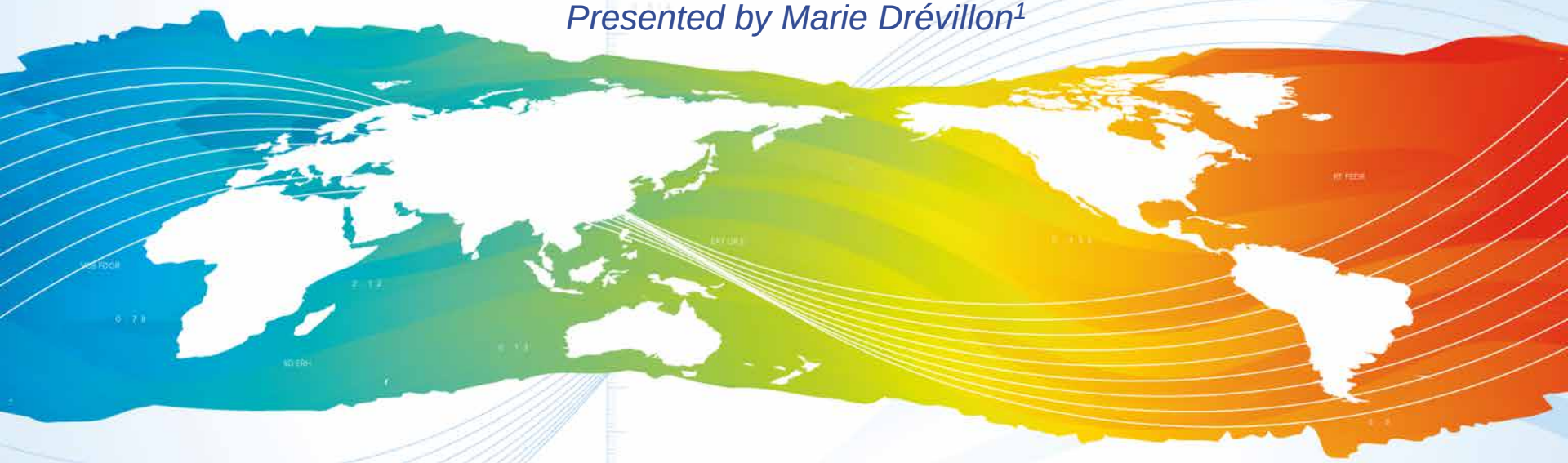
Argo observation impact studies on ocean analysis and forecast at Mercator Ocean

Victor Turpin[1], Elisabeth Rémy[1], Charly Regnier[1], Jean-Michel Lellouche[1],Olivier Legalloudec[1], Pierre-Yves Le Traon [1,2]

(1) Mercator Ocean, (2) IFREMER

Presented by Marie Drévillon[1]



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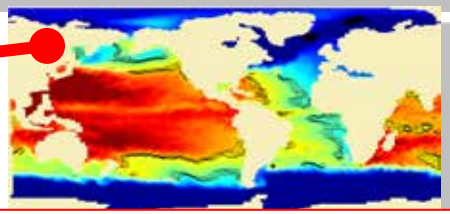
Mercator Ocean Monitoring and Forecasting Center

SATELLITE observations

MyOcean

3D MODELISATION & ASSIMILATION



MyOcean
GLOBAL MFC 1/12°
+R&D for
IBI (North East ATL) MFC 1/36°

IN SITU observations

MyOcean

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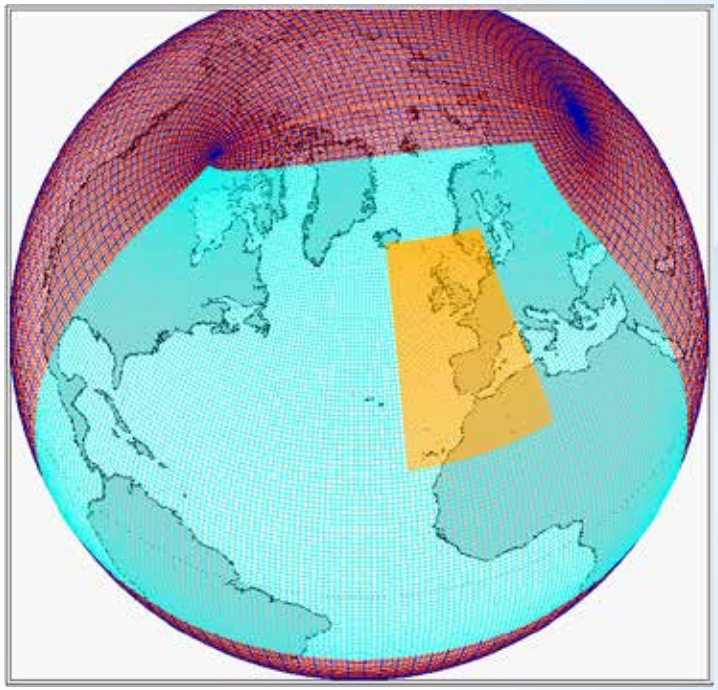
Mercator Ocean model configurations

- **1 single code : NEMO (LIM)**
- **1 single grid : all the configurations are on the same ORCA (tripolar) grid**

  1m vert sampling near the surface
- **1 single atmospheric forcing: based on ECMWF analysis and forecasts**
- **Some of these configurations are shared with the scientific community**
  - ORCA025, ORCA12: DRAKKAR and GLORYS Projects

www.memo-ocean.eu and www.drakkar-ocean.eu



ORCA025 1/4°
ORCA12 1/12°
ATL12 1/12°
NEATL36 1/36°

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Mercator Ocean assimilation tool SAM2v1

- Based on a multivariate SEEK filter (Pham, 1998)
- Control vector is T, S, U, V, SSH (and sea ice concentration for reanalyses)
- Assimilated data

  Along track altimetry (SLA from MyOcean: Jason-2, Cryosat-2, SARAL, HY-2A)

