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Altimetry to constrain Ocean analyses and forecasts

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Plan

- **Current operational global system**
  - **Continuous improvement**
  - **Description**
- **Impact of altimetry observations onto the analysis and forecast**
  - **The Mean Dynamic Topography**
  - **A new satellite: Sentinel 3**
  - **Future Wide Swath altimetry observations**
- **Evolution of the assimilation scheme, towards a 4D and smoother approach**
- **Conclusions and Perspectives**

Continuous improvement of the global system
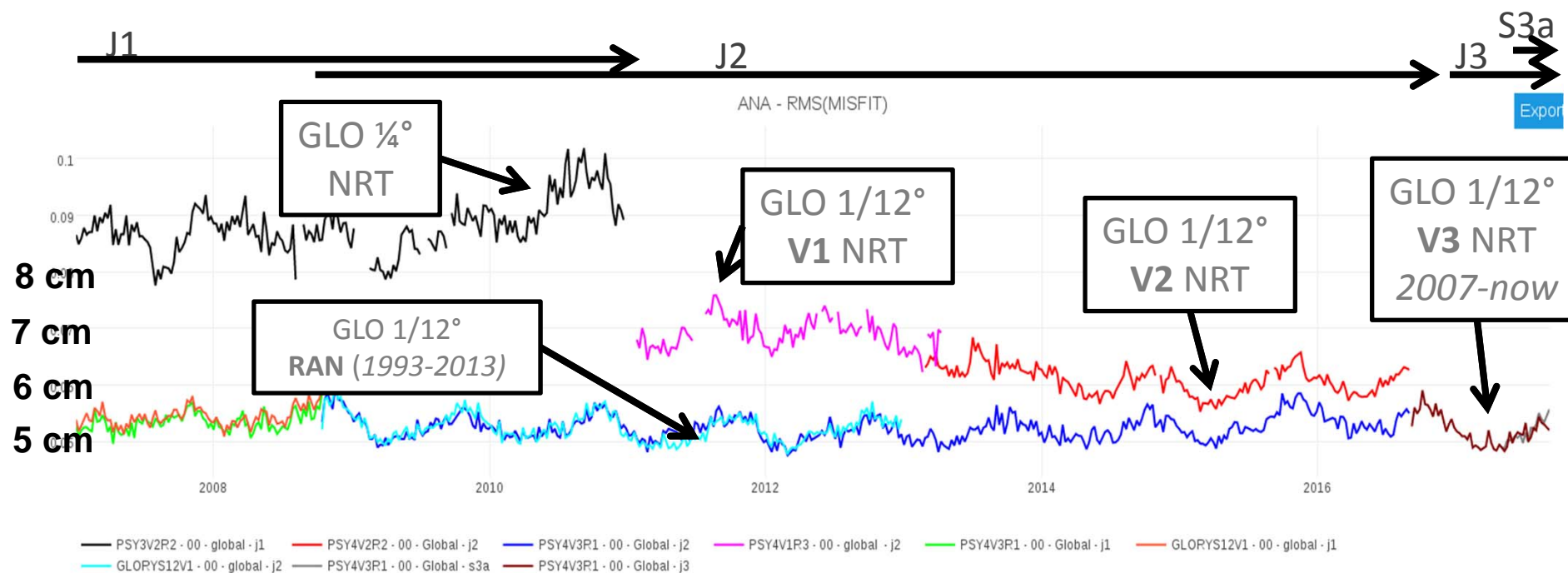
Global high resolution physical system for real time analysis and re-analysis

Real Time Forecasting System

Model

NEMO OGCM coupled with LIM2_EVP sea-ice model

Horizontal resolution 1/12° and 50 vertical levels (1m at the surface)

3h ECMWF atmospheric forcing

Data assimilated & Assimilation

SEEK (Kalman filter)

3D-Var large scales bias correction

SLA MDT CNES-CLS13 (SL TAC)

In Situ T/S profile (INS TAC)

SST OSTIA (OSI TAC)

Adaptive tuning of SLA and SST observation errors

WOA 2013 "weak assimilation" below 2000m

Sea-ice concentration (OSI TAC)

Service

Daily 10-day forecasts at 1/12°

Available Period: 2007 → now

High resolution reanalysis

Model

ERAinterim atmospheric forcing

Data assimilated & Assimilation

Assimilation of processed data (CORA insitu REP, Sea Ice from CERSAT, NOAA AVHRR SST)
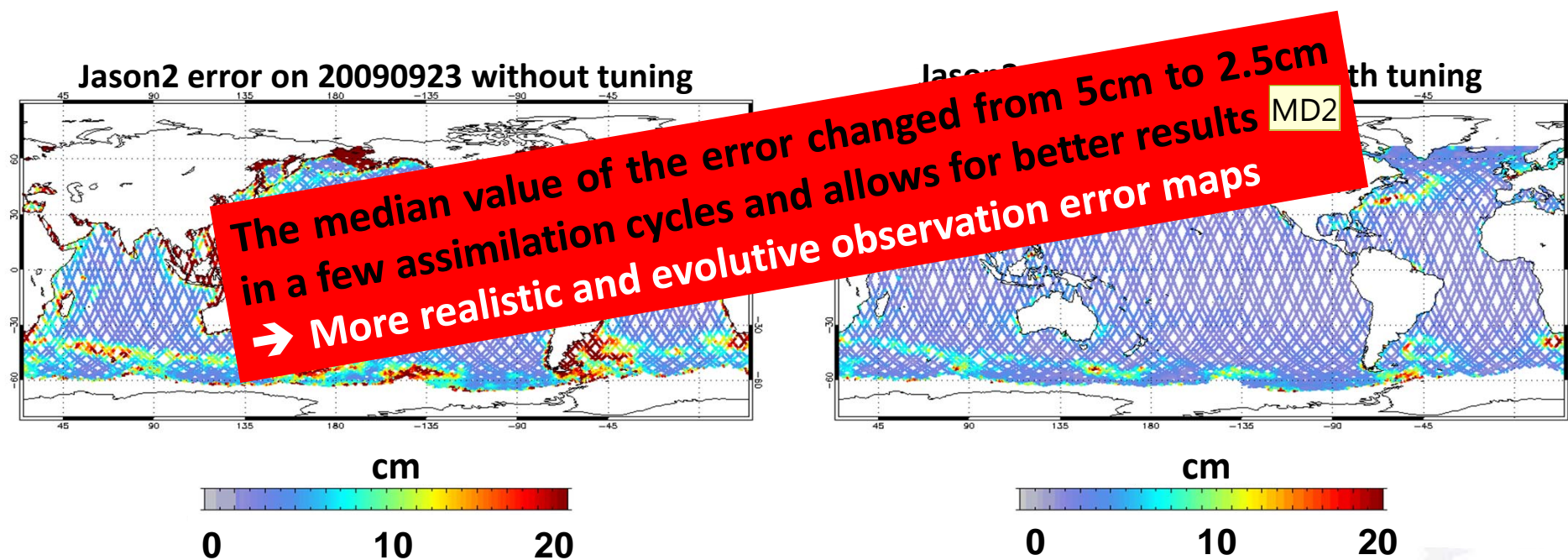
Available in 2018

