Error specification on SLA observations in the Mercator assimilation systems

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Introduction

Mercator Ocean runs ocean analysis and forecasting systems at regional to global scale constrained by in situ and remote observations (SST, SLA).

⇨ **produce a realistic 4D description of the ocean** in agreement with the assimilated observations within the prescribed error bars.

Requirements:

- a good knowledge of **observation information content and model physics** to compute their model equivalent
- a good specification of both model and observation **errors**

Applications range from climate model initialisation to regional model boundary forcing,,...

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Assimilation framework

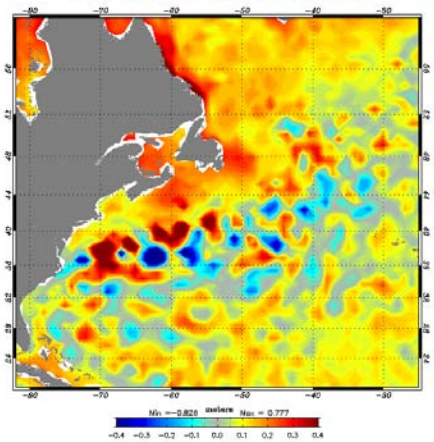
Weekly analysis and forecasts are produced with an assimilation scheme which requires the minimization of the mean square of the observation misfit.

The solution can be expressed as follow:

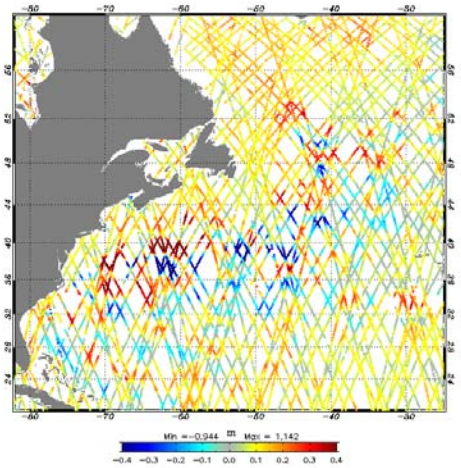
$$x_{analysis} = x_{forecast} + K(H(x_{for})-y_{obs}),\ K= BH^T(HBH^T+R)^{-1}$$

- **H: observation operator**
- B: model error covariance matrix
- **R: observation error covariance matrix**
- y_{obs}: observations

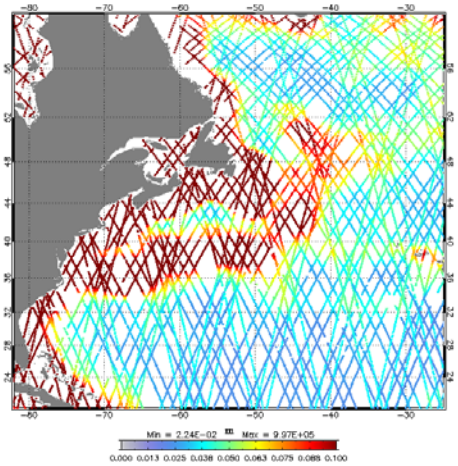
Forecast

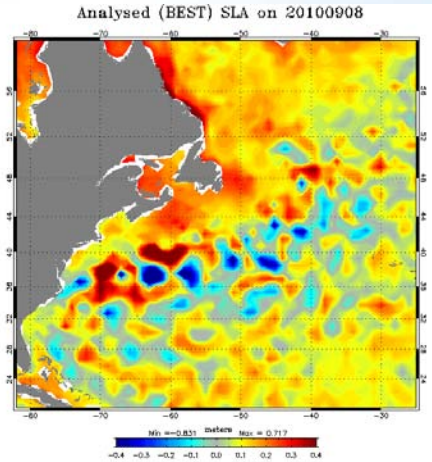


SLA tracks 1-8/09/2010



Observation error





Analysed SLA 8/09/2010

Outline

- Computation of the SLA model equivalent in the different ocean configurations
- Estimation of the observation error
- Error monitoring and diagnostics in the observation space
- Ongoing and future work

$$x_{analysis} = x_{forecast} + K(H(x_{for})-y_{obs}),\ K= BH^{T}(HBH^{T}+R)^{-1}$$

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NEMO model configurations at MO

The model spatial resolution, coverage and physical parameterizations largely differ from one system to an other.

