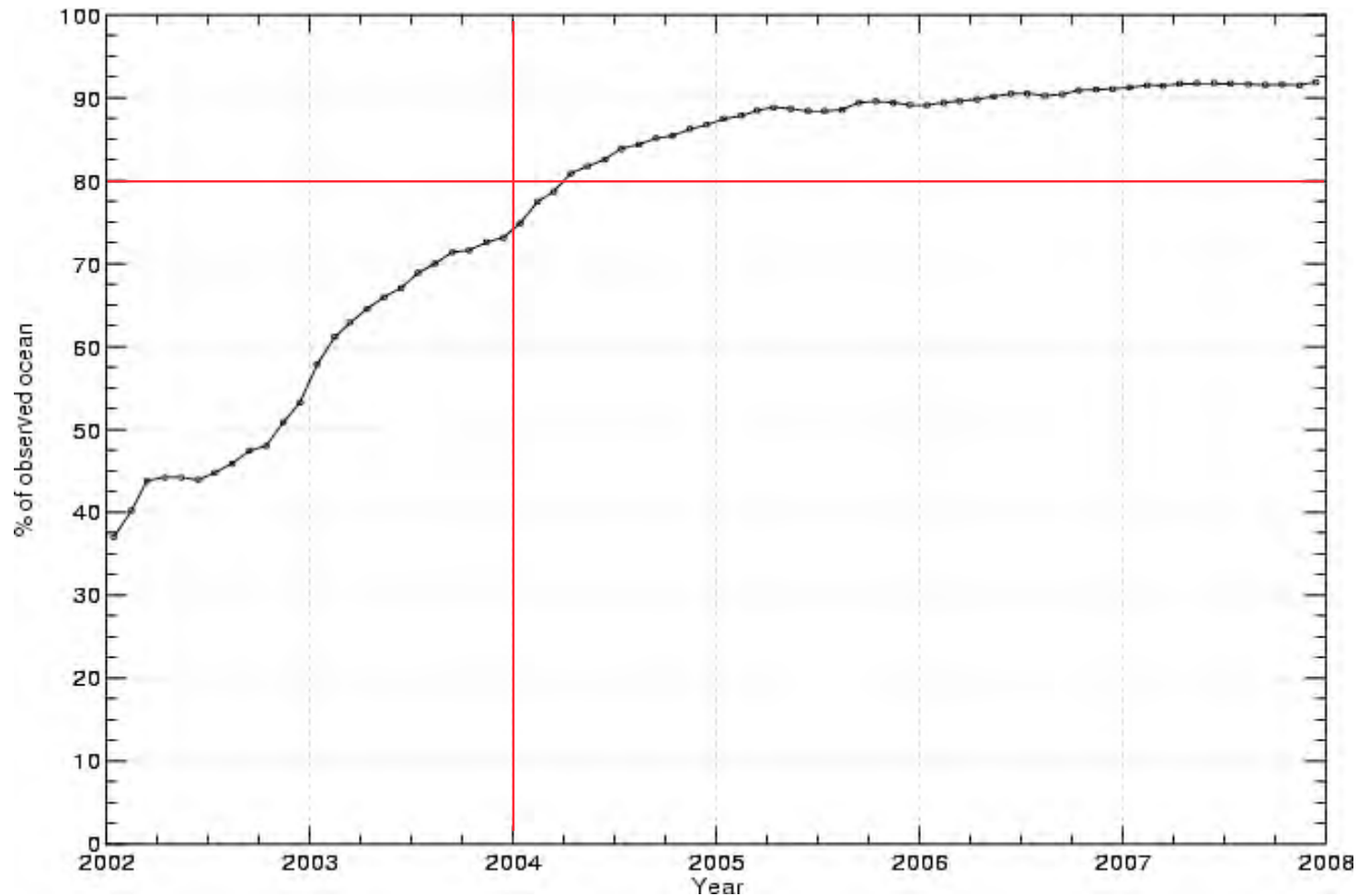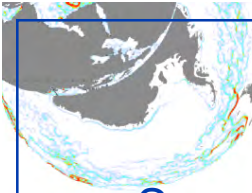# Sea level variability : *Argo data coverage - 2002-2007*
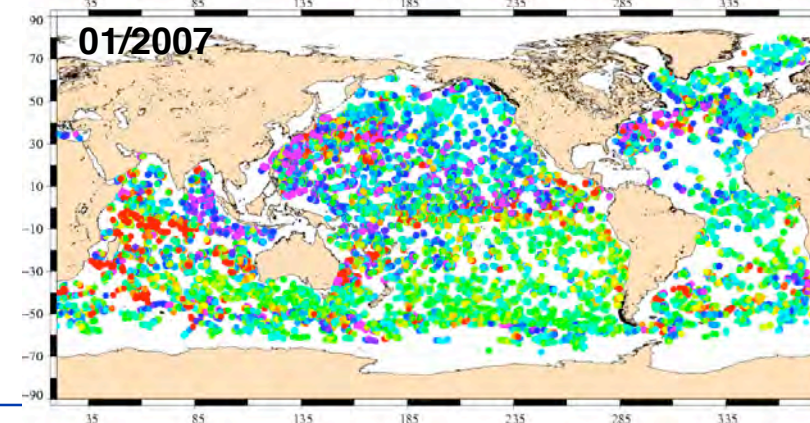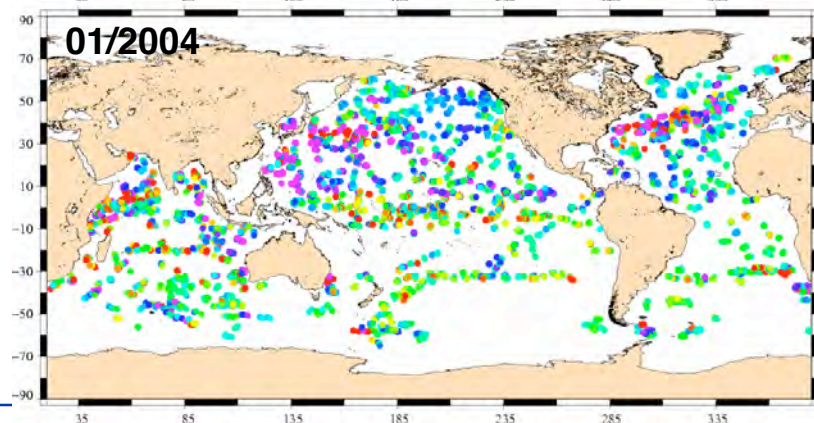