Service

Daily 3D fields at 1/12°

Available Period: 1993 → 2016

Adaptive tuning of observation errors (SLA)

Jason2 error on 20090923 without tuning

Jason2 ~~~~~~~~~~~ th tuning

MD2

The median value of the error changed from 5cm to 2.5cm in a few assimilation cycles and allows for better results
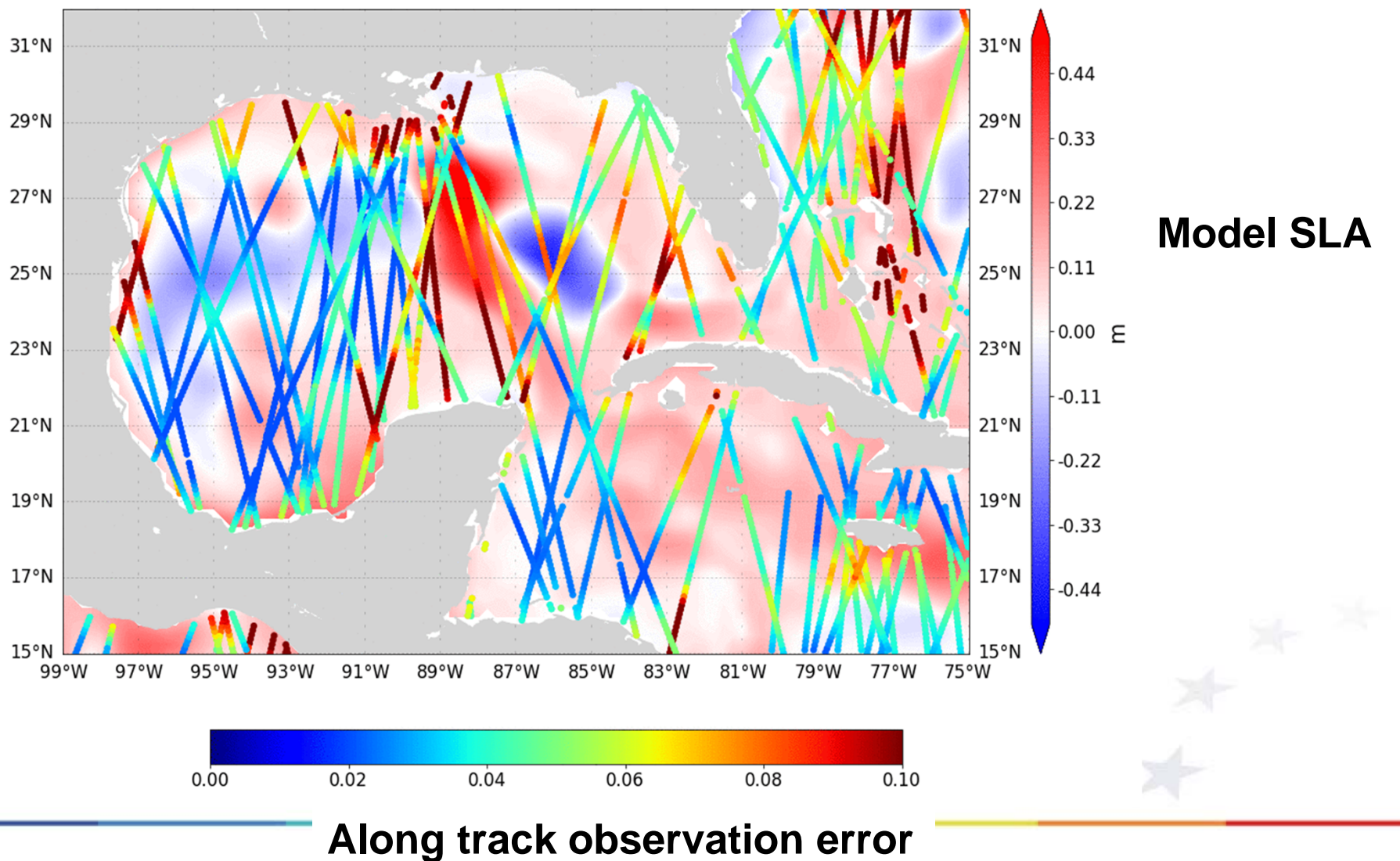→ **More realistic and evolutive observation error maps**

cm

0   10   20

cm

0   10   20

MD2   j'enlèverais le "and allows for better results"

Marie Drevillon; 20/10/2017

Adaptive tuning of observation errors (SLA)

Zoom GulfMexico SLA PSY4V3R1 and obs error for Date 20150101

Model SLA

Along track observation error

Uncertainties on surface reference

Impact of Mean Dynamical Topography (MDT) <u>on analyzed Sea Surface Height</u>

MDTv2 – MDTv3 in cm

$DT_{v2\ forecast}$ - $(MDTv2 + SLA_{obs})$ in cm

$DT_{v3\ forecast}$ - $(MDTv3 + SLA_{obs})$ in cm
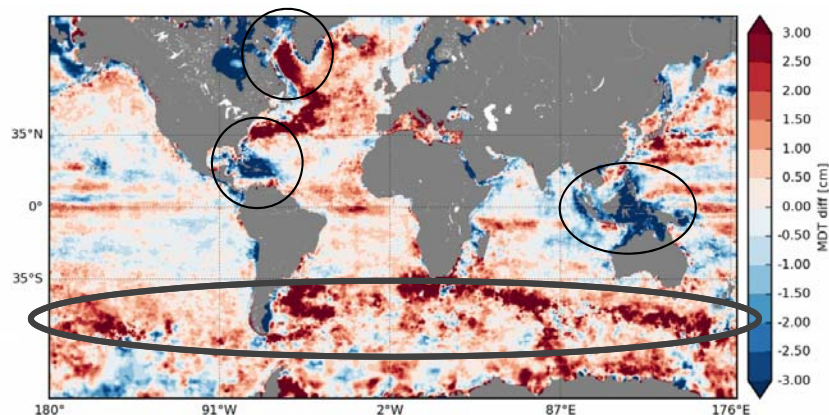
Assimilation of the updated MDT (MDTV3, 2013) reduces high biases maxima of SSH located in closed seas, Indonesian Sea, Caribbean Sea, Labrador...