⇨ the model SSH represents different physical processes to take into account the model observation operator and error specification.

PSY3
- Global coverage
- ¼°spatial resolution
- daily forcing
- no tide
- cst volume

IBI
- European shelves
- 1/12°
- 3h atm forcing, including the atmospheric pressure forcing
- Tide
- Variable volume

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Along track SLA model equivalent

Observation operator for the AVISO along track SLA

$$SLA_{model} = \overline{SSH - SSH_{tide}}^{25h} - \overline{IB}^{25h} - LargeScaleFilter(\overline{HBar}^{24h} - \overline{HBar}^{21days}) - MDT$$

Data treatment

Tide removed

IB using daily atm. pressure (ECMWF)

MOG2D with 6h frequency forcing

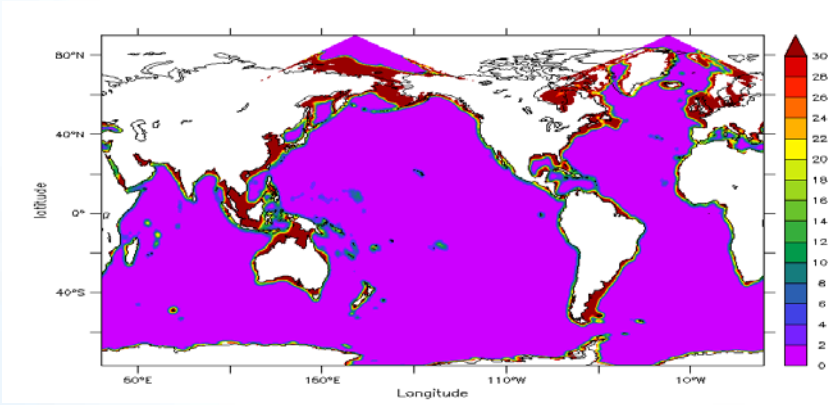
MOG2D: Barotropic ocean model simulating the high frequency barotropic response of the ocean to the atmospheric forcings (wind and pressure).

⇨ Difficult to compute an exact model equivalent

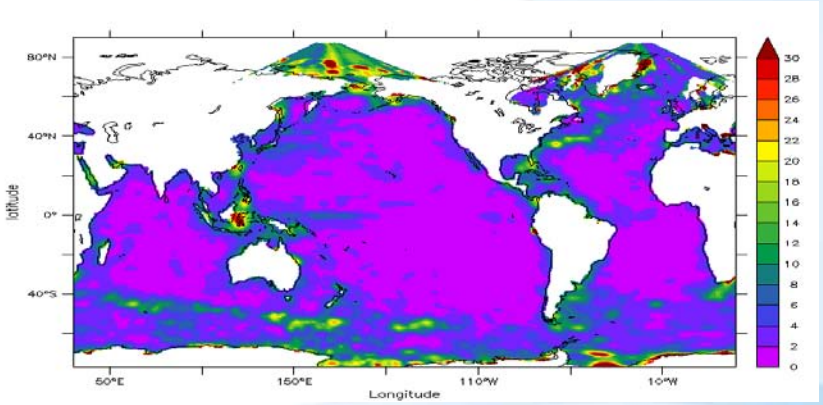
Error specification in the DA system

SLA observation Error = “instrumental” error + representativity error + MDT error

- *“Instrumental” error* : 2 cm (Jason, Topex), 3,5 cm (Ers, Envisat) and 5,5 cm for Envisat on its new orbit.
- *Representativity error* : error due to missing physic in the model compared to the observation content.
- *MDT error*



Instrumental error, inflated in shallow and coastal areas



MDT and representativity error

The observation covariance matrix R is diagonal and constant in time
The MDT error can be larger than the « instrumental » error.