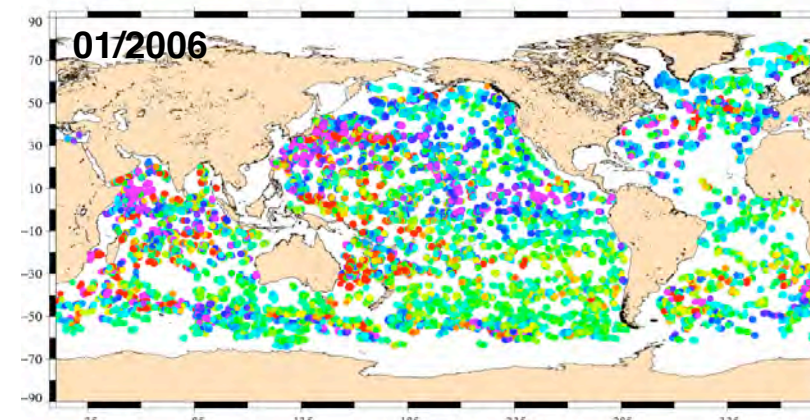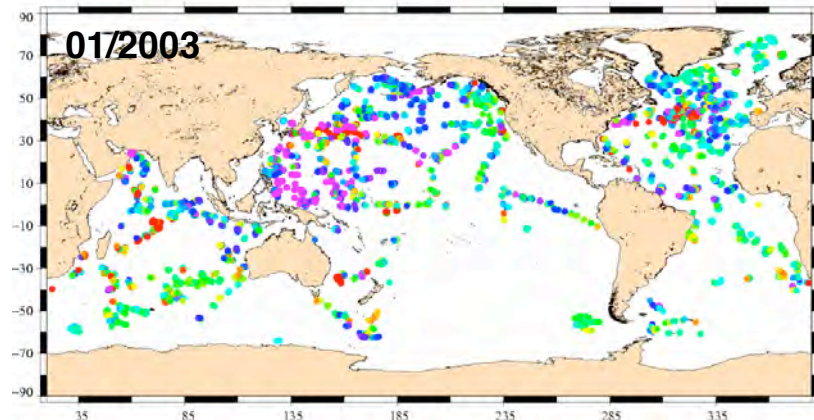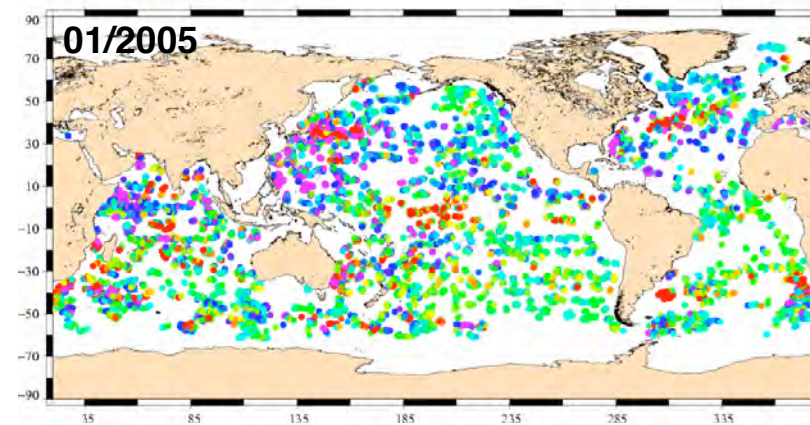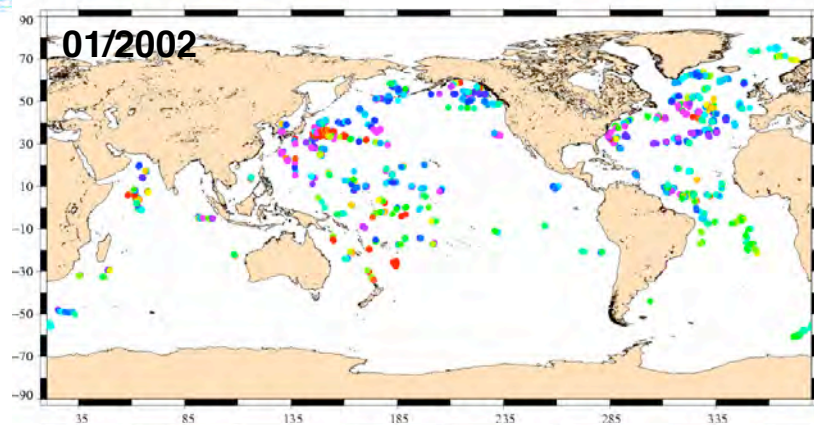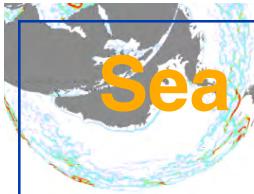
Sea level variability : *Argo data coverage - 2002-2007*

