The impact of the assimilation of SLA along track Observation with high-frequency signal in IBI system

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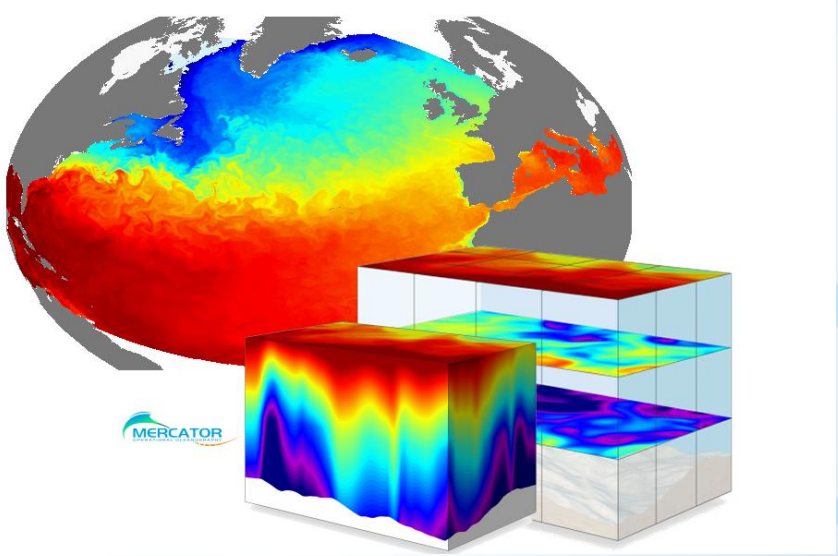
and Mercator Ocean Team



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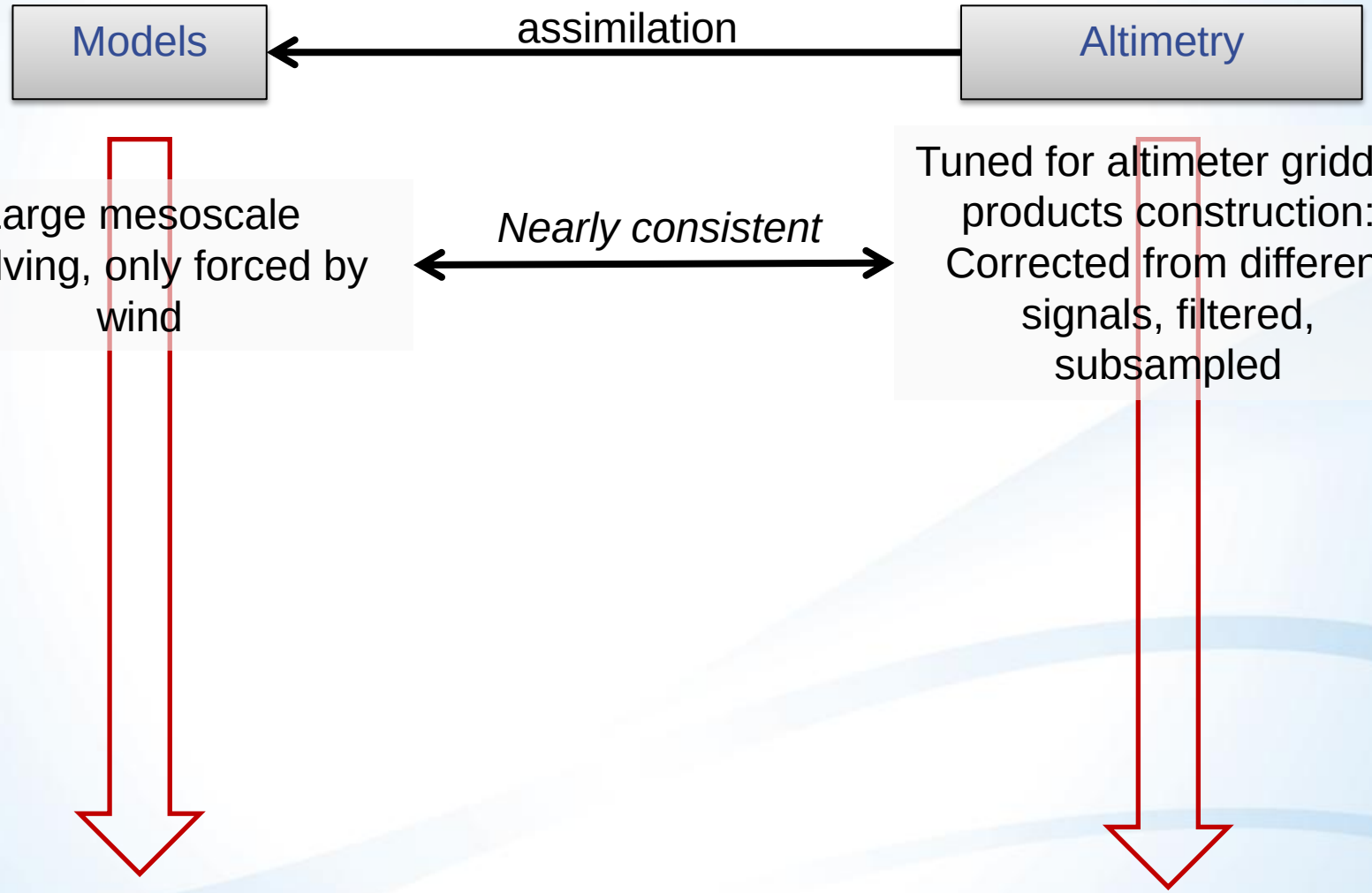
Context


Models
assimilation
Altimetry
Large mesoscale resolving, only forced by wind
Nearly consistent
Tuned for altimeter gridded products construction: Corrected from different signals, filtered, subsampled