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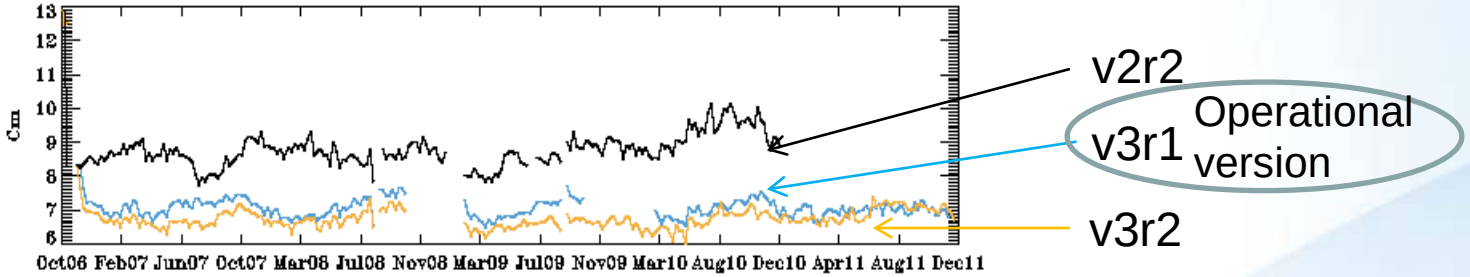
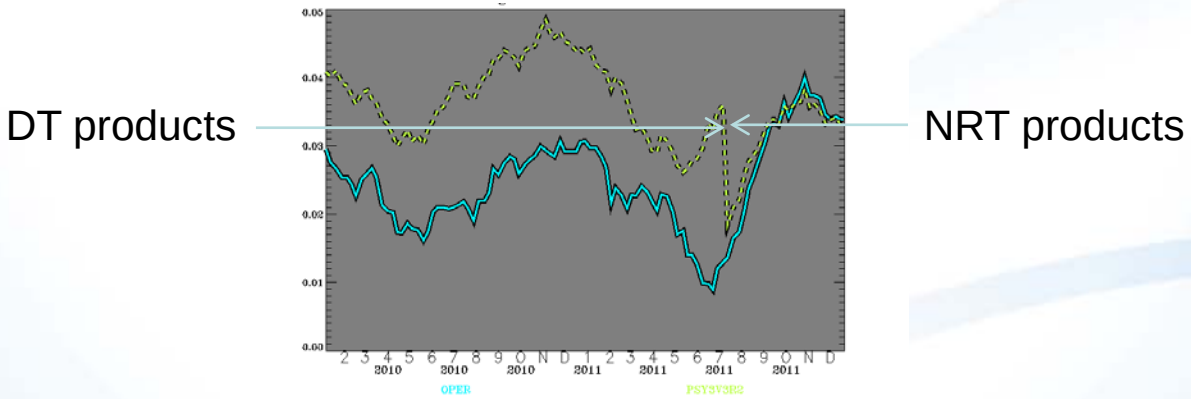
Monitoring of the system performance in SLA (1)

Different diagnostics help measuring the efficiency of the SLA constrain, the quality of the estimated SSH in the products and identifying problems.



Jason1 SLA RMS misfit evolution for different versions of the global ¼° system (PSY3)



Average along track SLA (Jason 2) assimilated in the operational system and the future system