  SST maps (NOAA), T/S vertical profiles (From MyOcean, including ARGO)
- Innovations are calculated using "3DFGAT"

  forecast and observation are compared at the exact time and location of the observation
- 7-day assimilation window
- 3D forecast error covariances & localization
- Adaptive scheme for the first guess variance

  First guess variance is adjusted at each assimilation cycle to be consistent with the innovation statistics (Tallagrand, 1998)
- IAU (Incremental Analysis Update) scheme

  Efficient way to smoothly restart the model. IAU is set for SSH, T, S, U, V
- Bias correction on 3D T and S

  Based on innovations of the last 3 month, variational (3D-var) large scale correction

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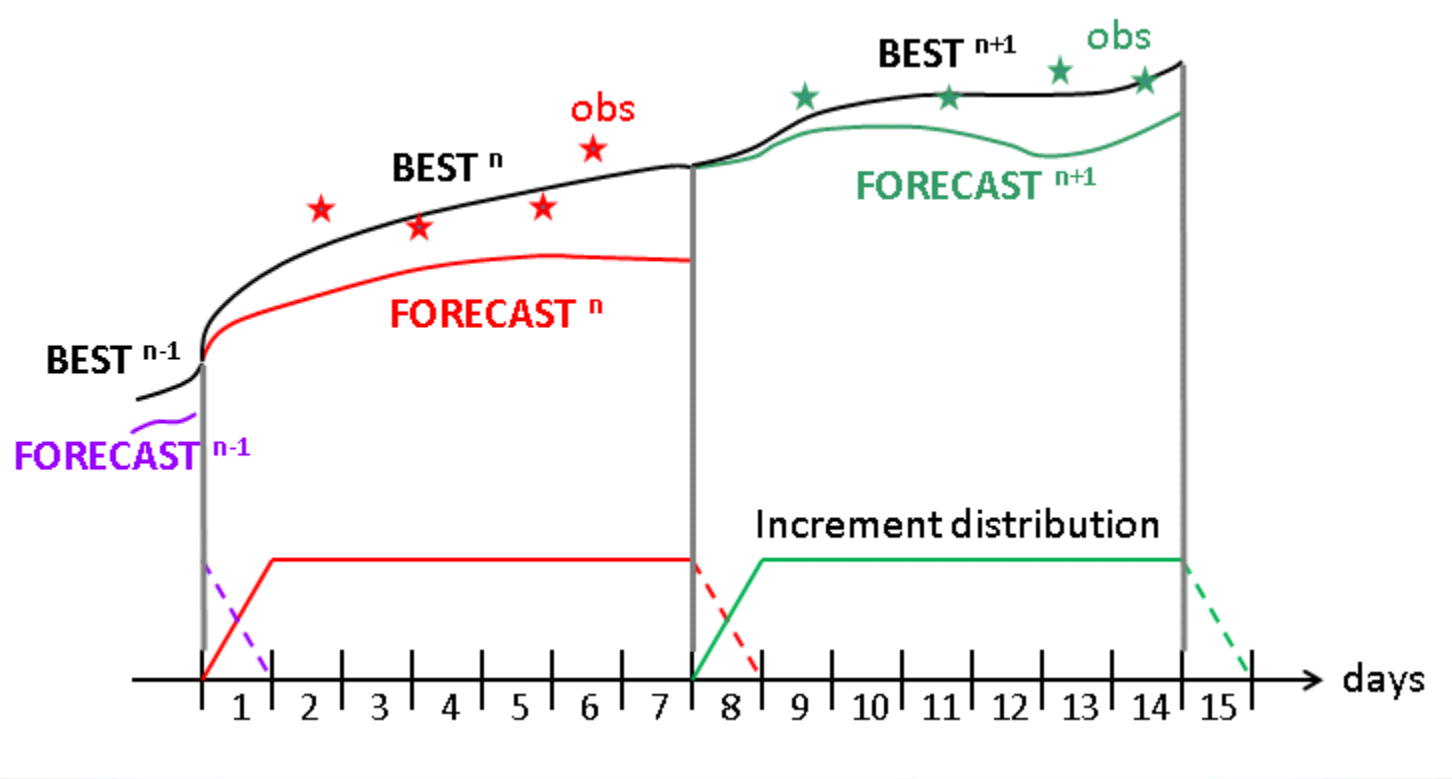
Lellouche *et al.*, Ocean Science (2013)