- From the distribution of the Argo measurements
  - ➔ Percentage of observed ocean (= the area of the ocean reconstructed by the mapping method compared to the area of the ocean sampled by the altimeter maps) :
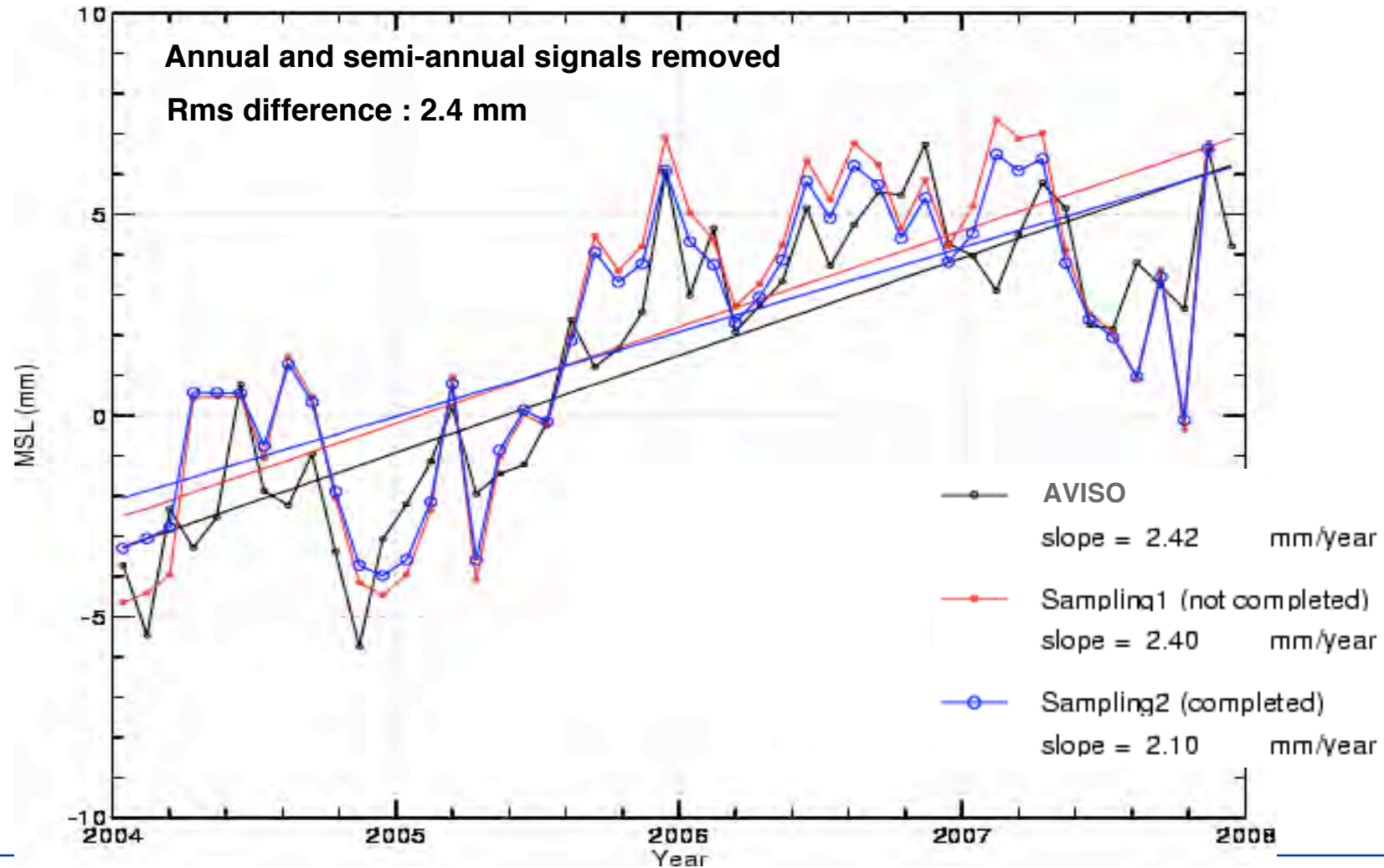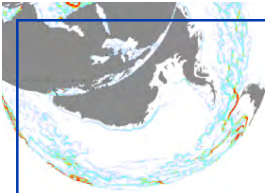