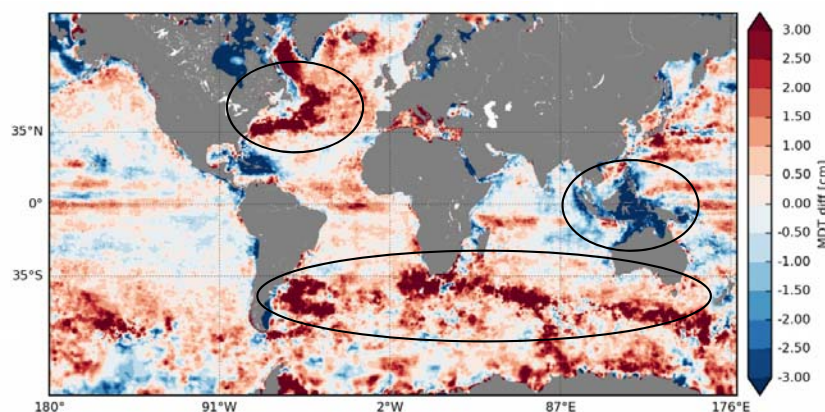In spite of large MDT differences in southern hemisphere, both OSEs show very low biases in that area!
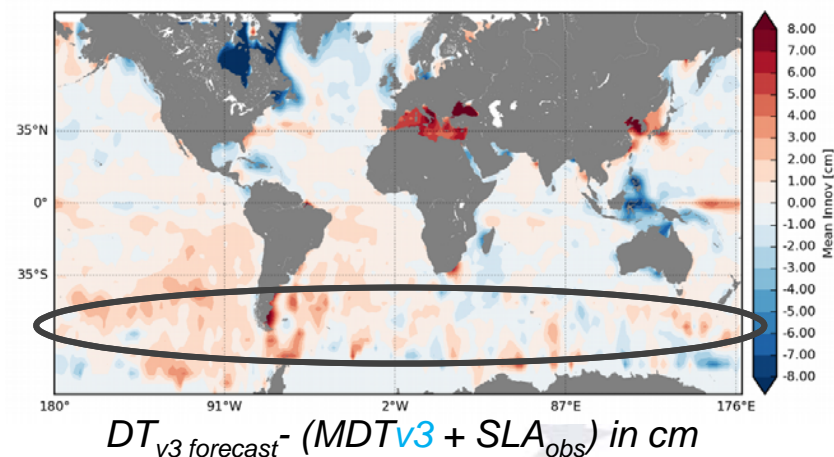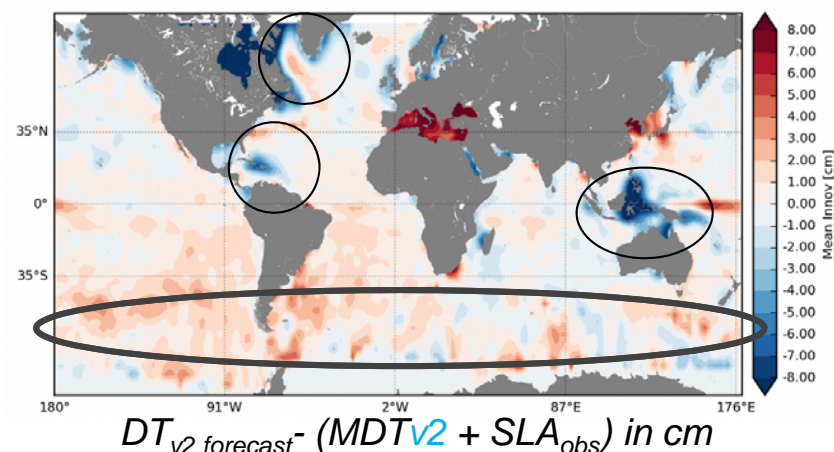
Uncertainties on surface reference

