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Observation impact studies with the Mercator Ocean analysis forecasting system

Mathieu Hamon[1], Elisabeth Remy[1], Jean-Michel Lellouche[1], Victor Turpin[2], Olivier Legalloudec[1], Pierre Yves Le Traon[1]

[1] Mercator Océan, Ramonville-St-Agne, [2] LOCEAN, Université Pierre et Marie Curie, Paris

Impact of the Argo float density on the ocean ¼° analysis and forecasts

1-year OSEs with different Argo array density were performed to assess the sensitivity of the ocean global ¼° analysis and forecasts to the Argo float network. Other in situ data, SLA and SST are assimilated.

Figure A: Analysis error reduction on temperature (0-300m): run without Argo data (left) and run with all Argo data in 2012.

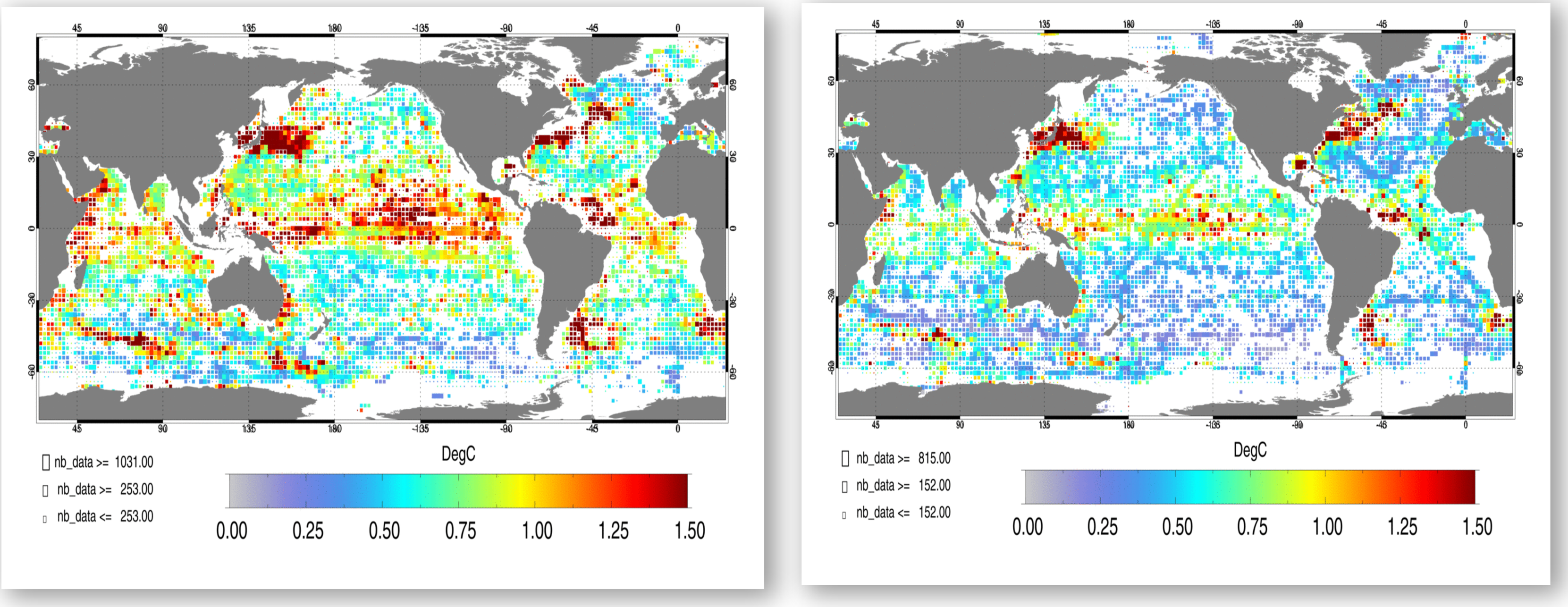
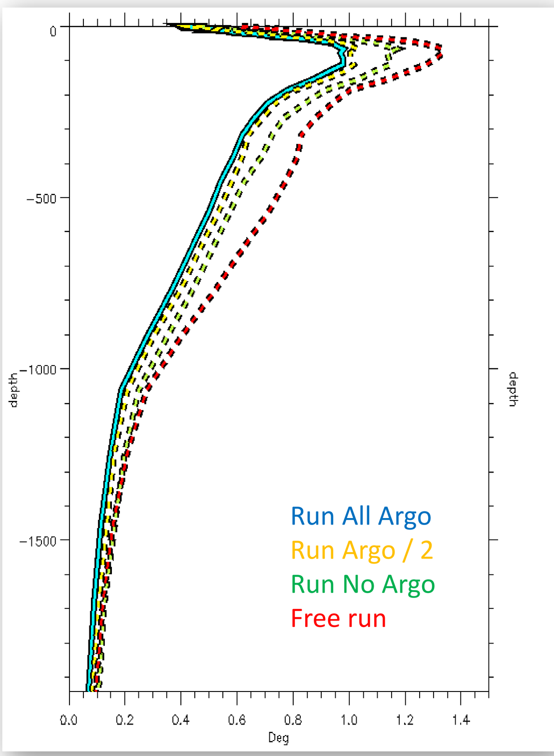