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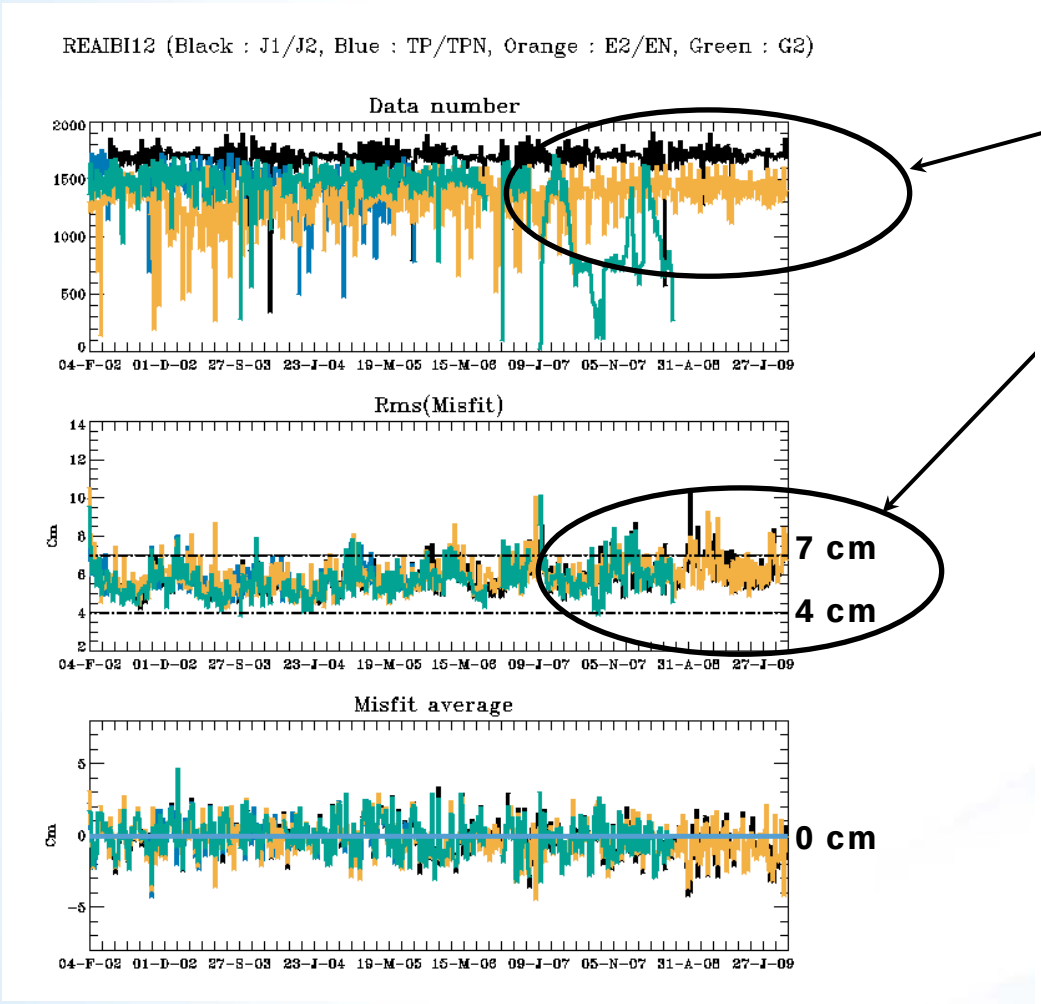
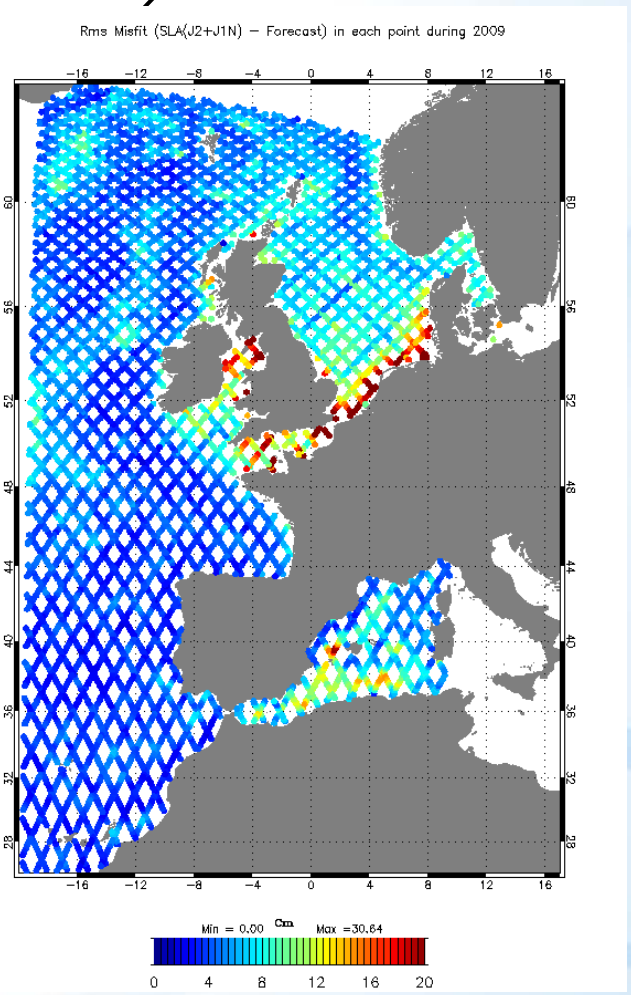
Monitoring of the system performance in SLA (2)