Impact of Mean Dynamical Topography (MDT) <u>on analyzed T/S</u>

MDTv2 − MDTv3 in cm

T0-2000m − T0-2000m in °C

MDTV2   *MDTV3*
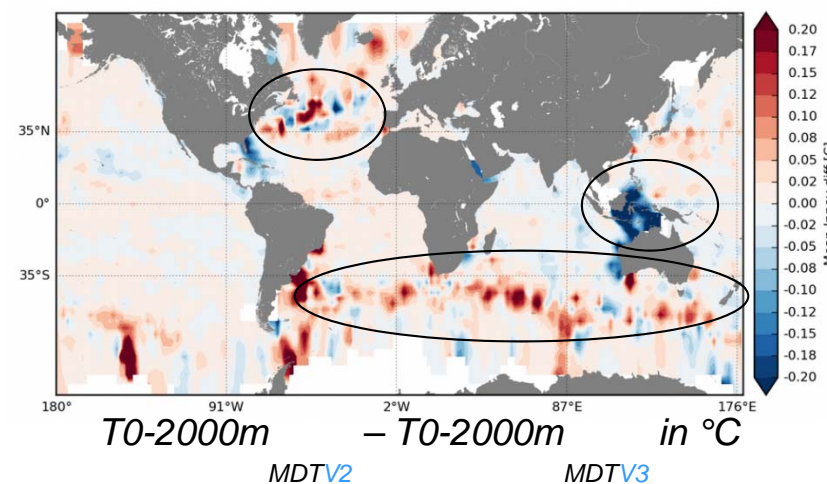
Due to steric compensation effect, the use of MDTV3 allows the **reduction of large temperature biases** in the deeper layers of the southern hemisphere (and salinity to a lesser extent).
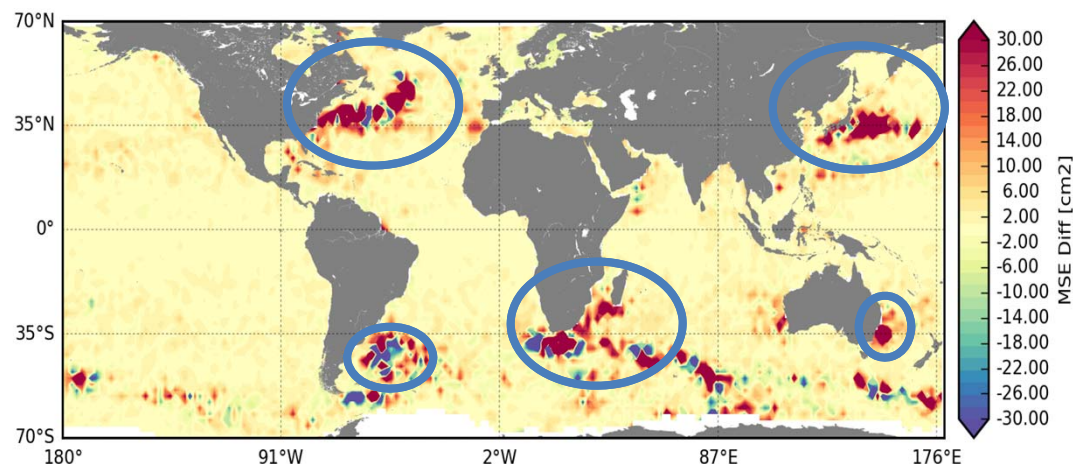
Impact of Sentinel3-a data in the operational (real time) system

twin experiment in parallel with the operational hindcast since May 2017

In the operational system, all available data (AVHRR SST fields, in situ profiles and altimetric along track data J3, AltiKA, Cryosat, S3) are assimilated. In its twin experiment, we removed S3-a.

In terms of forecast error, the maximum improvement adding S3-a is obtained in highly dynamic areas (-30cm2 error).

The use of a normalized parameter (difference of forecast error divided by oceanic variability) shows that the benefit of S3-a data is global (-10% error).

Mean difference of forecast errors between OSE without S3-a and operational forecasts
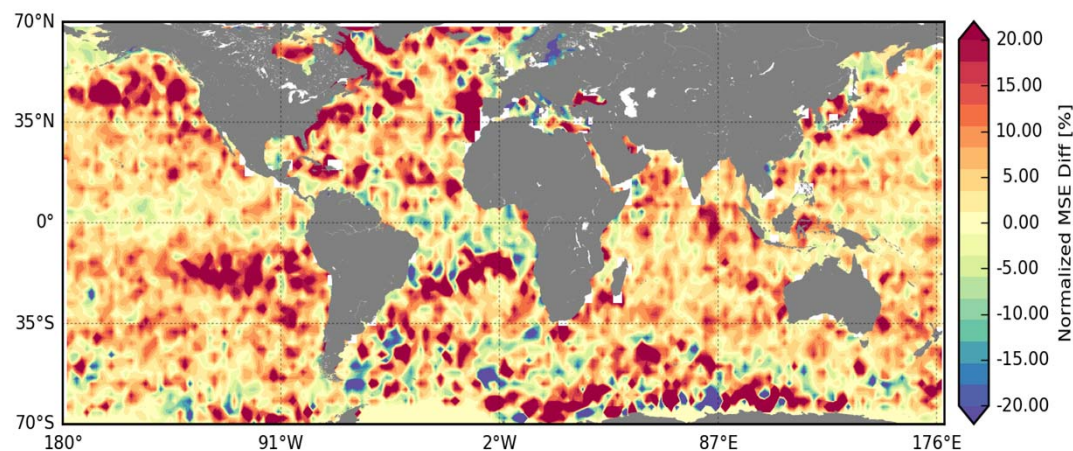
Mean difference of normalized forecast errors between OSE without S3-a and operationnal system.

Impact of Sentinel3-a data in operationnal system
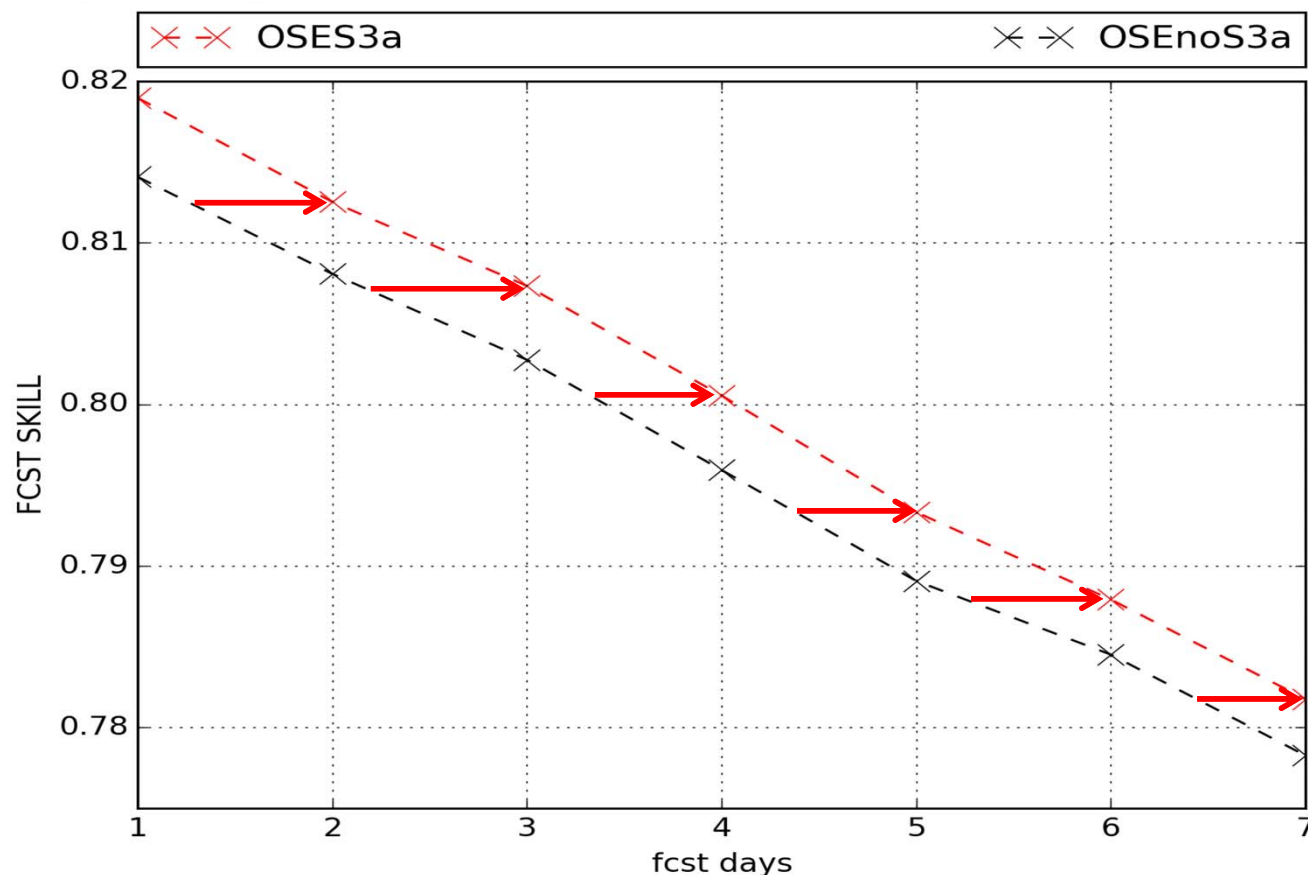
Globally averaged forecast skill function of the day in the assimilation window.