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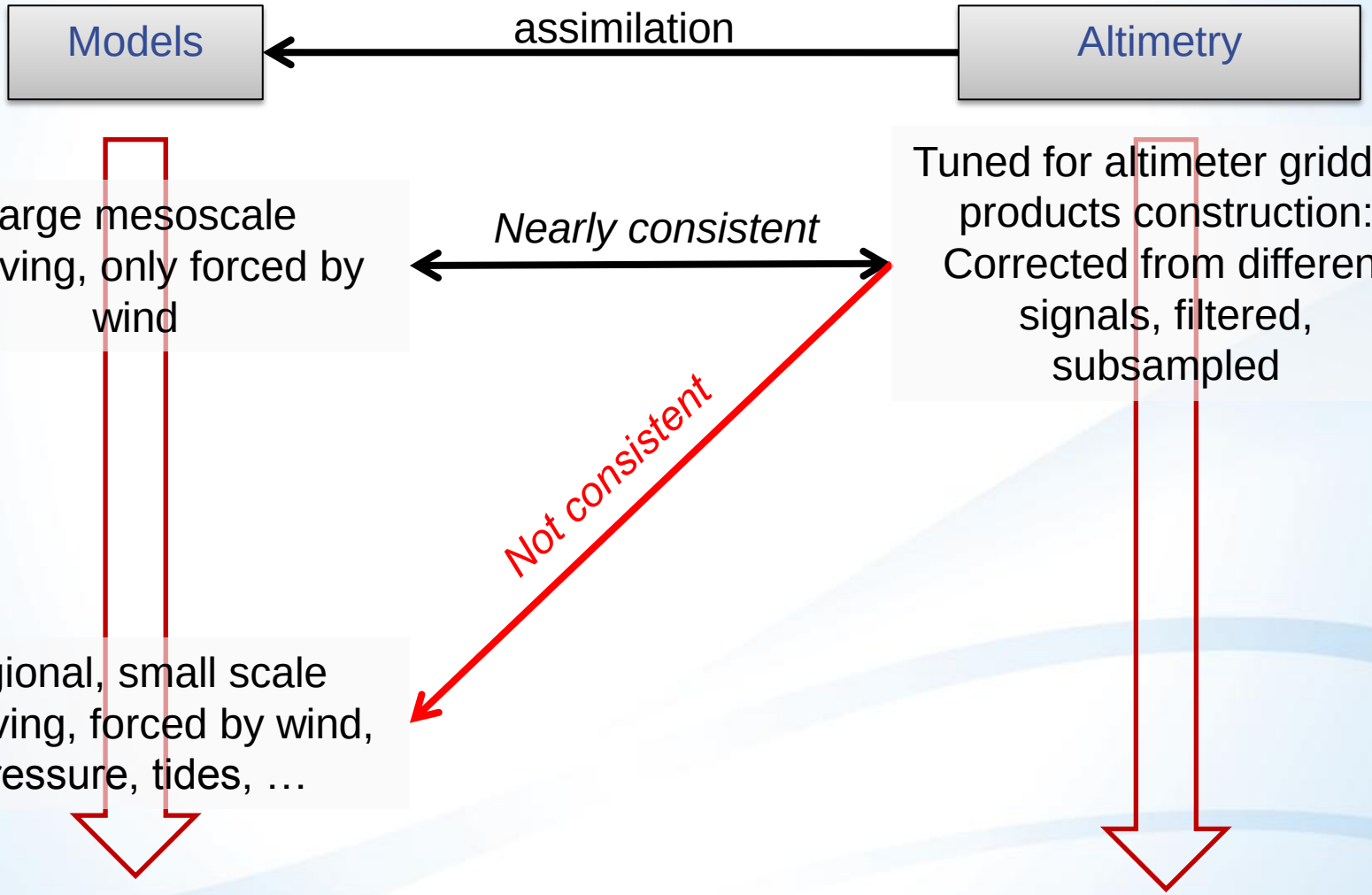
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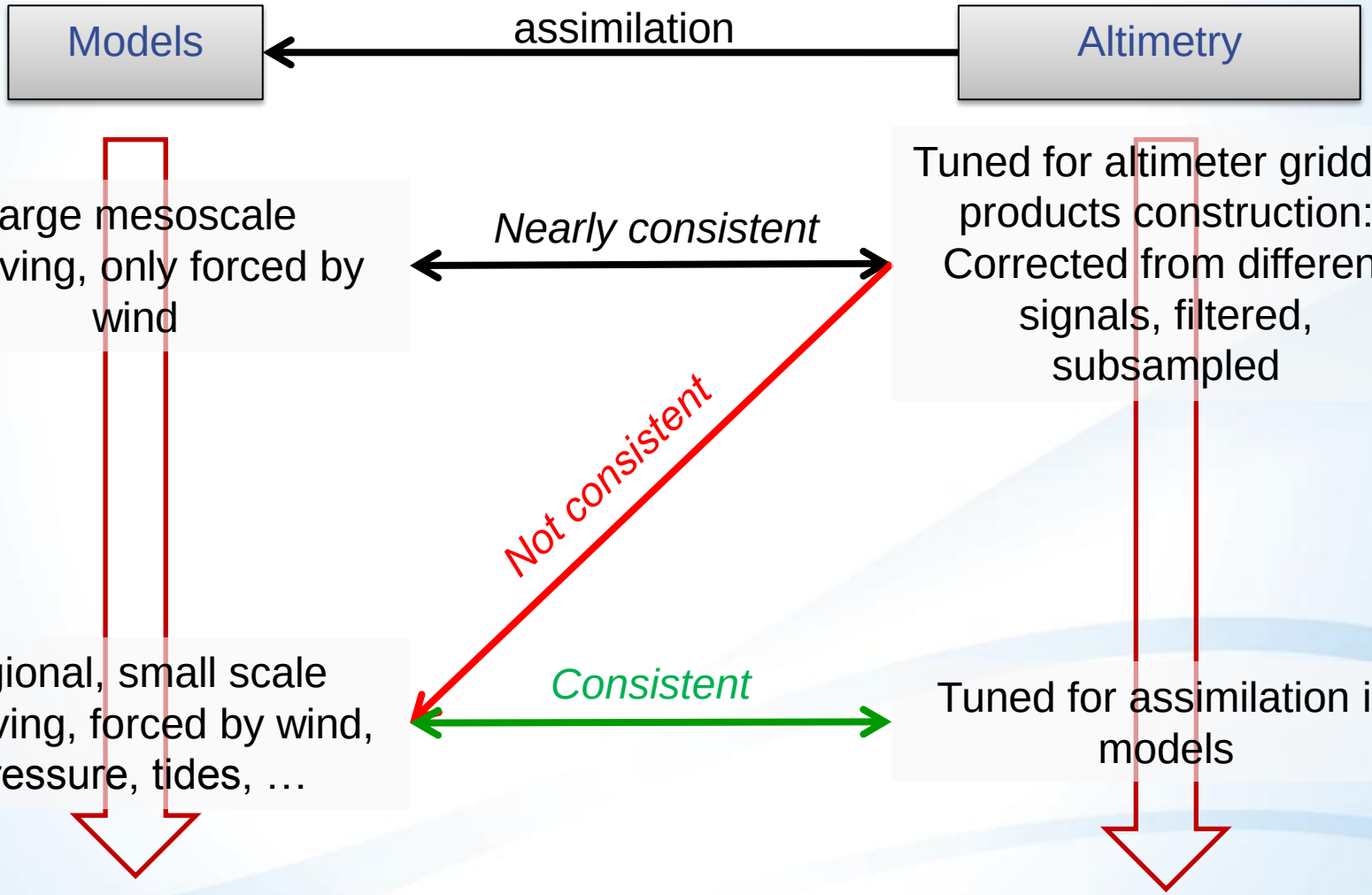
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regional, small scale resolving, forced by wind, pressure, tides, …
Consistent
Tuned for assimilation in models