Fig B: RMS of temperature innovations (obs-forecast) in °C



The most sensitive regions are:

- ✓ the tropical band and energetic ocean regions (WBC and ACC) for surface layers.
- ✓ outflow or deep convection regions at depth up to 2000 m.

Those regions are better represented with an increased number of Argo floats.
Assimilating only half of the ARGO floats compared to assimilate the full array degrades significantly the forecasts (figure B) and analysis error.
The in situ observations are complementary to satellite altimetry.

Those experiments were performed in the framework of the E-AIMS project, that will be followed by the AtlantOS project.

Motivations

Observation impact studies are performed regularly with the real-time Mercator Ocean monitoring and forecasting systems to:

- ✓ demonstrate the value of an observation network for operational ocean analysis and forecasts,
- ✓ draw recommendations on its evolution for space agencies and in situ data providers.

Conclusions fully depend on the system setup and the prescribed errors within the data assimilation system so they should be carefully interpreted.

Impact of satellite data on the ocean ¼° analysis and forecasts

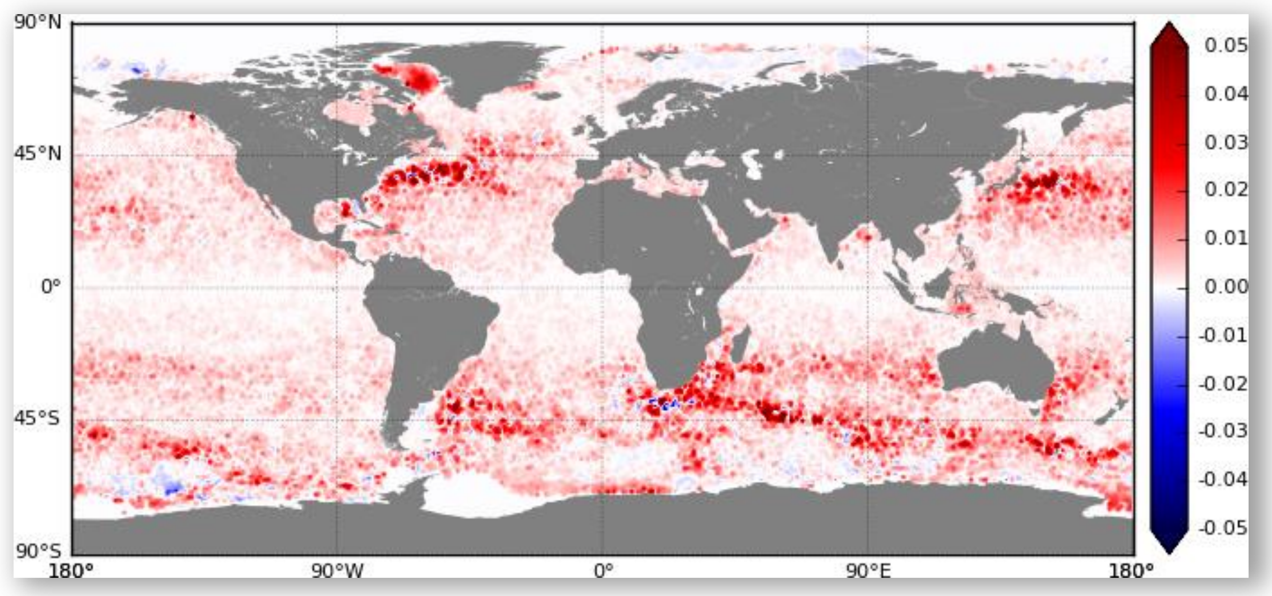
	Jason 2	Cryosat2	Altika/Saral	Haiyang-2A
RUN01	X			
RUN02	X	X		
RUN03	X	X	X	
RUN04	X	X	X	X

18-months OSEs with different satellite data were performed to assess the sensitivity of the ocean global analysis and forecasts. In situ and SST data are jointly assimilated. The Desroziers diagnostic has been used. Taking into account assimilation statistics, it allows to modify iteratively the observation error.