The forecast skill shows the ability of the model (forecast) to be close to the observations, compared to its persistence.

Thanks to S3-a data, global average forecast skill is increased.

In terms of forecast length (for a given forecast skill), forecast length is increased from 0,5 to 0,8 day thanks to S3-a assimilation.
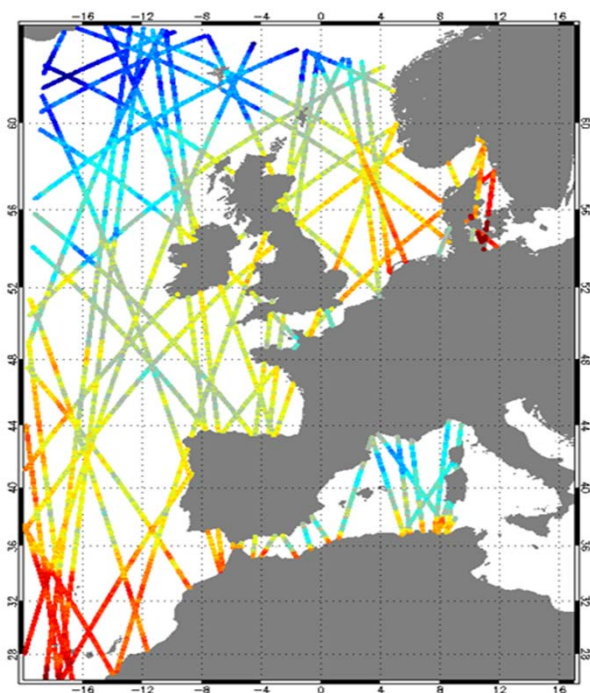
WIDE SWATH altimetry : Observing System Simulation Experiments (OSSEs)

Spatial coverage of different constellations of satellite altimeters in the Iberian-Biscay-Ireland (IBI) region, during 5 days

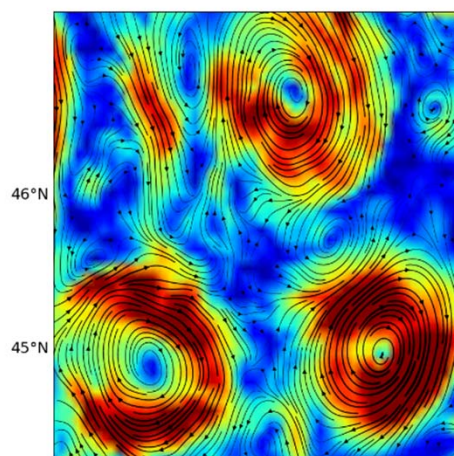**Jason-2, Cryosat-2, Sentinel 3a**

Swath-1   **Swath-2**
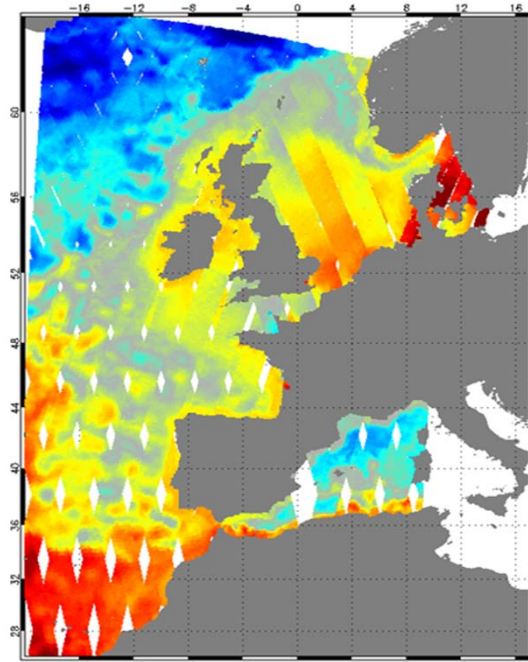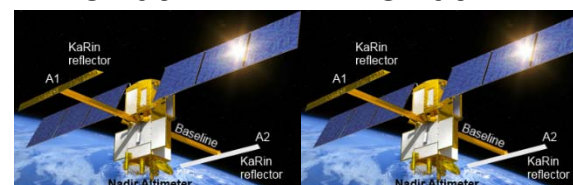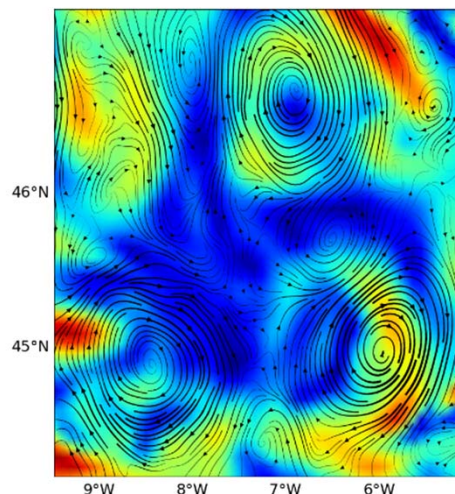
WIDE SWATH altimetry : ocean surface currents