Mercator Ocean assimilation tool SAM2v1



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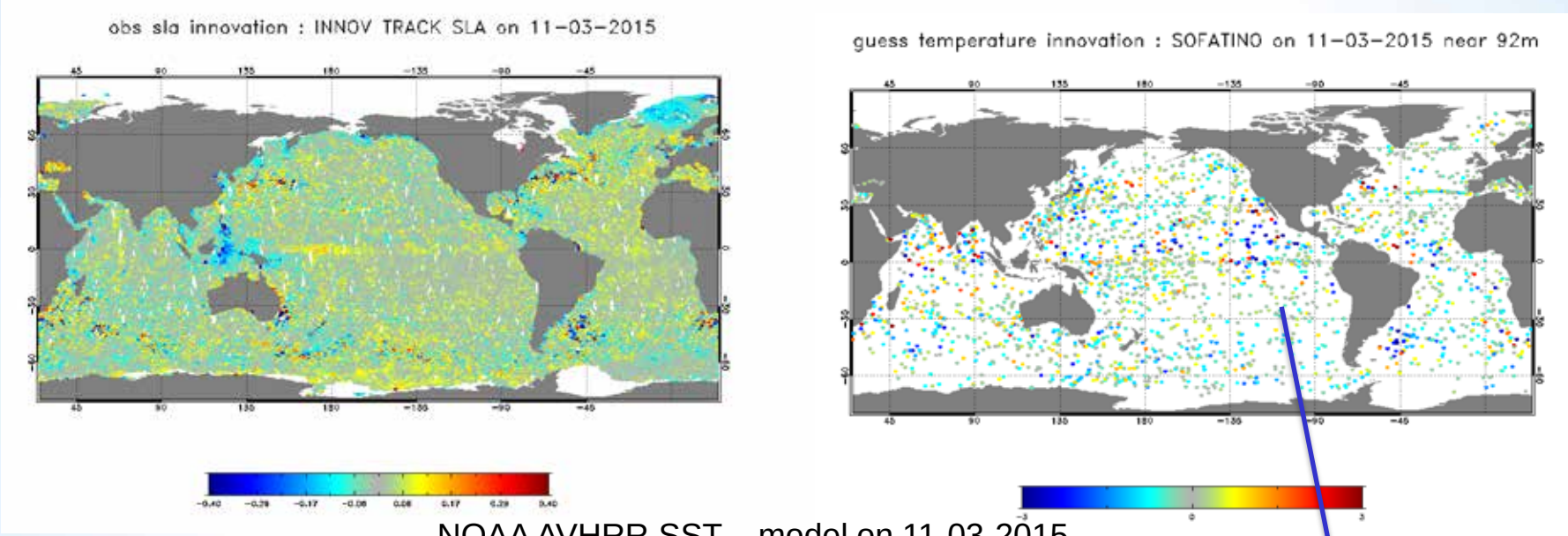
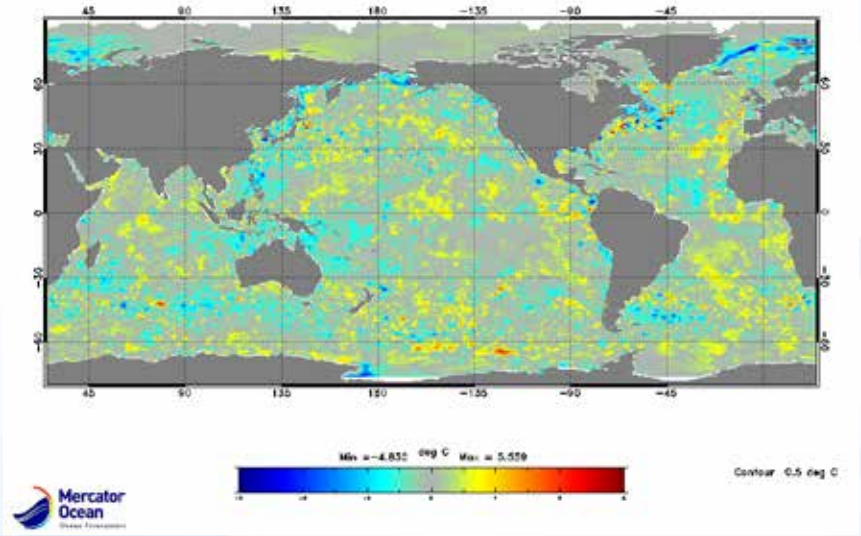
Global forecasting system at 1/12°: assimilated observations



NOAA AVHRR SST – model on 11-03-2015



What is the impact of the current ARGO network? Future ARGO network?

E-aims project

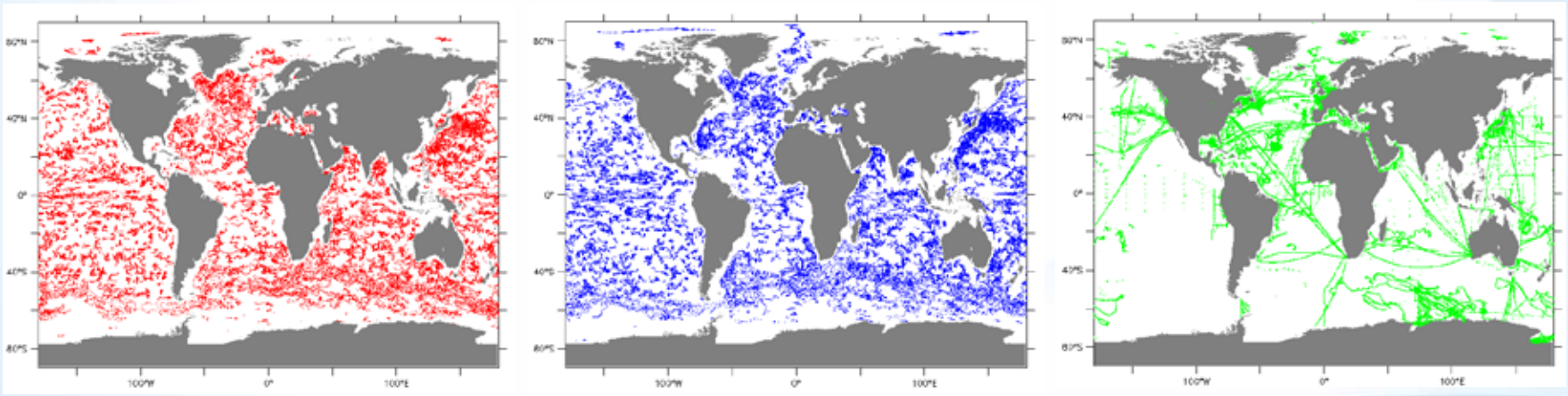
Observing system experiment OSE

Impact of one given type of observations on the analysis (model+data assimilation) quality?

Withdraw one type of observations and compare with the reference analysis (assimilating all observations)

Argo OSEs with global ¼° ocean system, year 2012

Run name	Assimilated data sets			
	SST AVHRR	SLA	Other INSITU	Argo INSITU
Run Ref	all	all	all	all
Run no argo	all	all	all	**none**
Run argo/2	all	all	all	**50% only**



Spatial distribution of 2012 *in-situ* dataset divided is 3 sub datasets.
Red dots are the odd Argo profiles, blue dots are even Argo profiles, green dots are the other *in-situ* observations.