The "TAPAS" initiative

TAPAS : Tailored Altimetric Products for Assimilation Systems

OBJECTIVE :

Define an altimeter along-track product that fit the assimilation needs:

- spatial resolution
- physical content

Convential SLA Observations (e.g DUACS):
VFEC : Verified, Filtered, SubSampled and Corrected)

$$SLA_{vfec} = SLA_{Sat} - DAC - LWE - TIDE$$

TAPAS SLA Observations, verified and Corrected

$$SLA_{vxxc} = SLA_{Sat} - DAC - LWE - TIDE$$

No filtering, no subsampling;
DAC, LWE & TIDE are also provided to let to the user the possibility to use them or not

Residual $orbit_{ER}$, IB_{ER}, Residual Tide Corr and Aliased HF signals

The "TAPAS" initiative

TAPAS : Tailored Altimetric Products for Assimilation Systems

TAPAS SLA Observations, verified and Corrected

$$SLA_{VXXC} = SLA_{Sat} - DAC - LWE - TIDE$$

No filtering, no subsampling;
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➔ TAPAS products are used to assess the assimilation of altimetry data containing high frequency signals in a regional model (IBI12).

- ✓ Non along-track filtered
- ✓ Non sub-sampled (i.e. 7km instead of 21 Km)
- ✓ Without Dynamical Atmospheric Correction (DAC= IB_{LF} + $MOG2D_{HF}$)

IBI-1/12° SYSTEM
(IBI : Iberian-Biscay-Irish area)

Model(NEMO2.3, Madec et al. 1998, Madec,2008**):**

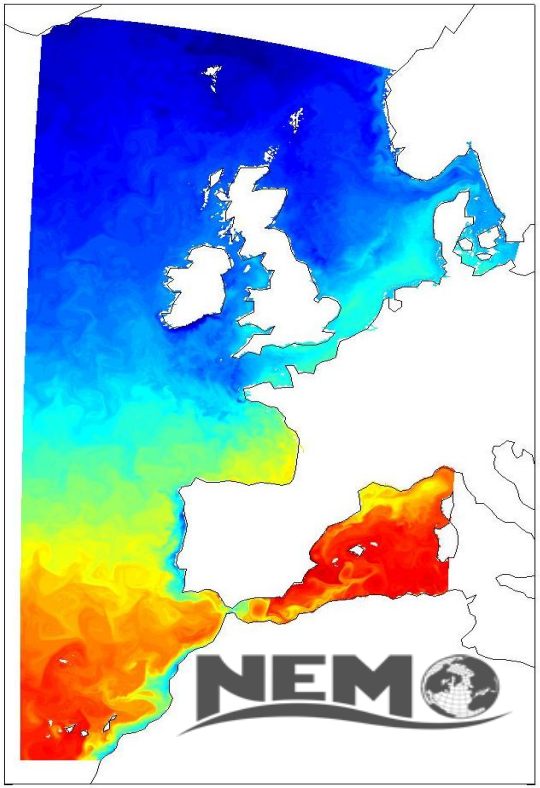
- **explicit free surface**, « **time splitting** » + Variable volume formulation
- **k-ε** : the Generic Length Scale (GLS) formulation (Umlauf and Burchard, 2003)
- **Tides (including potential) : M2, S2, K2, N2, K1, O1, P1, Q1, M4,Mf, Mm**
- **Atmospheric pressure forcing**
- Open boundaries from GLORYS2V1 ¼° reanalysis (daily)

Data Assimilation:

- Reduced order Kalman Filter (SEEK formulation)
- 3D-VAR Bias corrections : for T and S
- Incremental Analysis Updates (IAU) : Analysis J-2.5
- SST Correction in Bulk
- Quality Control of in situ observation

Assimilated Observations:

- Along track **SLA** observations From AVISO, usual **corrections applied → filtering of tides in the model Background**
- In situ profiles **T** & **S** from CORA3.1 data base
- Reynolds AVHRR ¼° **SST**