➔ temporal window of the study : **2004-2007**

# Sea level variability : *Impact of the sampling*

- Sampling experiment performed using the Altimeter maps as a proxy for the Argo data
    - Altimeter maps subsampled at the time and position of the Argo data set
    - Monthly maps reconstructed using the same mapping method as for the Argo date
    - Globally averaged values compared to the one obtained from the Altimeter maps

Annual and semi-annual signals removed

Rms difference : 2.4 mm

AVISO
slope = 2.42 mm/year

Sampling1 (not completed)
slope = 2.40 mm/year

Sampling2 (completed)
slope = 2.10 mm/year

Sea level variability : *Steric seasonal signal*

- From the Argo data sets : annual and semi-annual cycles fitted
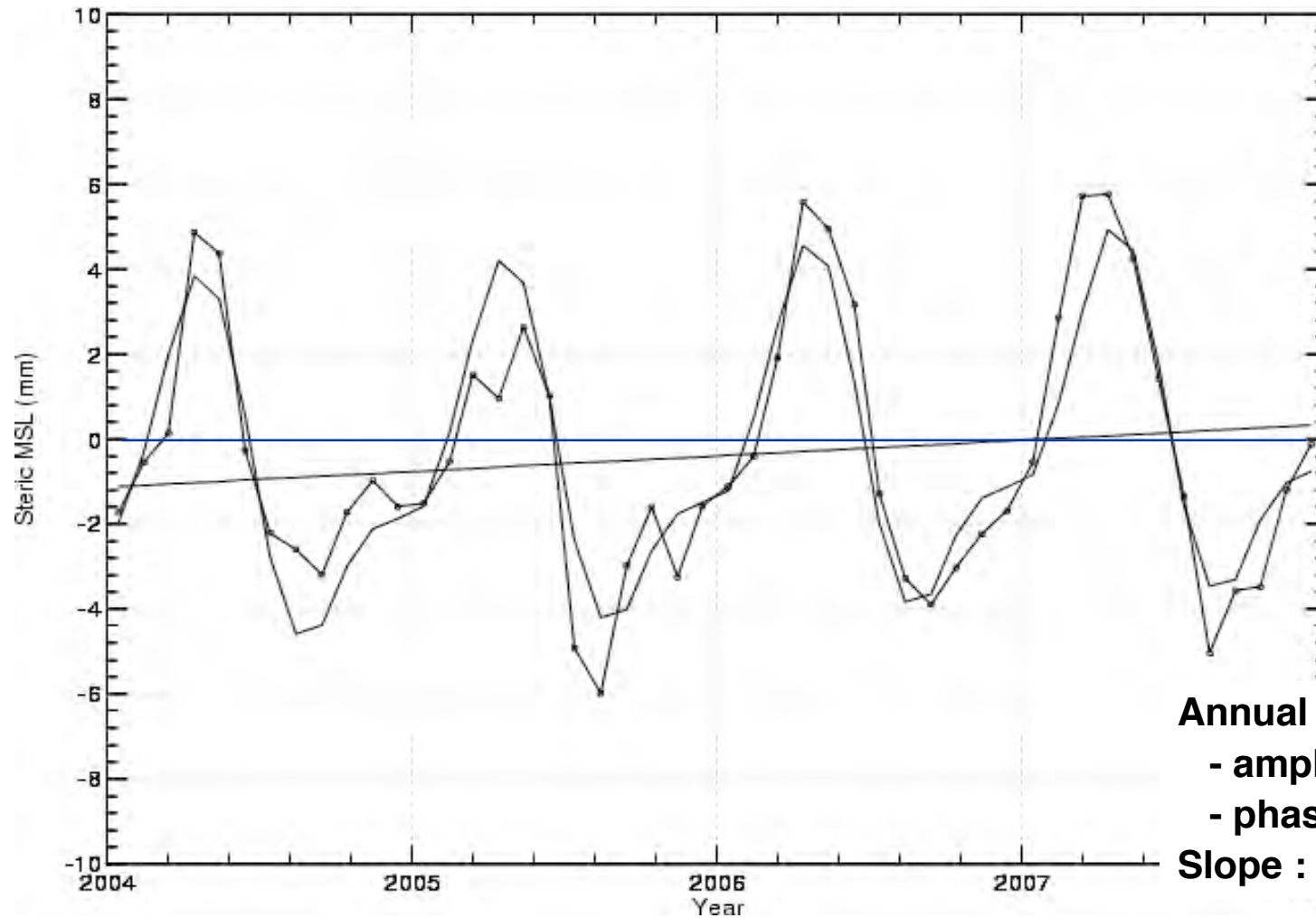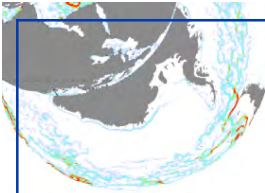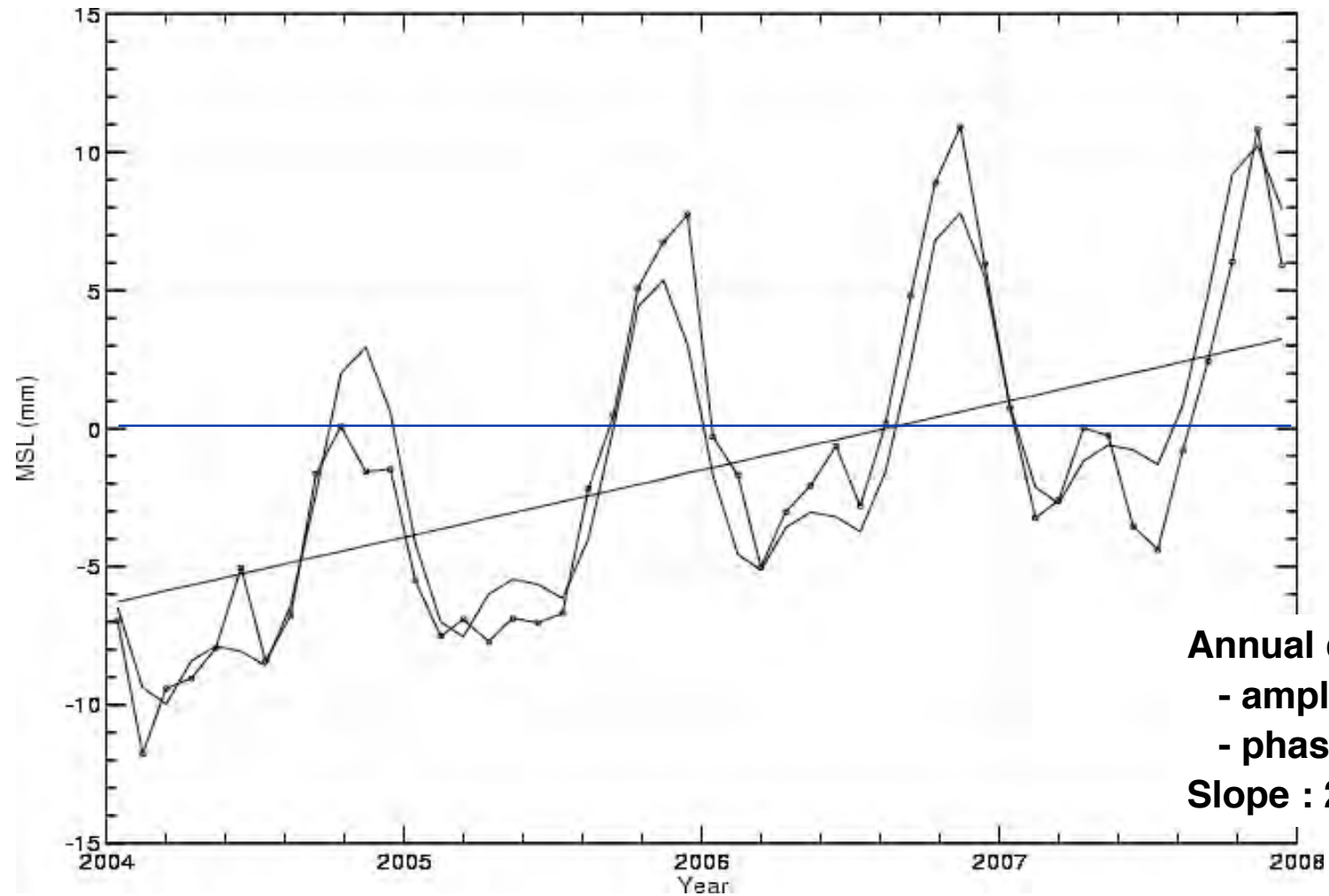

Annual cycle :
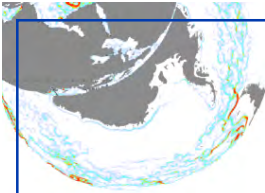- amplitude = 3.5 mm
- phase = 95 °