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Argo OSE: innovation statistics

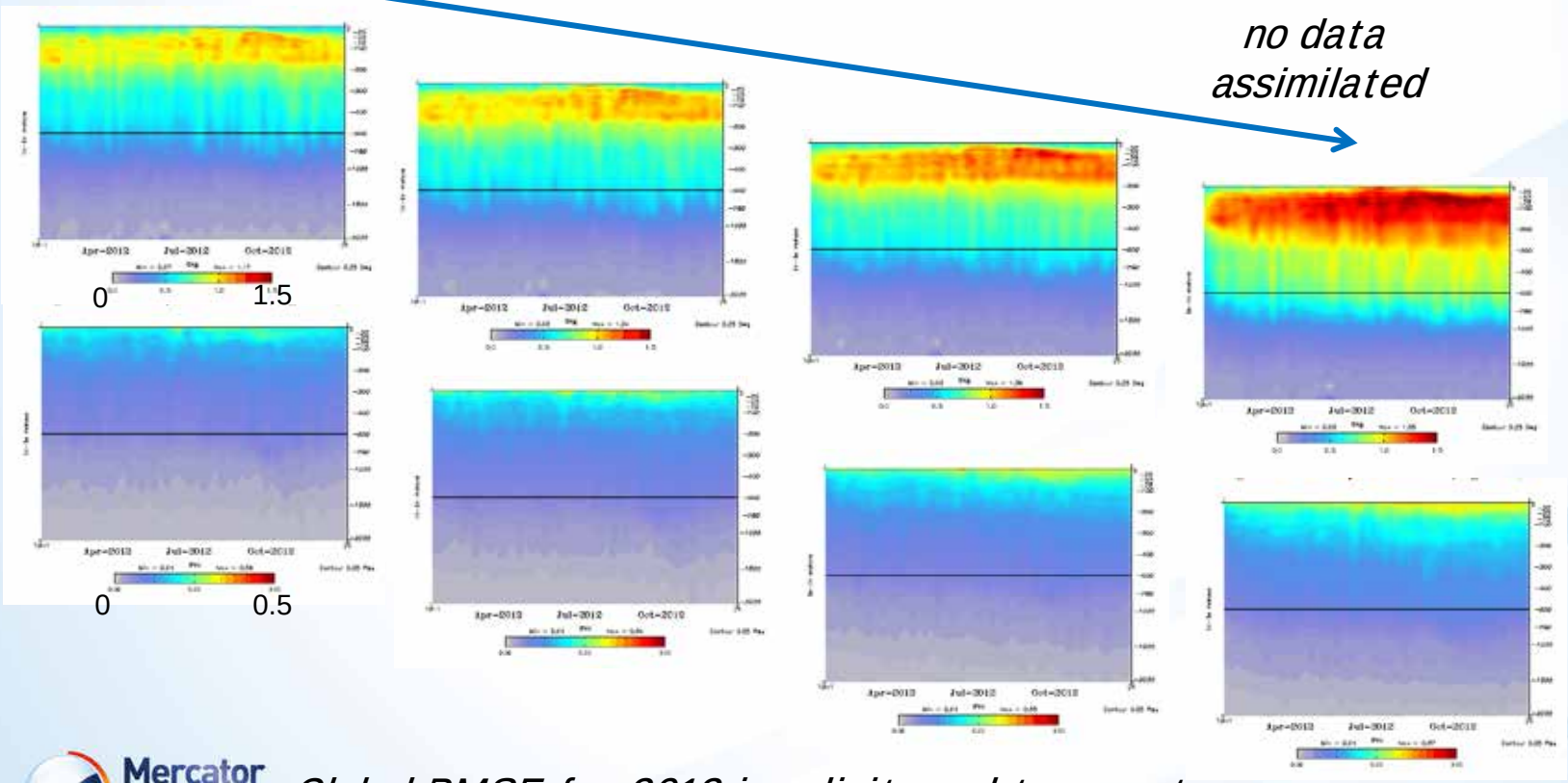
Impact of the current ARGO network on the global ¼° analysis system: simulation comparisons in terms of observation minus model **forecast** misfits for all in situ T,S data in 2012.