Ocean currents speed in each experiment with **NatRun streamlines superimposed**

Two wide swath altimeters significantly contribute **to resolve the mesoscale structures** in the Bay of Biscay
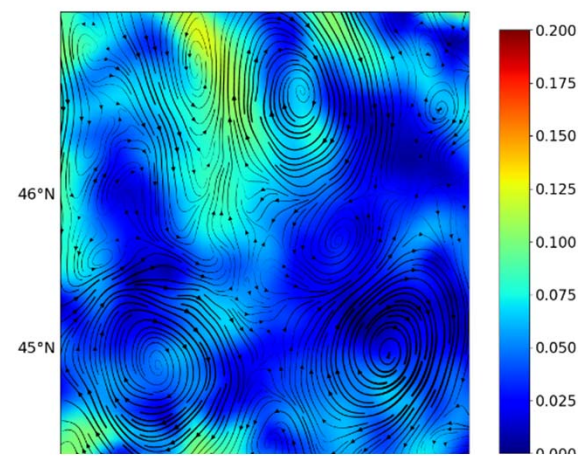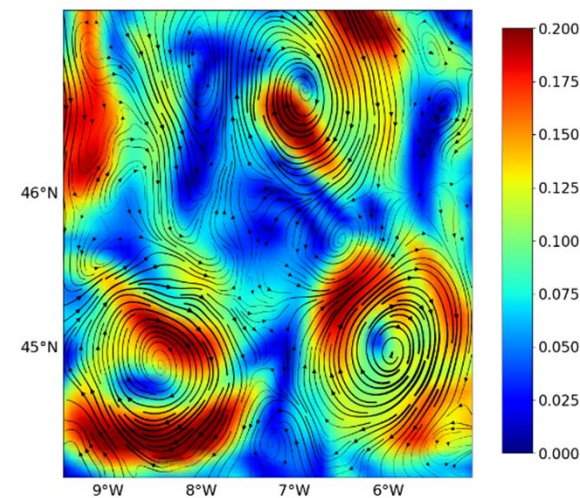
Evolution of the assimilation scheme → smoother

MERCATOR OCEAN

4D scheme
5-day cycle
Daily analysis

Innovation

Fcst

Analysis

Delta (IAU)

Ana

Smoother scheme
5-day cycle
Daily analysis

D day

Delta (IAU)