Slope : 0.37 mm/year

Sea level variability : *Total seasonal signal*

- From the Altimeter : annual and semi-annual cycles fitted

Annual cycle :
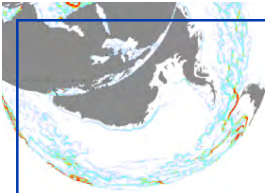- amplitude = 4.5 mm
- phase = 236 °
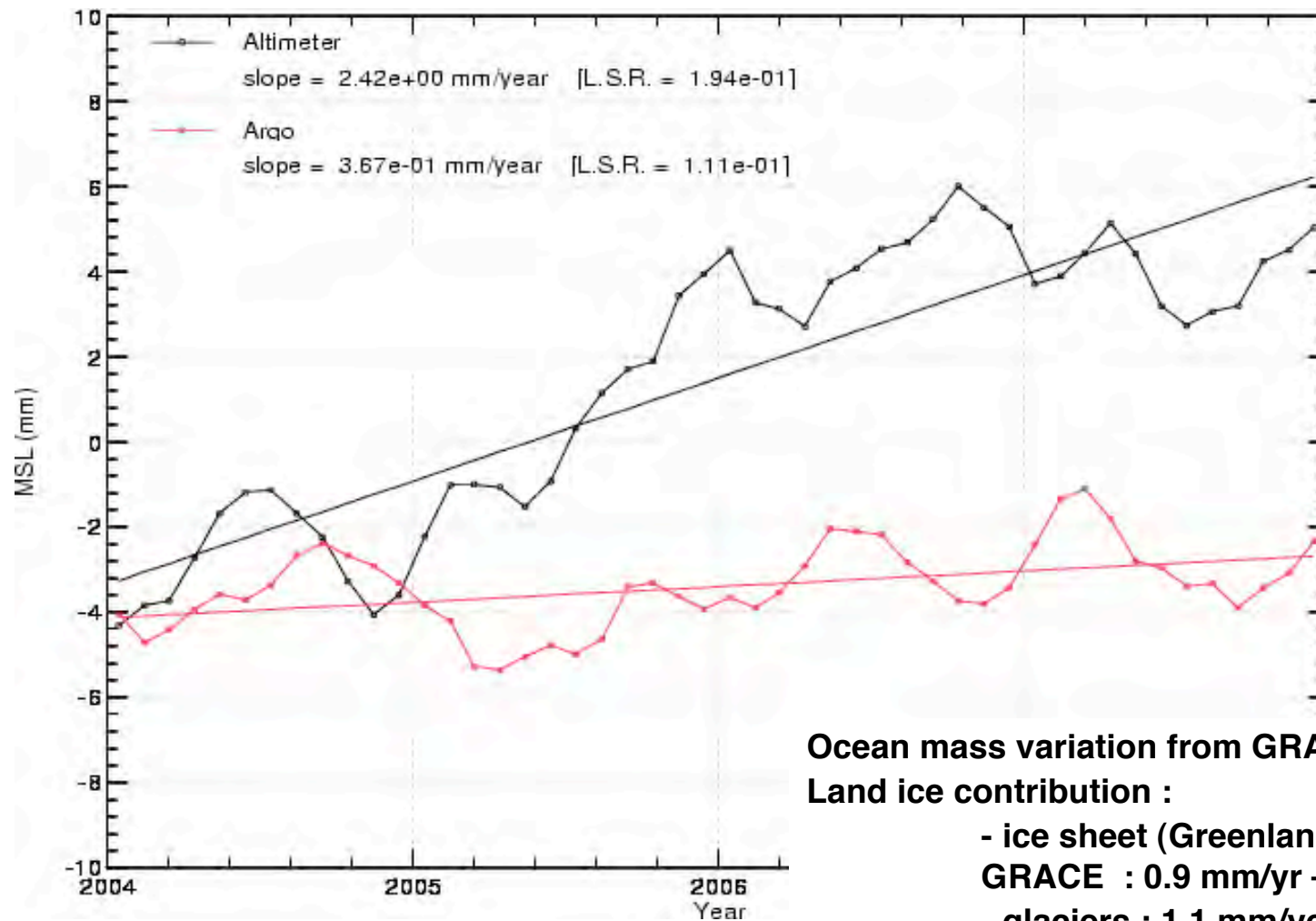Slope : 2.42 mm/year