Reference run

without ½ ARGO floats

without ARGO floats

no data assimilated

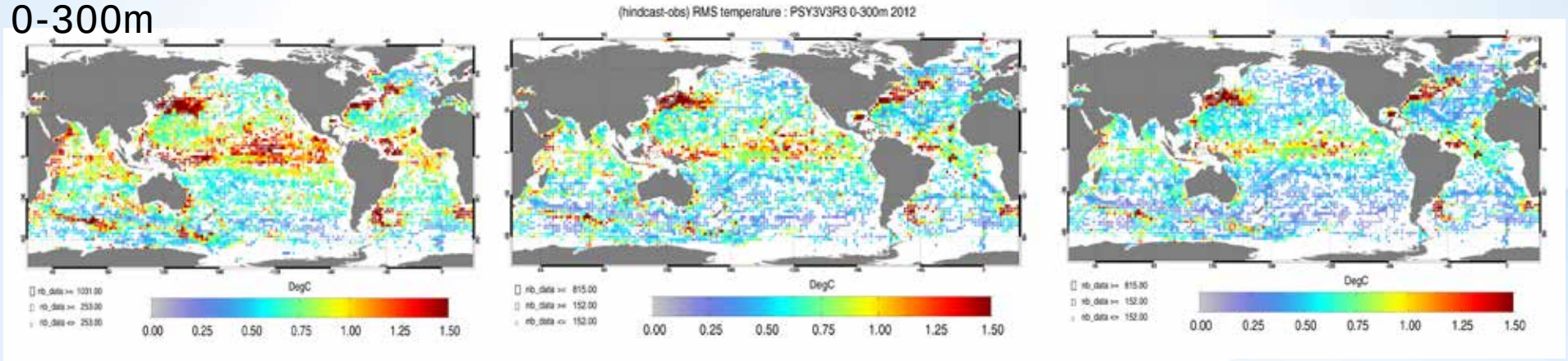


Global RMSE for 2012 in salinity and temperature

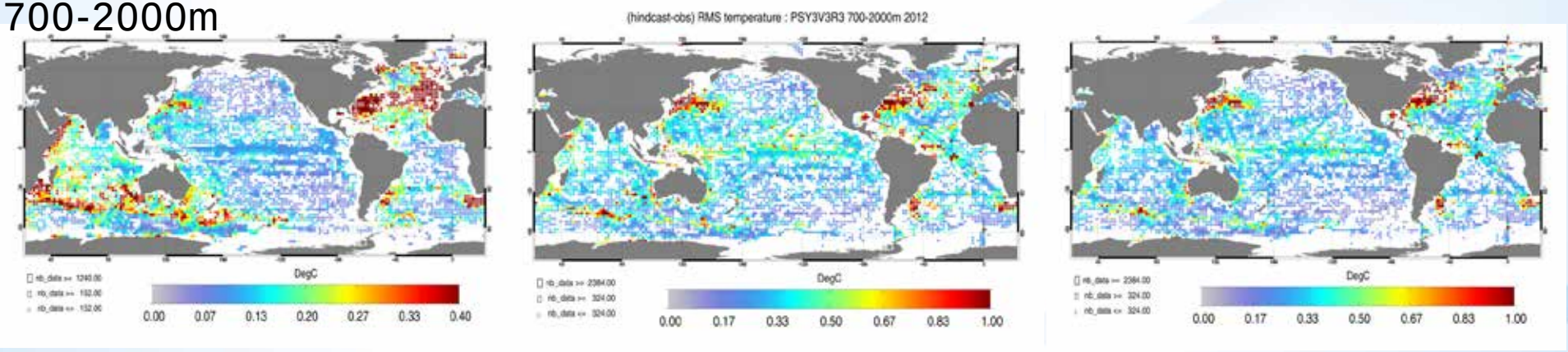
Argo OSE: residual statistics in temperature

Global RMS misfit between the in situ observations and OSEs analysis (last 6 months)

0-300m



700-2000m



Run-NoArgo Run-Argo/2 Run-Ref

Spatial distribution of the RMS temperature differences between Run-NoArgo / Run Argo/2, Run-Ref and Argo observations in the 0-300m and 700-2000m layers

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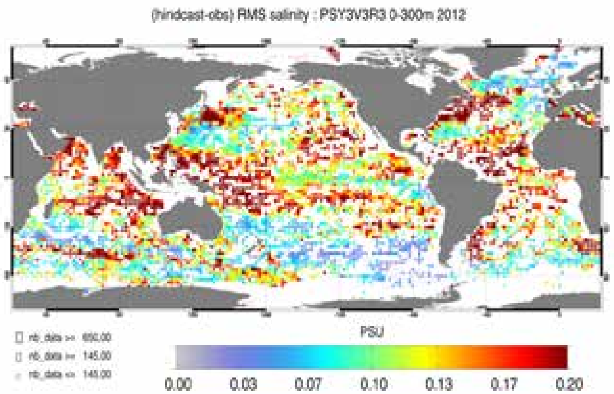
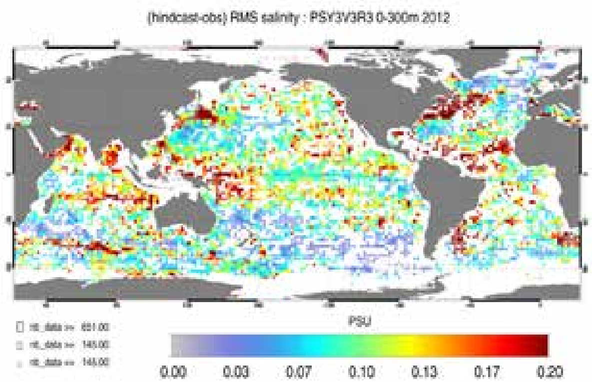
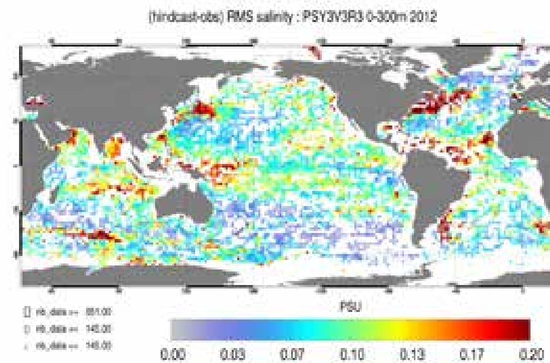
Argo OSE: residual statistics in salinity

Global RMS misfit between the in situ observations and OSEs analysis (last 6 months)