Objective : Assimilation of SLA along track Observation with high-frequency signal in regional model

Experience	Atm. Pressure forcing in Model	High-frequency signal in Observation	Period
CONTROL	Yes	No	2009
HF_ASSIM	Yes	Yes	2009

Assimilation of SLA with the high-frequency signal (DAC = IB+MOD2G)

Control Experience

Model:

$$\begin{cases} \dfrac{\partial U}{\partial t} = \ldots\ldots - \dfrac{1}{\rho_0}\nabla p_A + \ldots \\ \text{OpenBoundaries} \;:\; ssh = ssh - SSH_{IB} \end{cases}$$

Assimilation:

$$\begin{cases} SLA_{\text{Background}} = SSH - SSH_{TIDE} - \left[SSH_{IB} + SSH_{LS\_Bar}\right] - MDT \\ SSH_{IB} = -\dfrac{1}{g\rho}(p_A - \langle P \rangle): \text{ Inverse Barometer} \\ SSH_{LS\_bar}: \text{ Large Scale of the Bartropic height computer by the model} \\ p_A: \text{Atmospheric pressure (From ECMWF model)}, \ \rho_0: \text{the reference density} \\ \langle P \rangle: \text{Spatial Averge (over the ocean)} \end{cases}$$

TAPAS SLA Observations, verified and Corrected

$$SLA_{vxxc} = SLA_{Sat} - DAC - LWE - TIDE$$

$$DAC = IB_{LF} + MOG2D_{HF}$$

LWE(Long Wave Error) : Residual orbit$_{ER}$, IB$_{ER}$, Residual Tide Corr and Aliased HF signals

Assimilation of SLA with the high-frequency signal (no more DAC = IB+MOD2G)

HF_Assim Experience

Model:

$$\begin{cases} \dfrac{\partial U}{\partial t} = ... - \dfrac{1}{\rho_0}\nabla p_A + ... \\ \text{OpenBoundaries} \;:\; ssh = ssh - SSH_{IB} \end{cases}$$

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$$SLA_{vxxc} = SLA_{Sat} - DAC - LWE - TIDE$$

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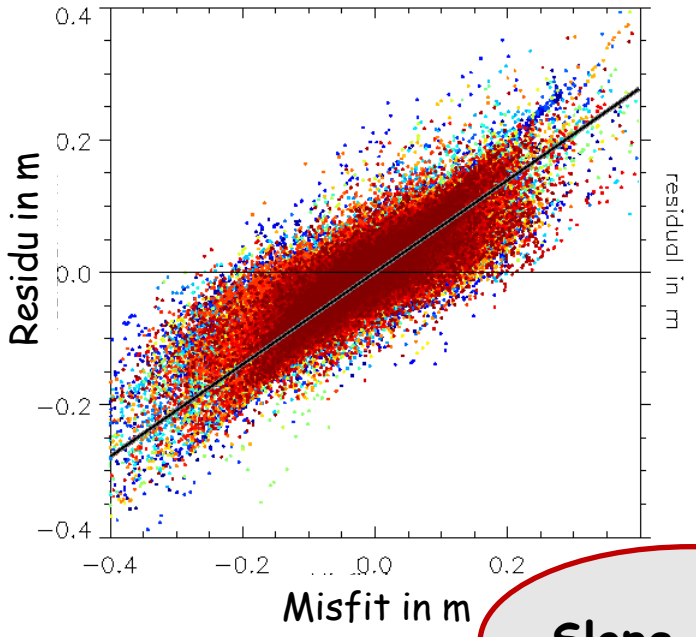
LWE(Long Wave Error) : Residual $orbit_{ER}$, IB_{ER}, Residual Tide Corr and Aliased HF signals

Impact of the assimilation of HF (SLA): Control vs HF_Assim (no DAC)

Misfit = Data - $Model_{forecast}$

Cloud Dispersion
Residual vs Misfit in SLA on 2009 (**Control**)



Slope : 70%
Too large

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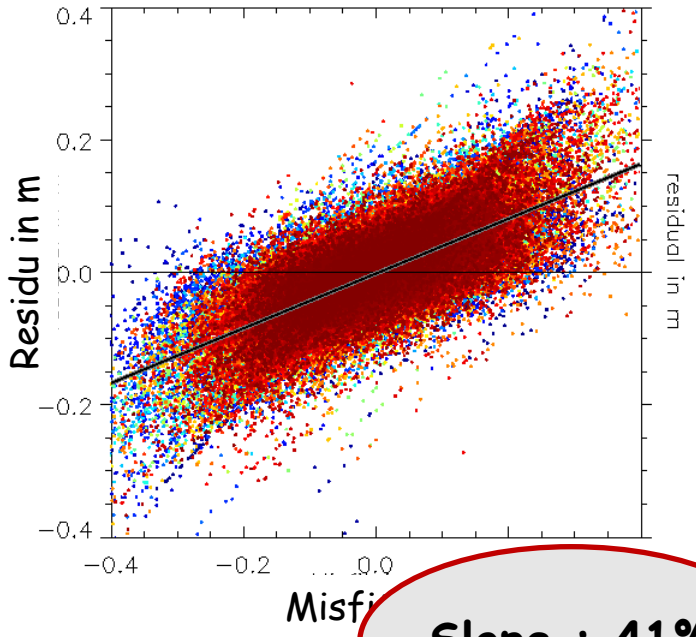