Sea level variability : *Total / Steric*

- Phase shift on the seasonal signal : ocean mass annual cycle – exchange of water between lands and oceans
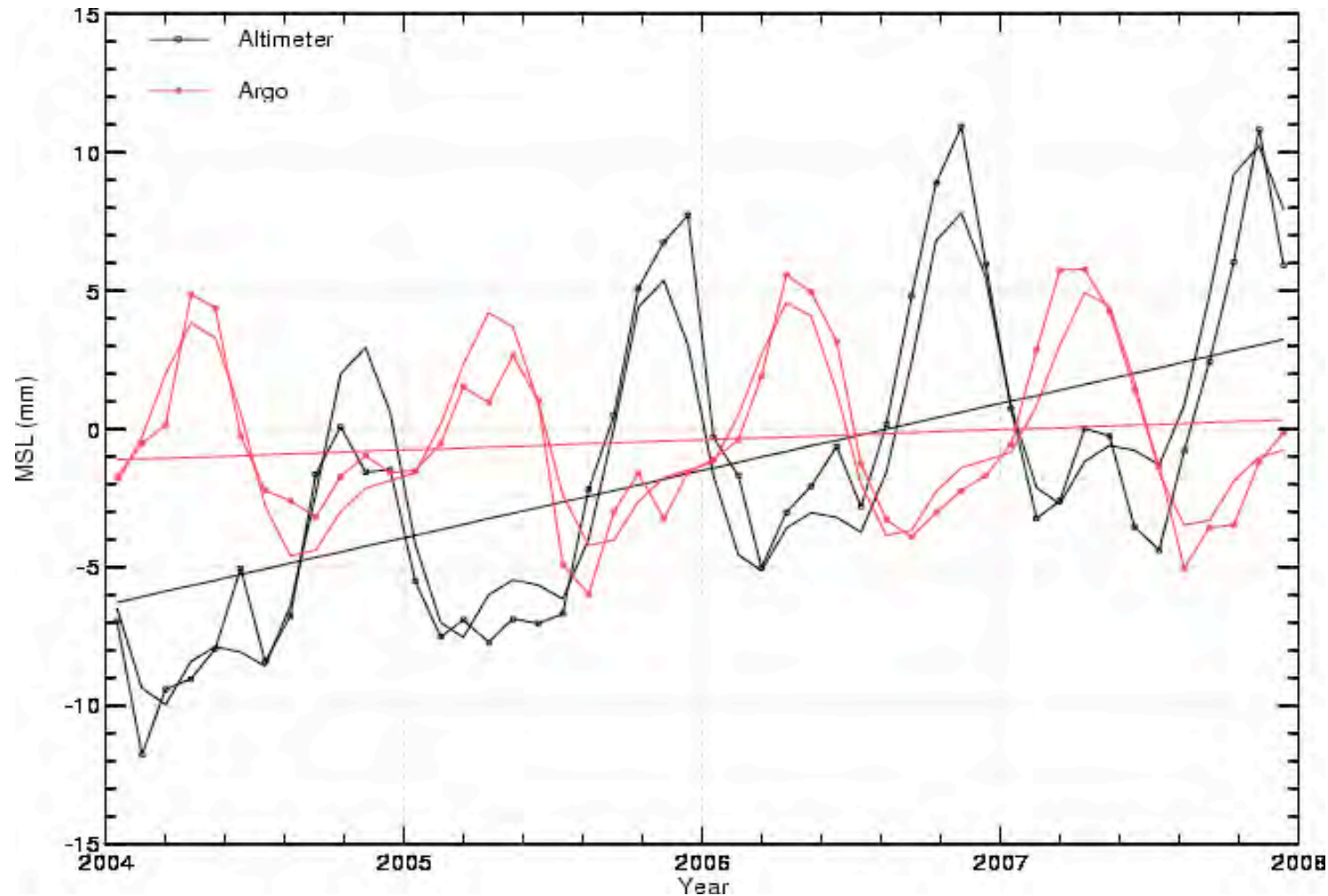
Sea level variability : *Total / Steric*

- Interannual variability (annual and semi-annual cycles filtered) :

Cazenave et al., 2008 :

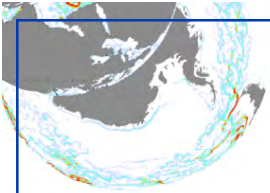**Ocean mass variation from GRACE : 1.7 mm/yr – 2003-2007**
Land ice contribution :
- ice sheet (Greenland and Antarctica) – from GRACE : 0.9 mm/yr – 2003-2007
- glaciers : 1.1 mm/year – 2006 (Meier et al., 2007)
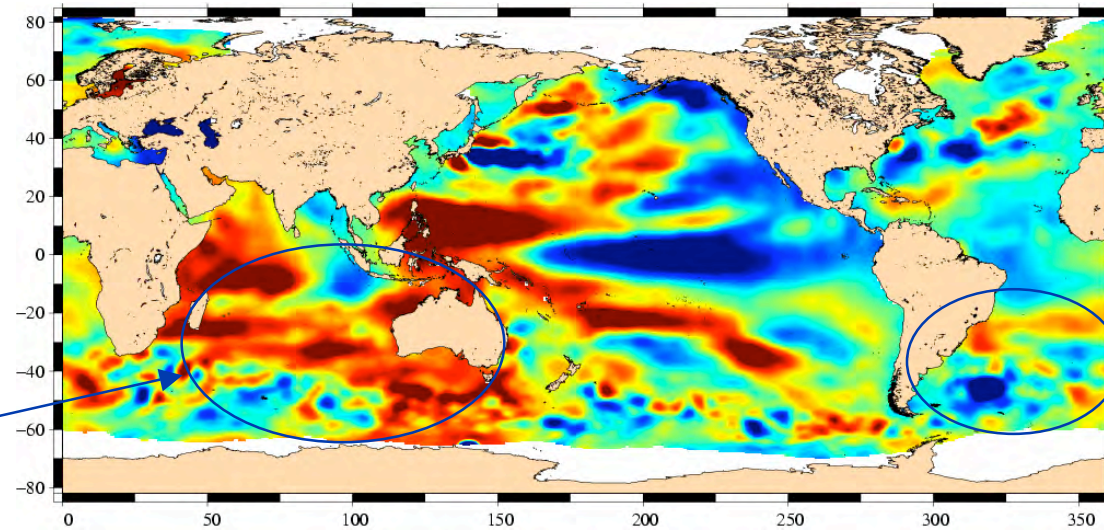➜ **Nearly closing the sea level budget**