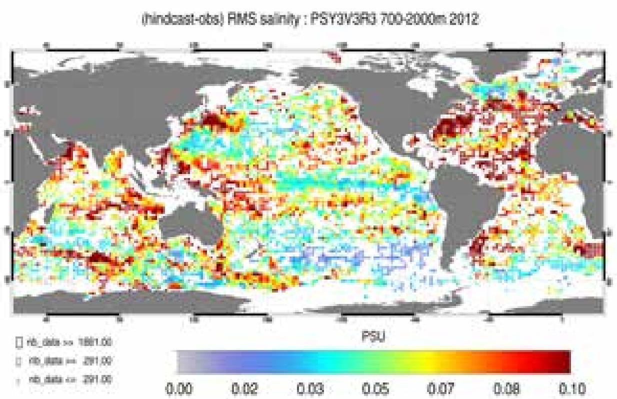
0-300m

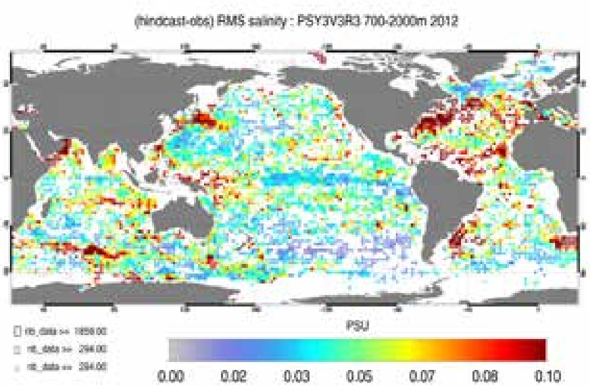


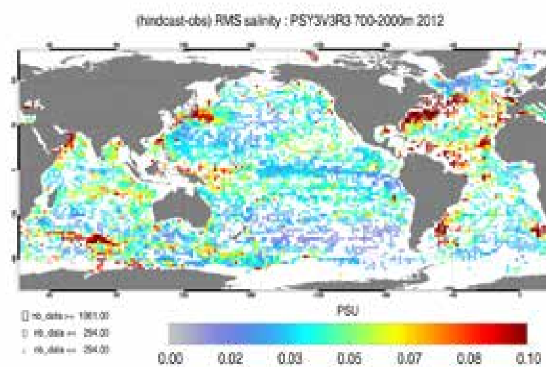




700-2000m







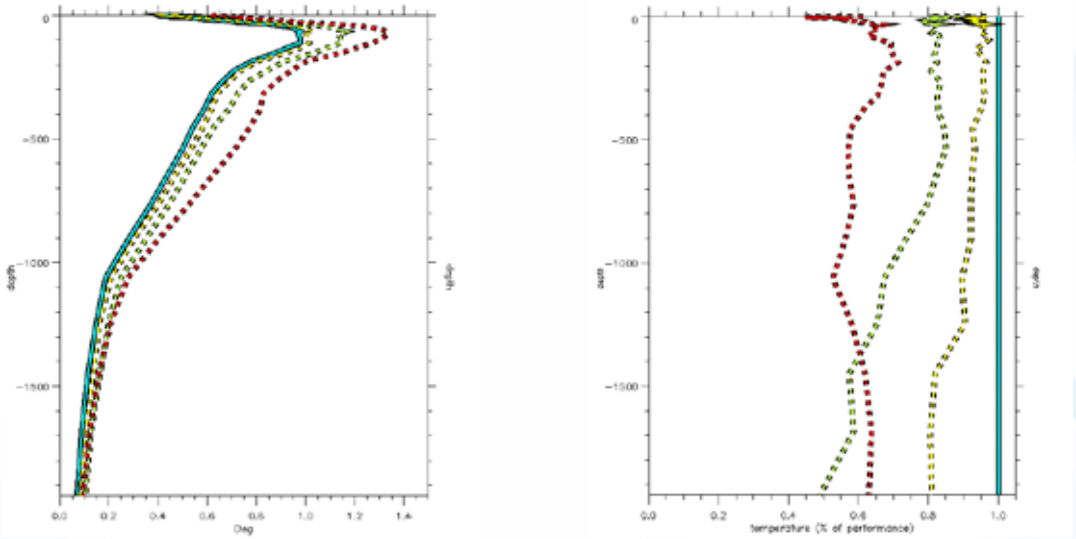
Run-NoArgo Run-Argo/2 Run-Ref

Conclusion of Argo OSE

The system reacts as we expected to the ARGO floats assimilation in terms of observation errors.

Regions of higher impact were highlighted:

- at depth, water masses from outflow or deep convection are better represented,
- in the surface layers, the largest impact is found in the tropical band and energetic ocean regions (WBC,…),
- keeping only half of the ARGO floats degrades significantly the analysis.



Vertical structure of RMS of temperature innovations (left) and normalized RMS temperature innovations (right) from 0-2000m for Run-Ref(blue), Run-Argo2(yellow), Run-NoArgo (green) and Free Run (red)

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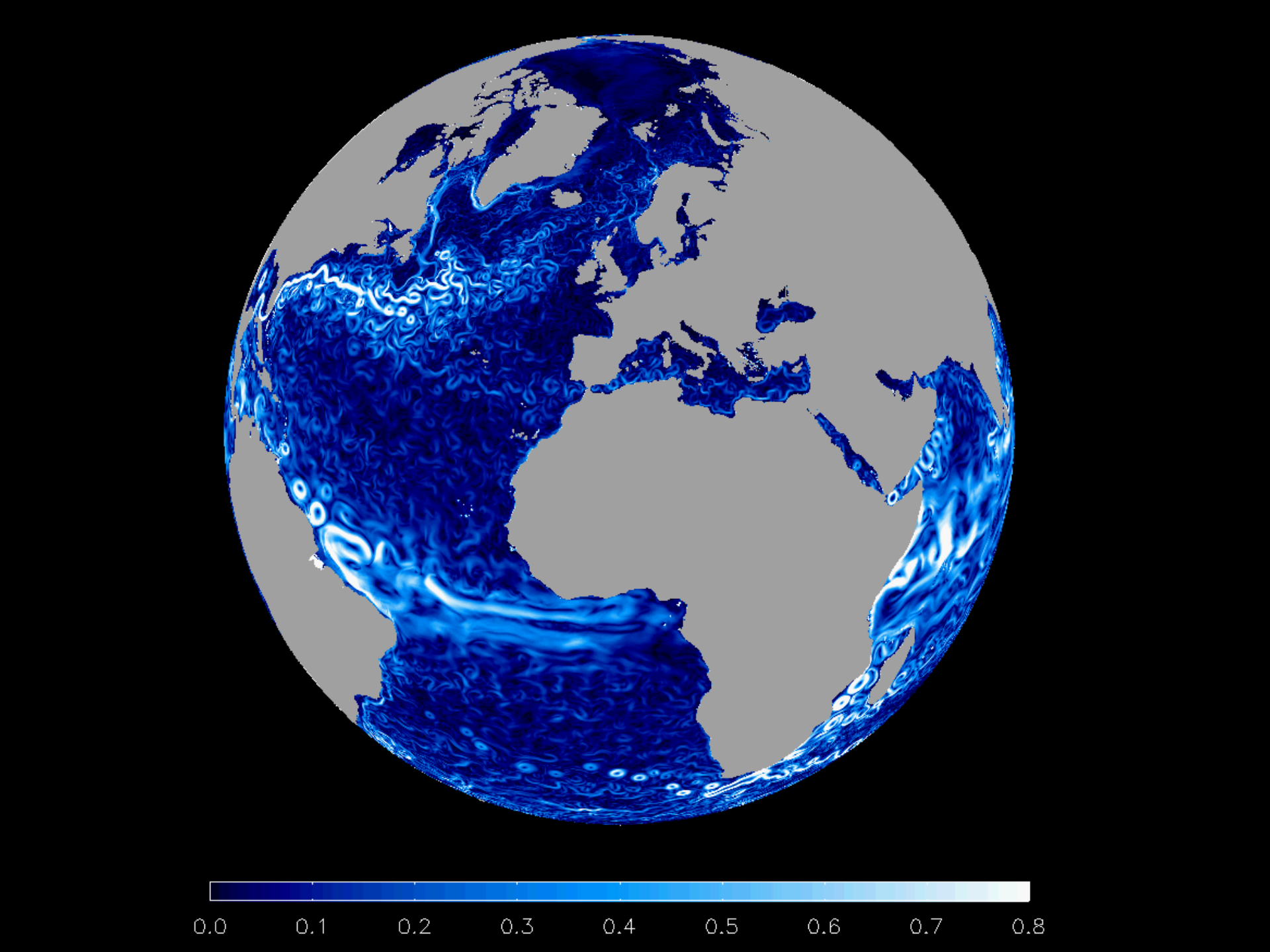
Observing system simulation experiment OSSE