Slope : 41%

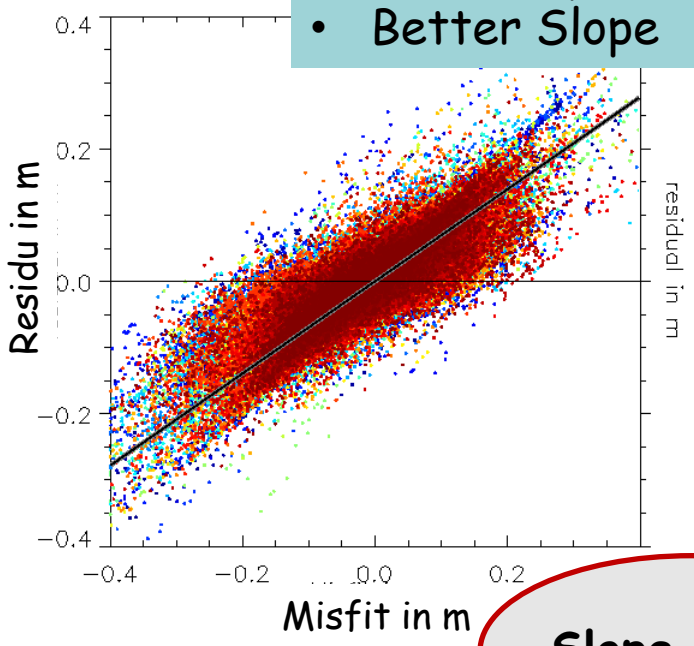
SLA : J2 + J1n + En

Impact of the assimilation of HF (SLA): Control vs HF_Assim (no DAC) Misfit = Data - $Model_{forecast}$

More efficient with High Frequency signal:
- More dispersed cloud
- Better Slope

Residual vs Misfit

009 (**HF_Assim**)



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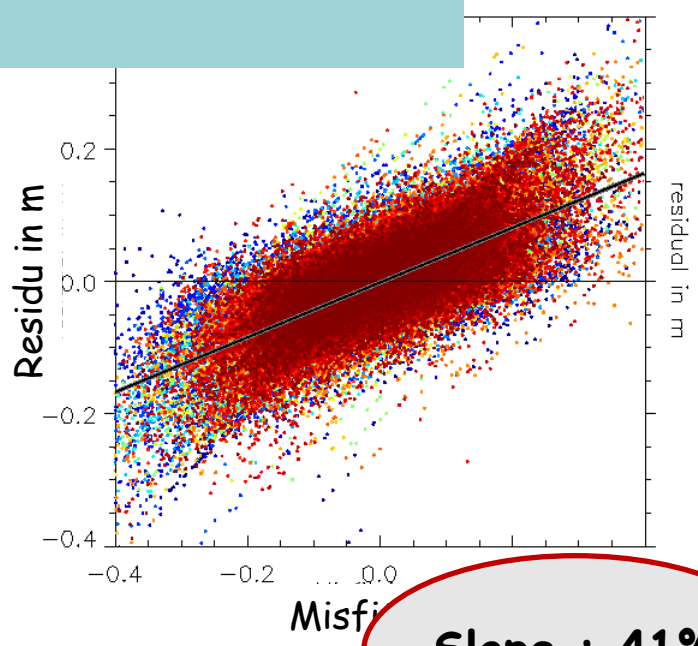

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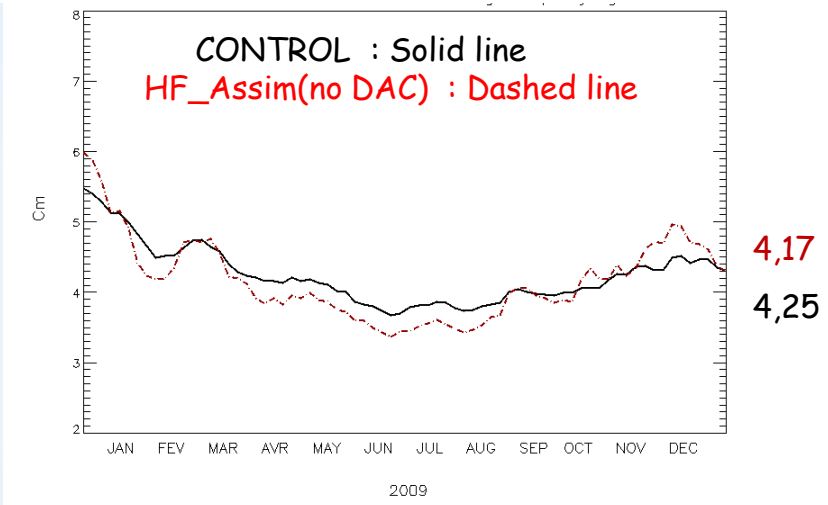
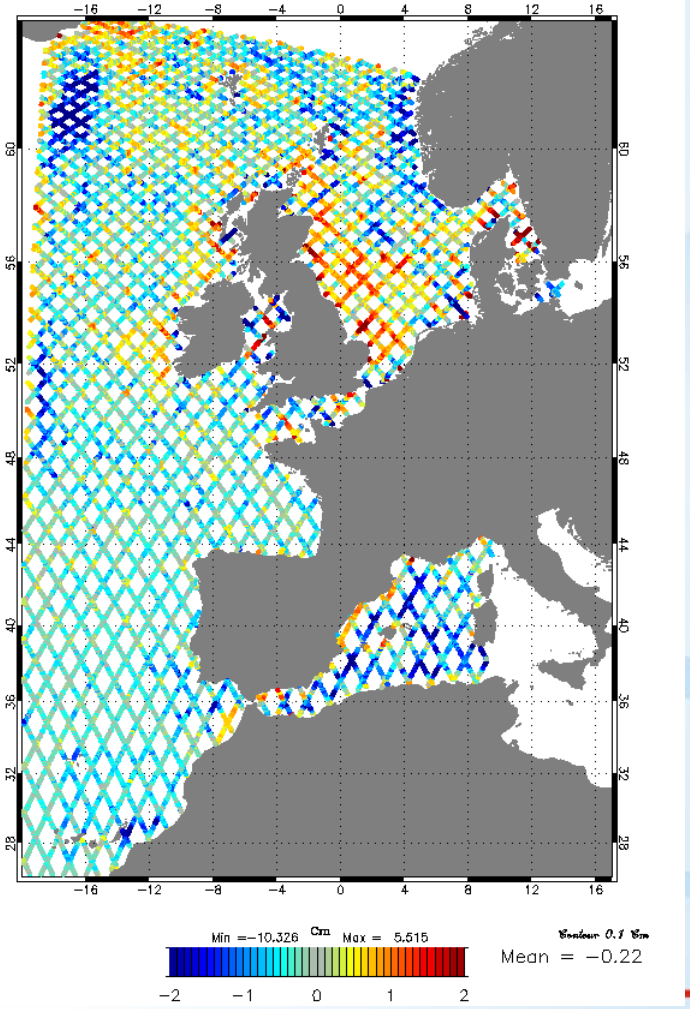
Rms of Residu SLA : With and Without HF signal