Data Number Impact



Evolution of the SLA misfit

IBI reanalysis (2002-2009)

SLA RMS misfit in 2009 (J2 and J1N)

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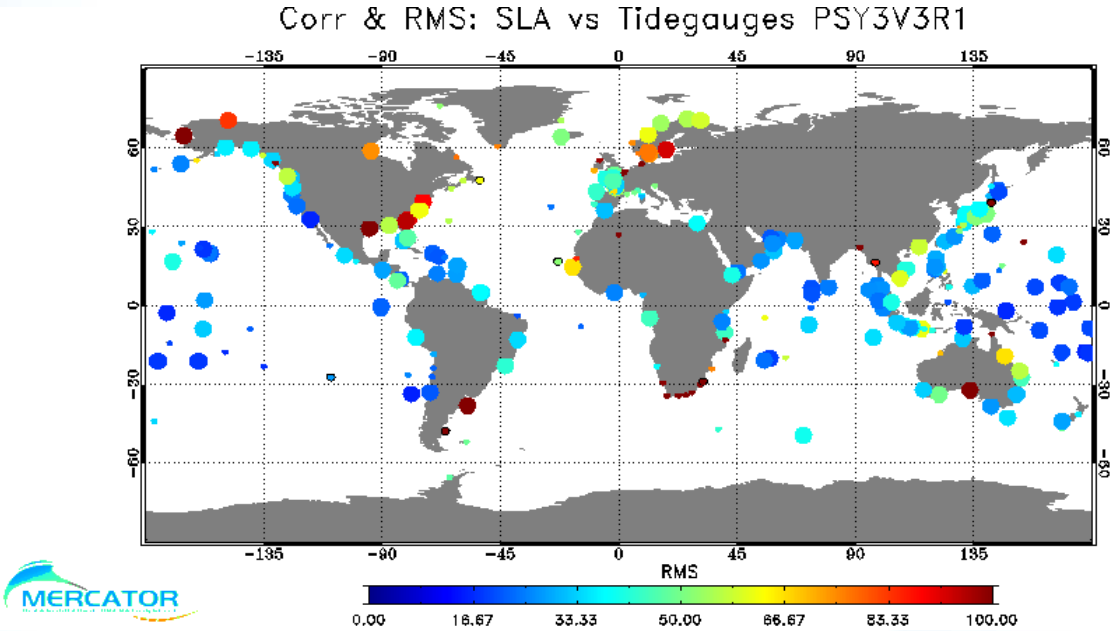
Diagnostics

- Cross validation with tide gauges



RMS misfit in mm between SLA and tide gauges in 2010, the dot size increases with the correlation (large=corr>0,75).