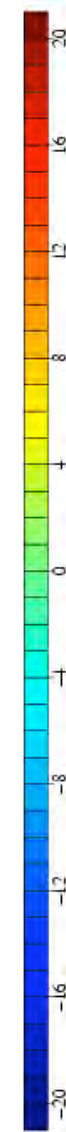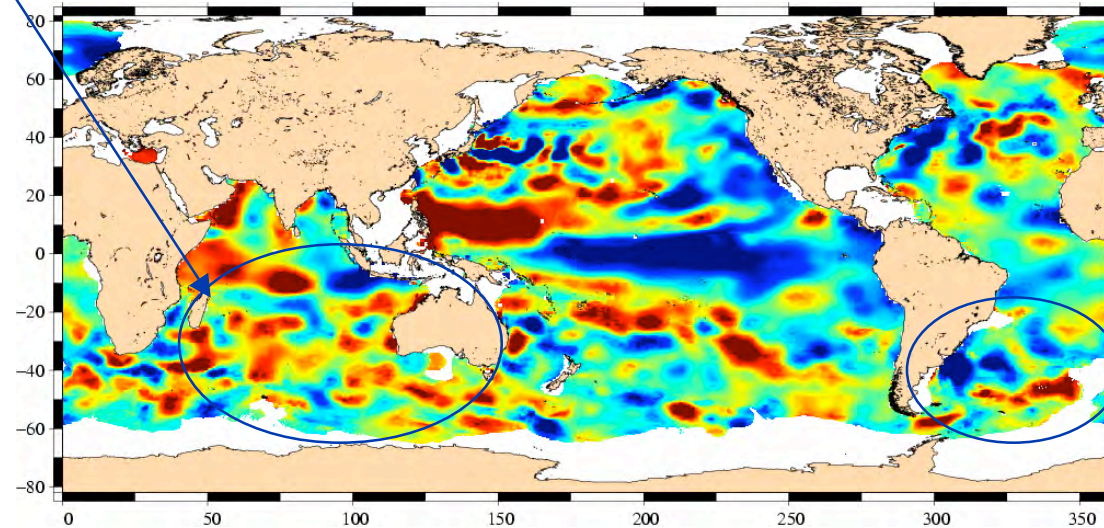# Sea level variability : Steric/*Total*
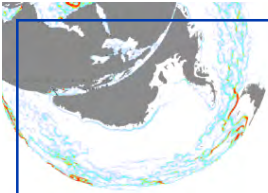
- Spatial distribution : 2004-2007

Total

Large discrepancies in the Indian and South Atlantic Ocean
➔ to be further analysed

Steric

mm/year

Conclusions and Perspectives

- Argo/Altimeter comparisons are able to detect different kind of anomalies : spike, drift, offset ...
    - Some Argo floats should be carefully checked and reprocessed by the PIs
    - Feedbacks from the PIs are highly welcome to improve the method
    - The method will be activated on the full Argo floats time series on a regular basis in order to detect suspicious floats earlier than in delayed-mode

- Argo/Altimeter comparisons appear to be very complementary to more classical method based on comparisons with climatological fields :
    - It works on a vertically integrated field : dynamic height
    - It gives a very quick idea of the behavior of the time series of the float
    - The use of contemporaneous altimeter measurements allow to have access to the mesoscale and interannual variability of the ocean
    - The same method can also be used to quantify the impact of the delayed-mode adjusted fields (salinity, pressure)

- Sea level variability study will be continued :
    - To work on the error budget on the different estimates
    - To understand the large discrepancies between the total/steric estimates in the Indian and South Atlantic Oceans (deeper signals ?)
    - To close the sea level budget
    - To study the vertical structure of the variability (upper layers / deeper layers)