4,17

4,25

Diff Rms of Residu (HF_Assim -Control)



Blue : improvement
Red : degradation

Impact of the assimilation of HF (SLA): Control vs HF_Assim (No DAC)

Misfit = Data - $Model_{forecast}$

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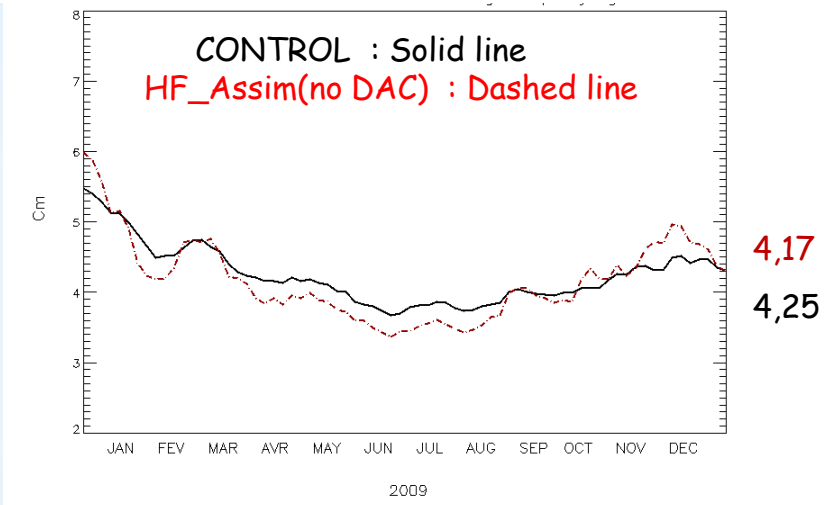

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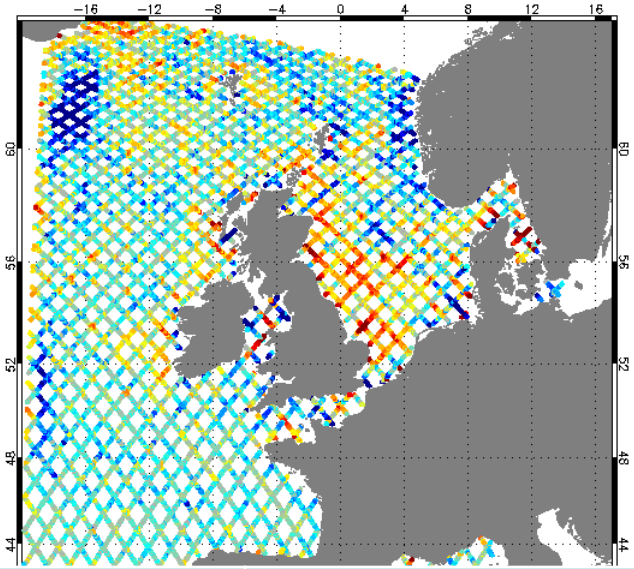
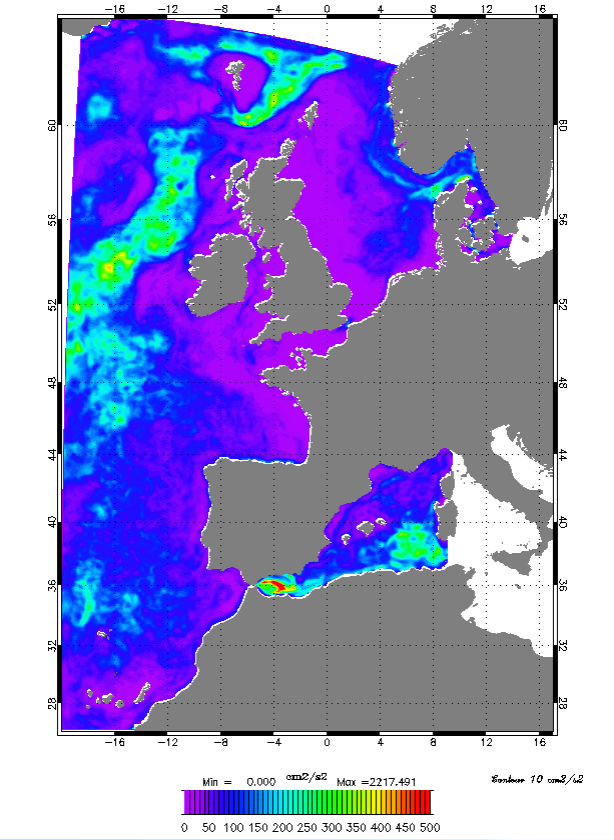


Domain / Experiment	IBI Rms(residual) Cm	Shallow Water Rms(residual) Cm	Deep Ocean Rms(residual) Cm
CONTROL	4.25	5.14	3.72
	-3.5%	+3,3%	-6,5%
HF_Assim	4.17	5.32	3.49

Impact of the assimilation of HF (SLA): Control vs HF_Assim (no DAC)