Impact of one given type of virtual observations on the analysis (model+data assimilation) quality?

Build a virtual dataset from a “nature run”: model experiment at high resolution and as realistic as possible

Assimilate these virtual observations into a coarser model and assess their impact.

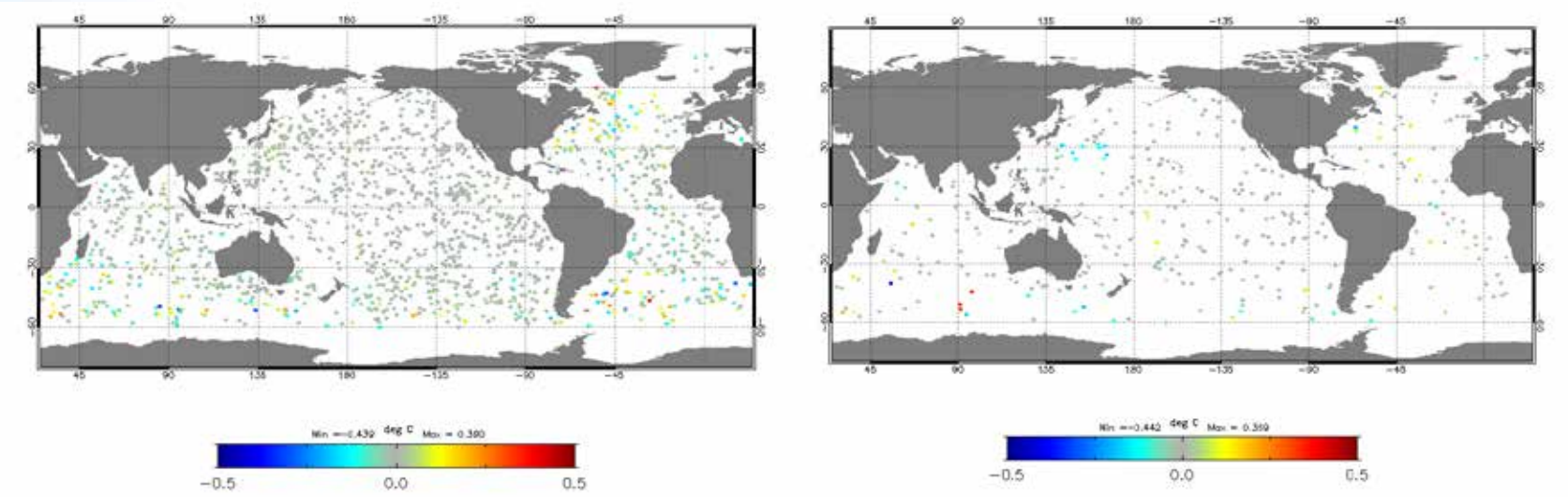

0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8

Argo OSSE with ¼° global system, 1/12° nature run, year 2009

List of OSSEs experiments

	Argo down to 2000m	Argo down to 4000m	Argo down to ocean bottom
Run1 – Reference	all	none	none
Run2 – all 4000m	all	all	none
Run4 – 1/9 4000m	all	11%	none
Run3 - 1/9 bottom	all	11%	11%