Ongoing and future work

Future improvements: to make the best use of the current observations

- Specify a spatially *variable "instrumental" error*
- Relax the hypothesis of *uncorrelated along track observation error*
- Take into account the changes of error level and discontinuity between *NRT and DT products* in the operational simulations
- *Tune the observation error* level using the Desroziers diagnostic

⇨ ***Introduce an error level depending on the length scales***

Dedicated studies: to understand the SLA *constraint efficiency* on MO systems

- ***Estimate the impact on the analysis and forecast*** (error spectra, transports, heat storage, reconstruction of the eddy fields…) of:
  - different constellations (present and future)
  - the different error components (time scale, length scale,...)
  - Test new products: TAPAS dedicated SLA products for DA (Tailored Altimeter Product for Assimilation Systems (adapted filtering and resolution),…

⇨ ***Keep a constant dialogue between Data Center providers and Modeling and Forecasting Centers.***

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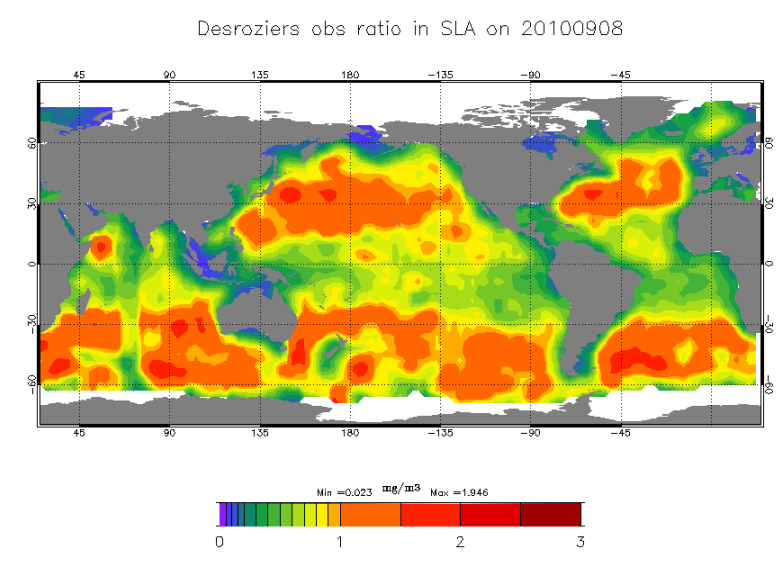
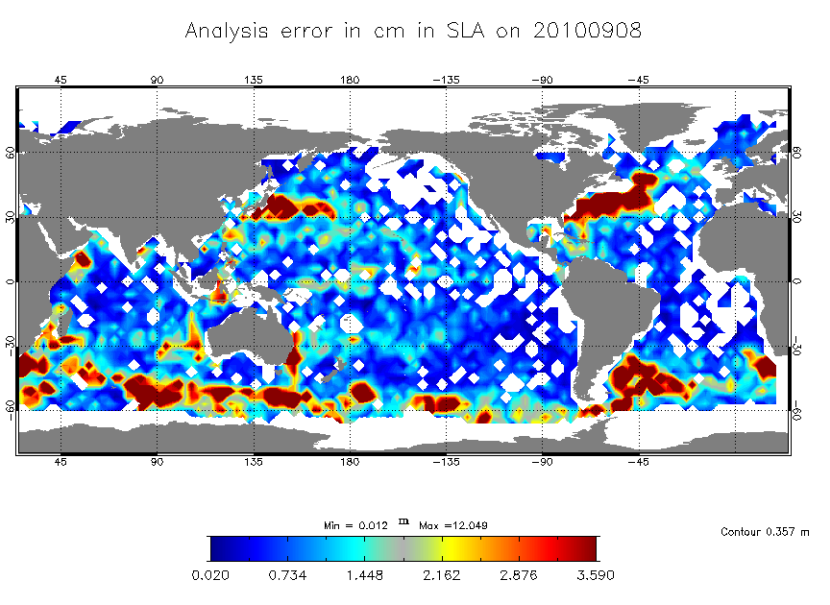
Ongoing work

Desroziers consistency diagnostics:

$$Observation\ error : ratio = \frac{R_{a\ posteriori}}{R_{a\ priori}}$$



Analysis error



Desroziers et al., 2005: *Diagnosis of observation, background and analysis error statistics in observation space*, QJRMS.

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Thank you for your attention!

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