In order to estimate the gain by adding a satellite (between experiments N and N+1), we defined the parameter D for each satellite C2, Al and H2 comparing the magnitude of the innovations (observation – forecast) .

$$D^{sat+1} = \frac{1}{ni}\sum_{i=1}^{ni}\left(\|Innov_i\|_N^{sat} - \|Innov_i\|_{N+1}^{sat}\right)$$

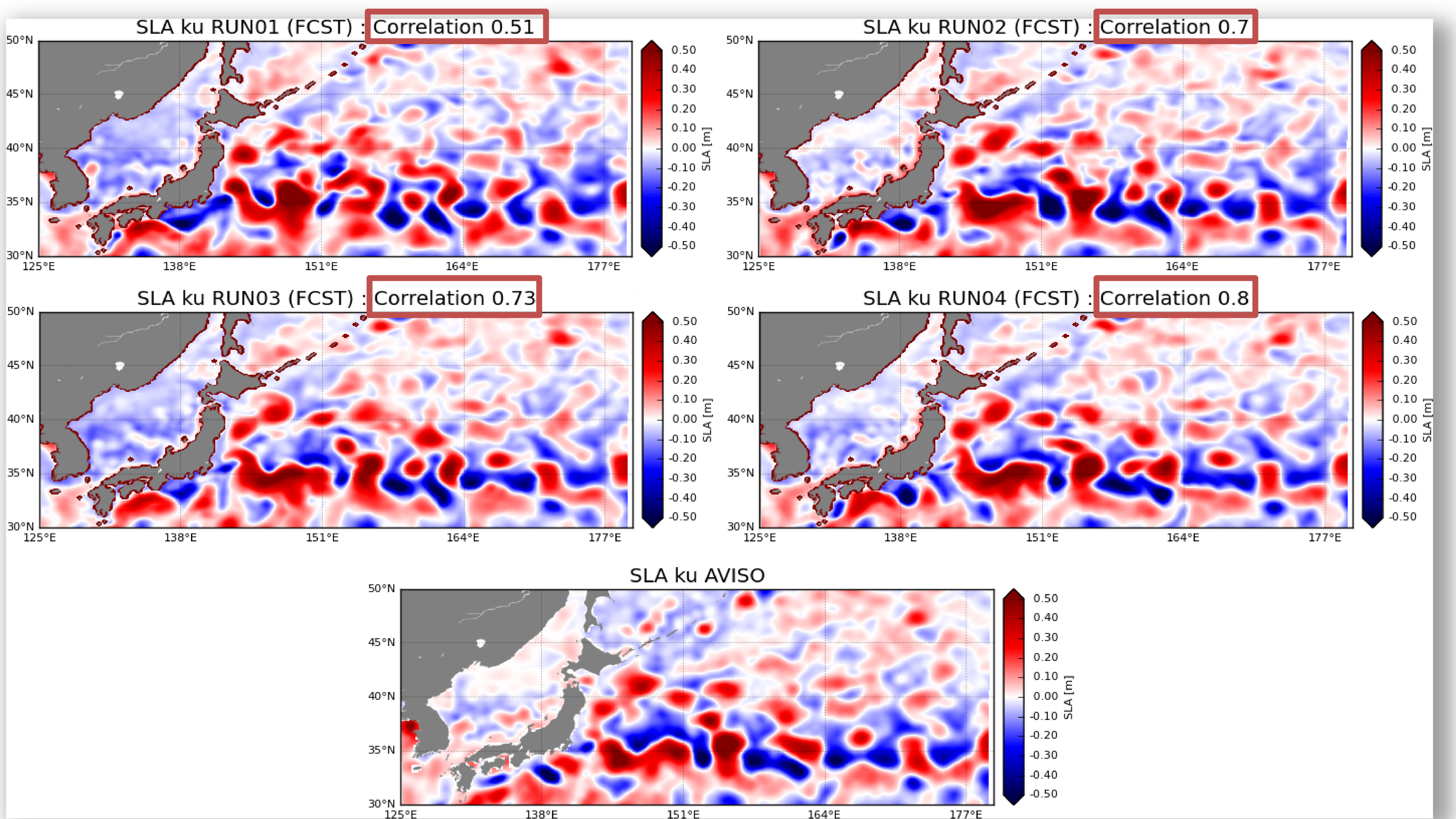
*Fig : D parameter (1°*1°) for Altika/Saral on the location of Cryosat measurement*



On average, adding a satellite leads the forecast to be closer to the observation. In high energy ocean regions (WBC, ACC), the difference between innovations (D parameter) can reach several centimeters.