Innovation
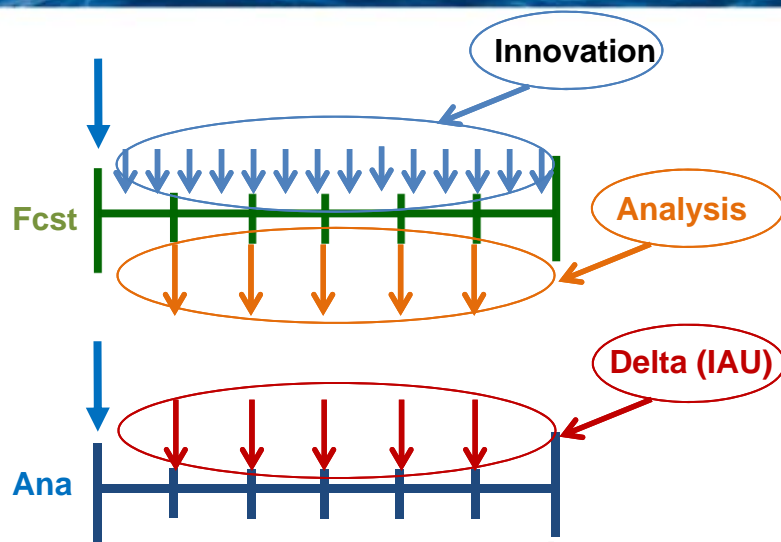
Analysis

Observations in the future in the analysis
More observations in each analysis
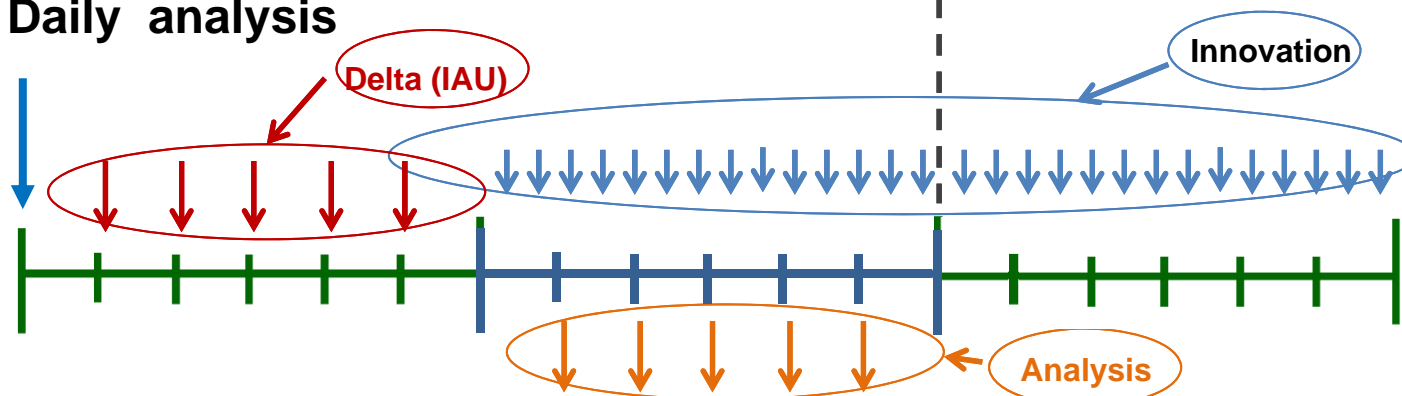
Cost of the analysis is increased simulation over 3 assimilation cycles instead of 2
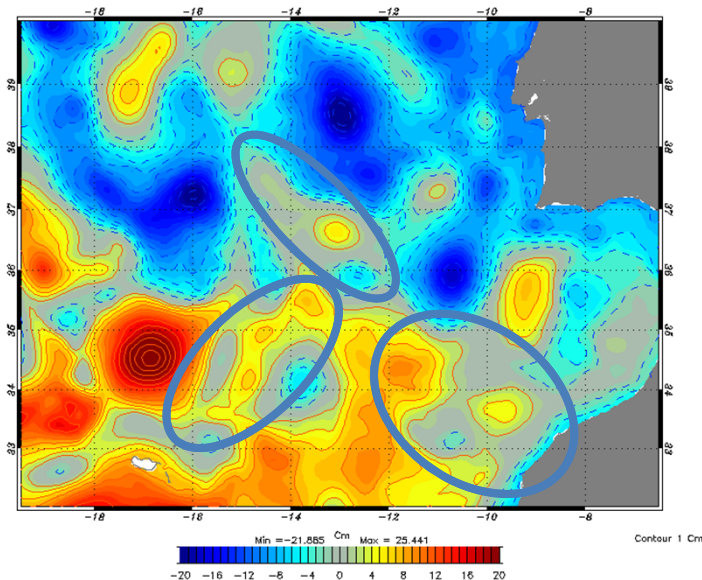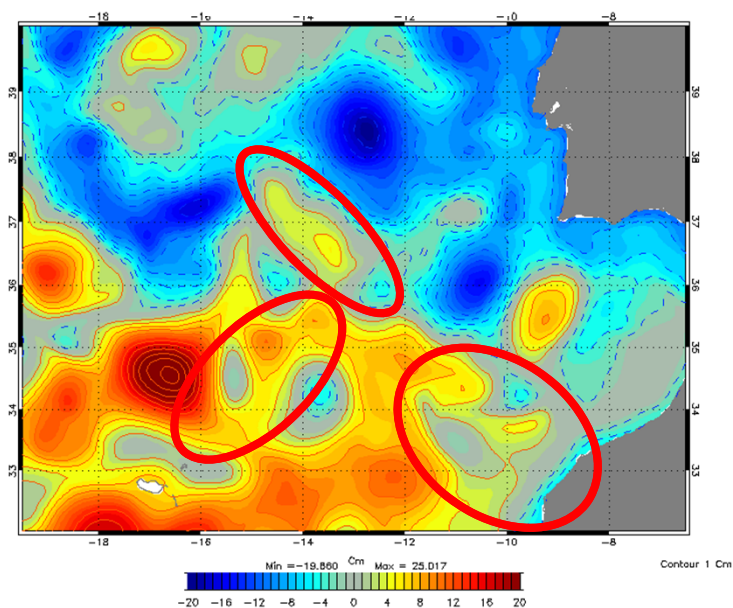
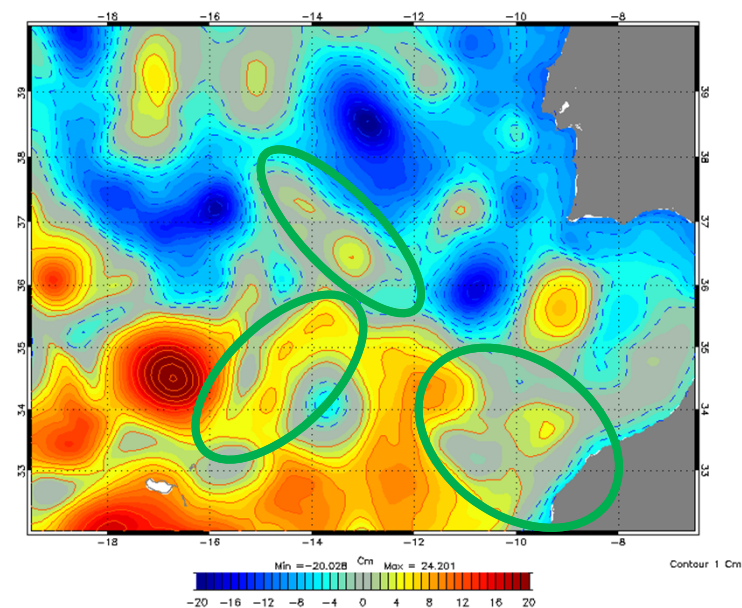**Cost of the scheme + 40%**