More Eddy kinetic energy

Eke Near Surface (Control) in 2009



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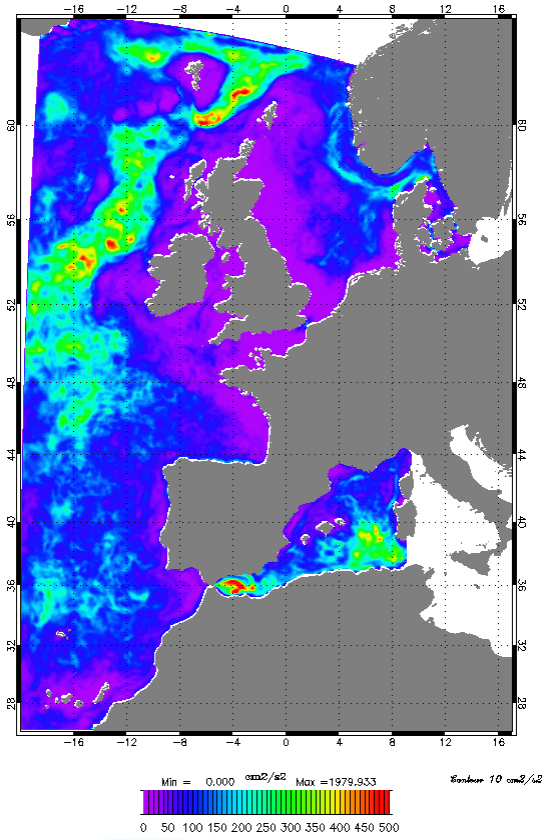
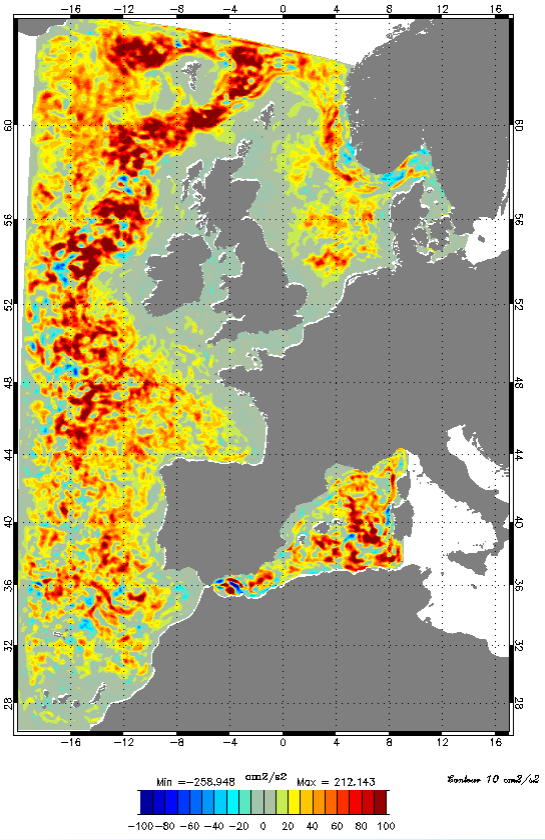


Diff Eke (HF_Assim – Control)

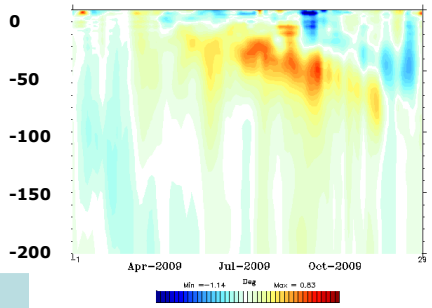


Impact on insitu data (Temperature& Salinity) Mean & Rms (Misfit)

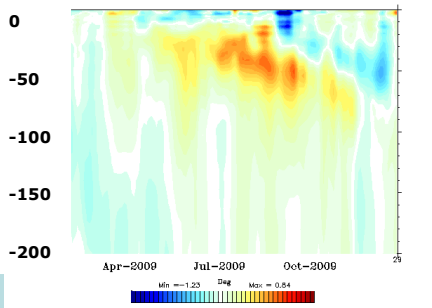
$$\text{Misfit} = \text{Data} - \text{Model}_{\text{forecast}}$$

Temperature (over all domain)

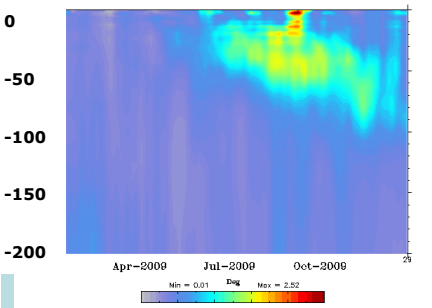
Mean misfit (Control)



Mean misfit (HF_Assim)



Rms misfit (Control)



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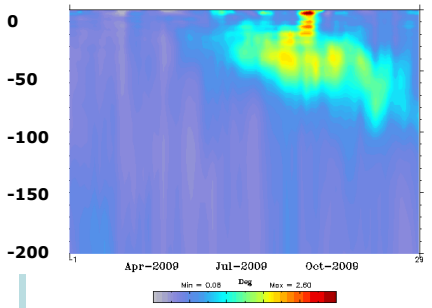
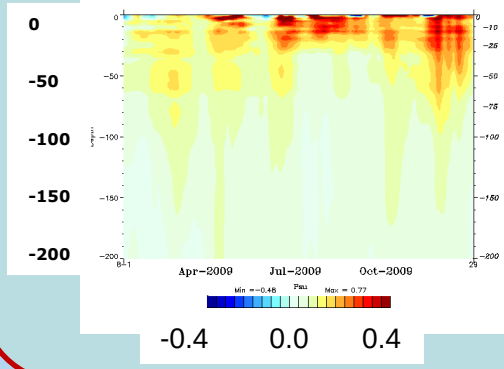
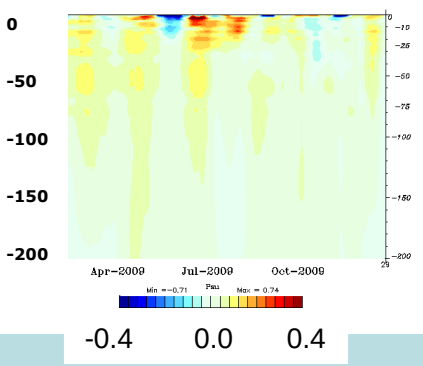