The correlation between Sea Level Anomalies from 7-day forecast fields and delayed time AVISO fields in energetic areas increases with the number of assimilated satellite data.

Fig : Example of SLA from 7-day forecasts (RUN01/RUN02/RUN03/RUN04) and AVISO field (12/30/2014) in Kuroshio area and the associated correlation



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Degree of Freedom of the System

An alternative approach for estimating the influence of the observations on the analysis is to compute the degree of freedom of the system (DFS) which represents the equivalent number of independent observations that constrain the model analysis at the observation point. The definition proposed by Cardinali (2004) is:

$$DFS = tr\left(\frac{\partial H(x_{ana})}{\partial y}\right)$$

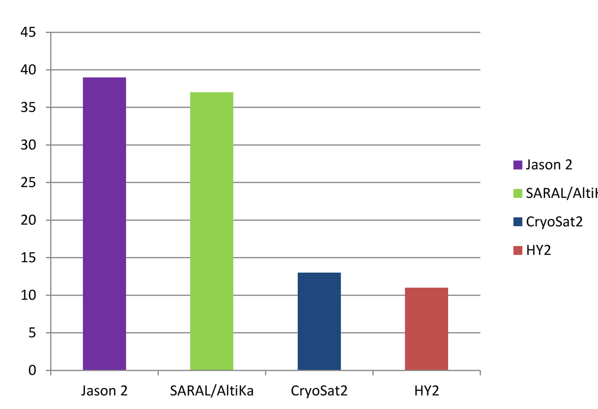
The comparison of the DFS with the number of observations gives the observation content:

$$IC = \frac{DFS}{N_{obs}}$$

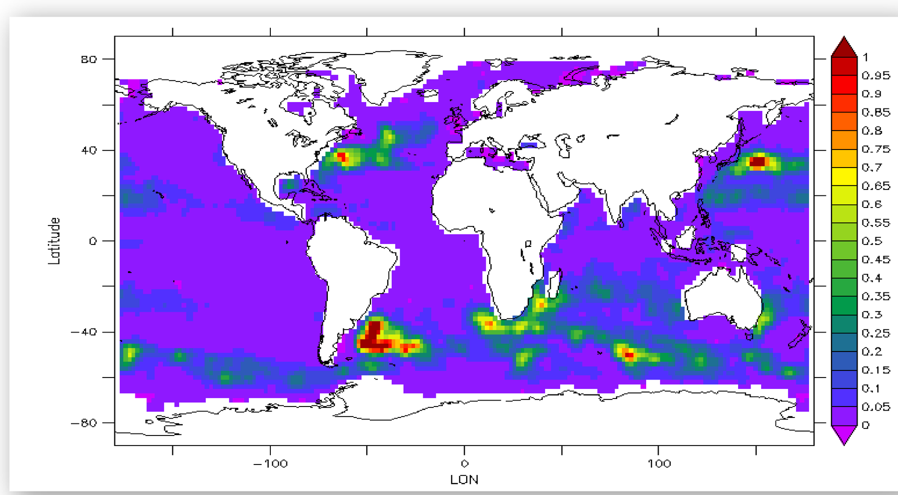
IC is close to 1 for fully « used » observations by the analysis and lower than 1 for redundant observations. We tested an approximate computation of the DFS proposed by Lupu et al. (2011) that does not require additional simulation.

$$DFS_{Lupu} = E[\left(H(x_{ana} - x_{fcst})\right)^T \widetilde{R^{-1}}(y - H(x_{ana}))]$$

Relative IC of each altimeter (%) in the real time ¼° global system – 1er semestre 2015



SARAL/AltiKa IC (2°x2° – smoothed estimate) in the Real time ¼° global system – 1st semester 2015



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Conclusion and outlook

- Tropical band, WBC and ACC are better represented with an increased number of Argo float in the global ¼° Mercator Océan analyzed fields.
- Adding satellite observations allows global ¼° forecasts fields to be closer to observations, especially in high energy areas.
- The computation of DFS has shown that, during 2015, Jason2 and Altika/Saral provided the most influent data for the Mercator Océan forecasting system.
- OSEs (Argo, Bio Argo, and satellite data) are currently under production with the 1/12° global system.