Impact of smoother scheme

Impact of smoother scheme


Variance(Misfit, OSSE2, SWOT)
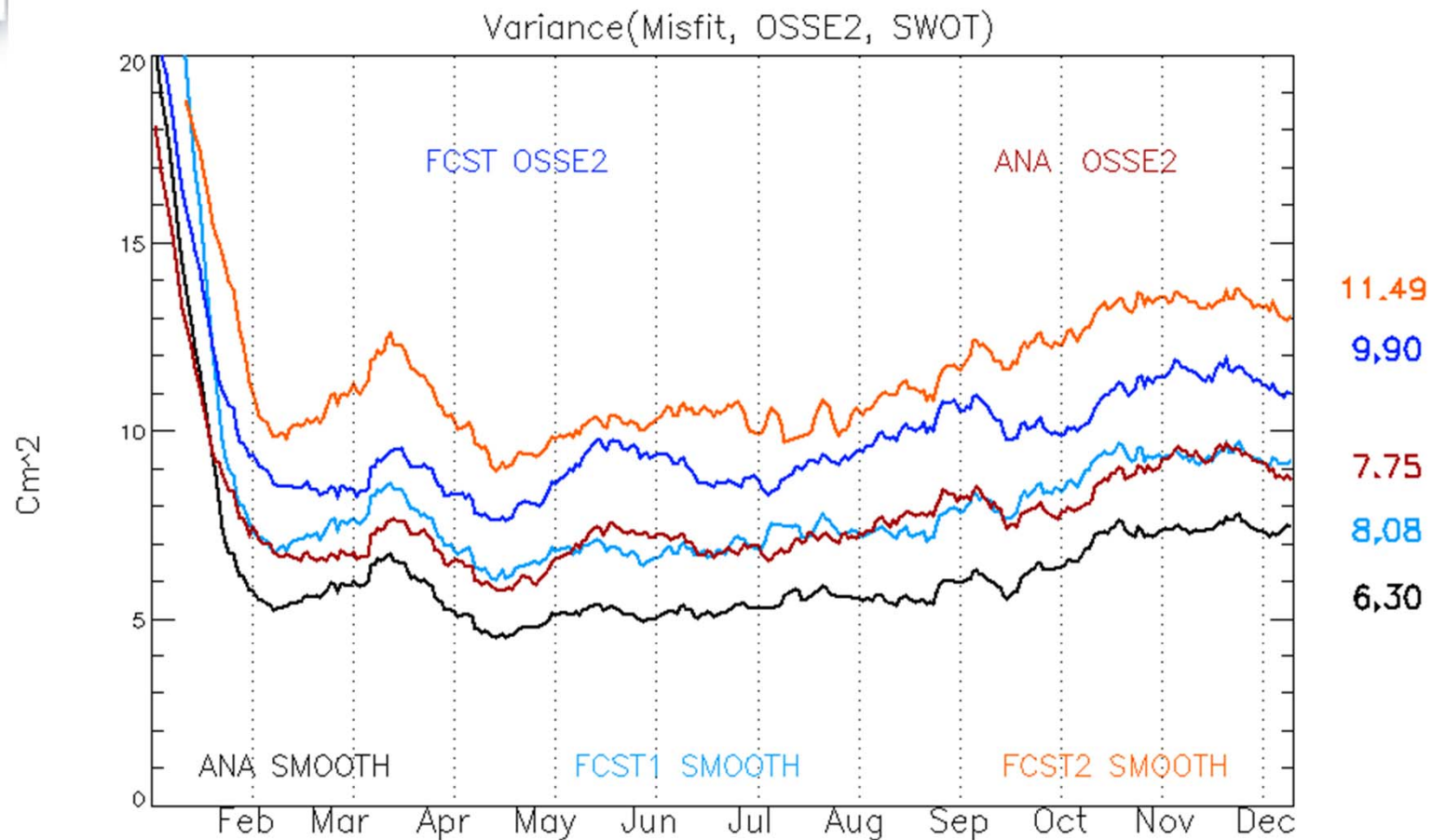
Conclusions and perspectives

- **Mercator Ocean's global high resolution** system is used to provide near real time ocean analyses/forecasts and a reanalysis over the full **altimetry period**

- **New satellite** observations and improvement of the **MDT** improve significantly the quality of the analysis/forecast

- Strong need to have in real time at least **4 altimetric missions**. Risk with J2.

- **Wide swath** altimetry observations are promising

- There is room to improve the **assimilation scheme**

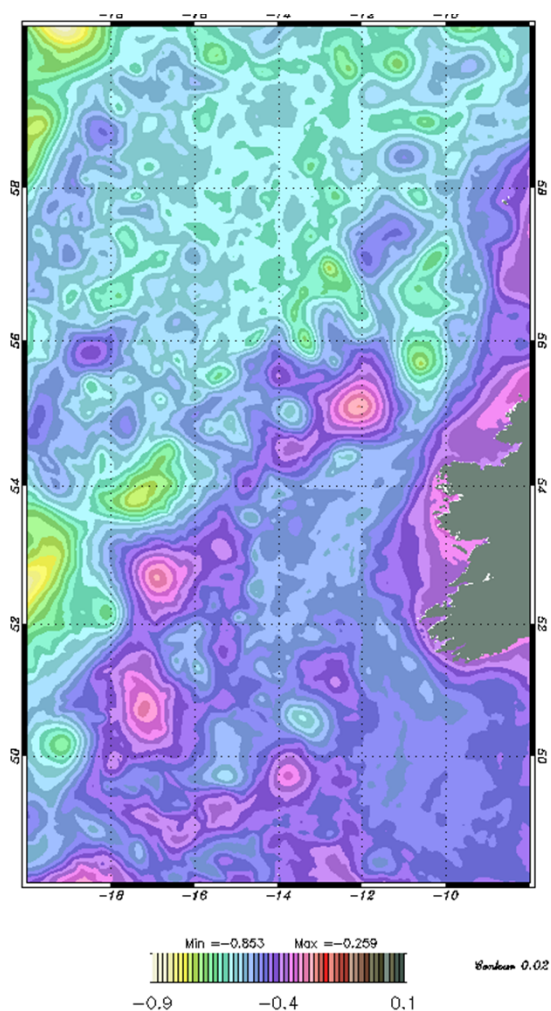- **Higher resolution experiments** are under progress

High resolution OSSE, first experiment
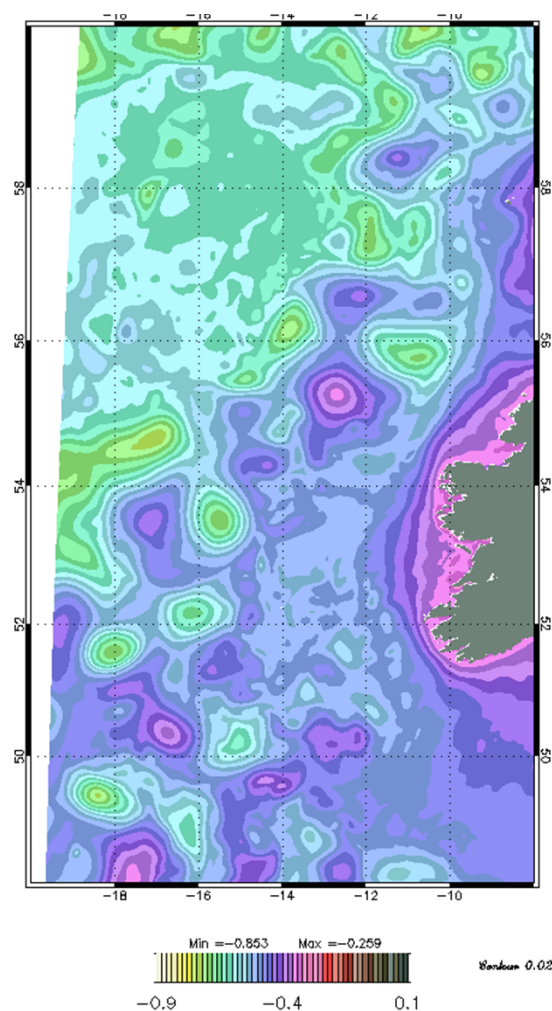
1/36° control run　　　　**1/60° nature run**　　　　**1/36° with assimilation**