Salinity (over all domain)

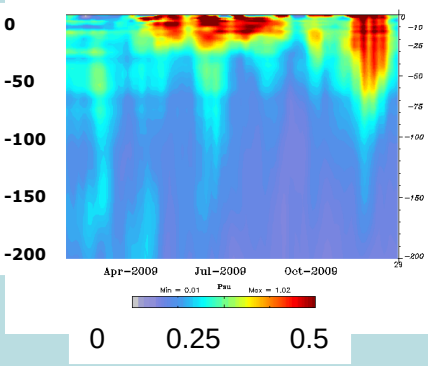
Mean misfit (Control)



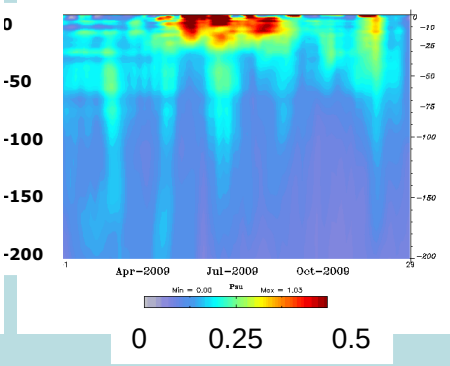
Mean misfit (HF_Assim)



Rms misfit (Control)



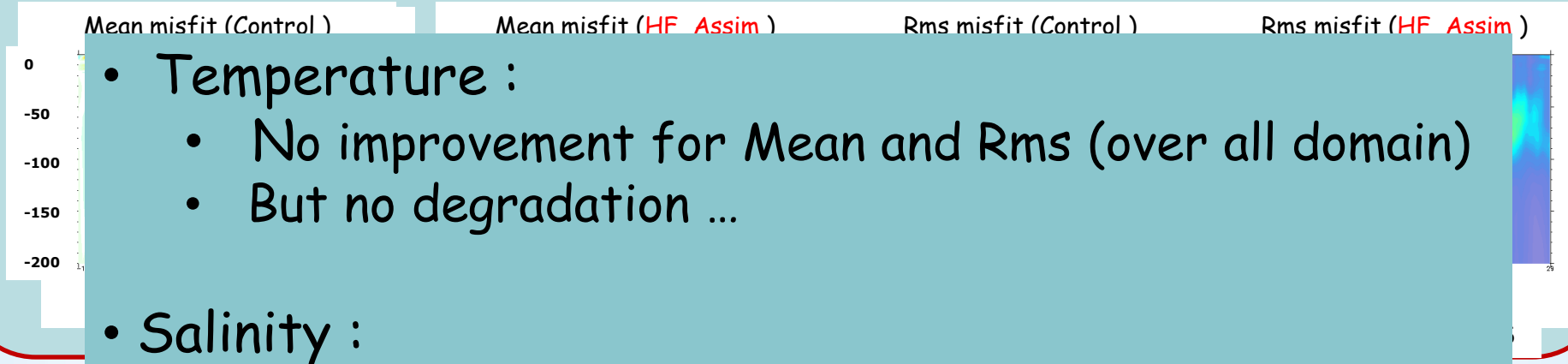
Rms misfit (HF_Assim)



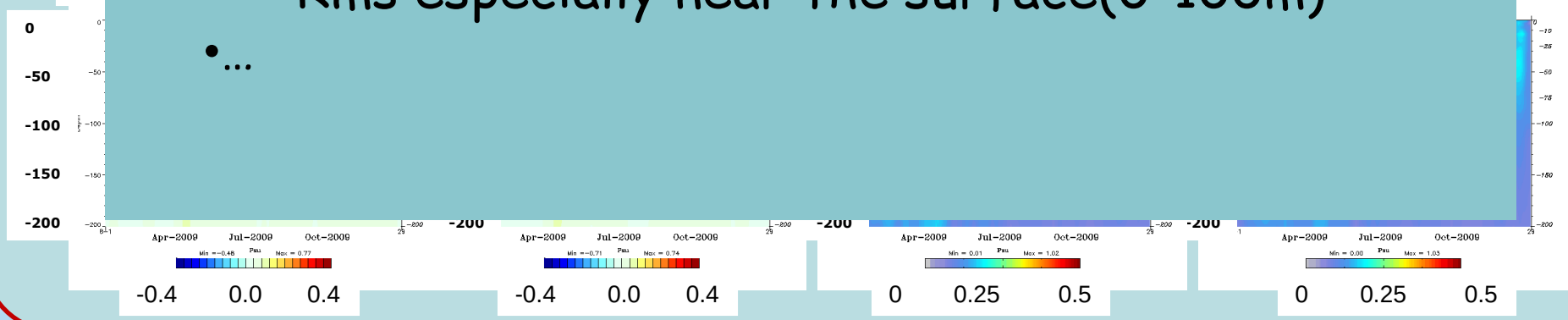
Impact on insitu data (Temperature& Salinity)
Mean & Rms (Misfit)

$$\text{Misfit} = \text{Data} - \text{Model}_{\text{forecast}}$$

Temperature (over all domain)



- Temperature :
  - No improvement for Mean and Rms (over all domain)
  - But no degradation …
- Salinity :
  - A improvement in both Mean and Rms especially near the surface(0-100m)
  - …



Conclusions

- Improvement of DA diagnostic **without the correction of the DAC in the model and data** (SLA).

- More energy even at small scales, Salinity improvement 0-100 m.

➔The physical content of the altimeter measurements assimilated need to be consistent with the physical content of the model

➔Models need a specific altimeter product in order to reduce they errors