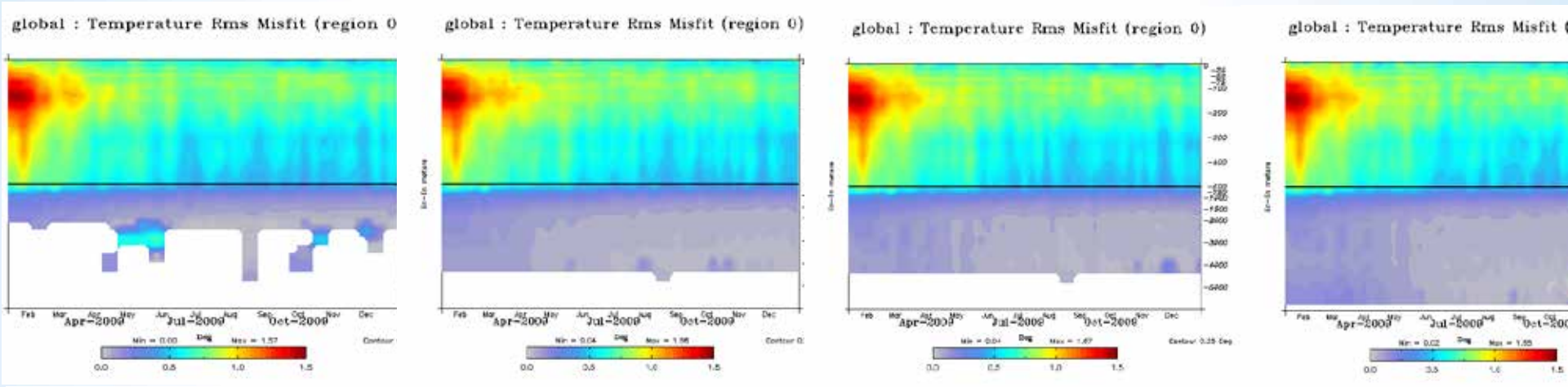
Observation location for one week in october 2009 at 3200 m depth



All Argo floats are diving down to 4000m depth

1/3 of the floats are diving down to 4000 m depth each 3 profiles.

Argo OSSE: mean and RMS temperature innovations



Down to 2000 m | *all down to 4000m* | *1/9 dive down to 4000 m* | *1/9 down to 6000*

Global RMS and mean assimilated observation – model differences in temperature in the different OSSEs

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Argo OSSE: impact on analysed temperature

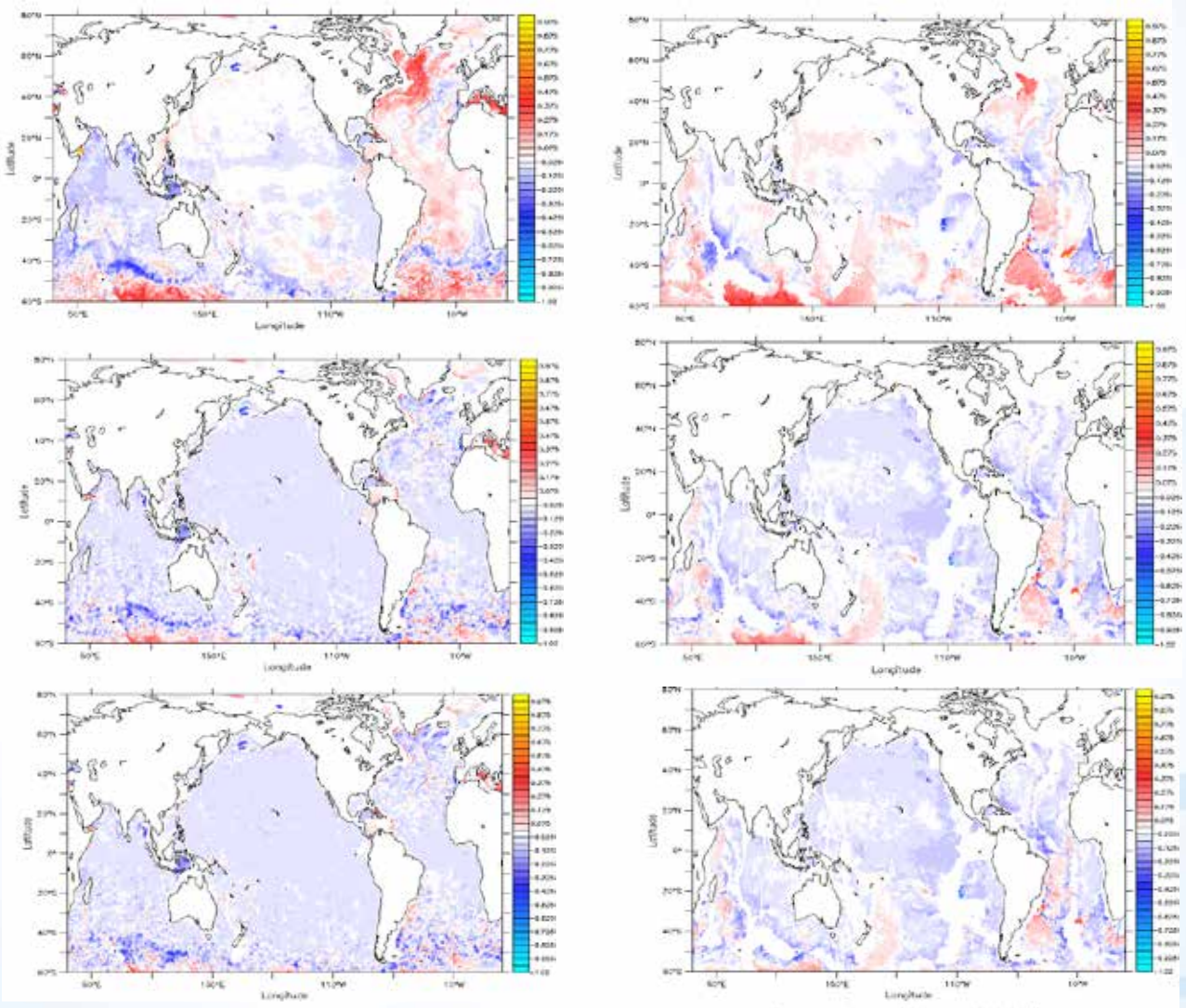
Mean temp. diff. 2000m-4000 m

Mean temp. diff. 4000m-6000 m

Run with Argo down to 2000 m

Run with 1/9 Argo down to 4000 m

Run with all Argo down to 4000 m



Mean deep ocean temperature misfits in °C between the "truth" and different OSEs for different depth ranges.

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Argo OSSE conclusion

OSSE experiments show:

- Increasing the depth of Argo floats **profiles down to 4000 m depth** instead of 2000m reduces the biais between 2000m down to the bottom where it was large,

- Increasing the depth of **only 1/9 Argo floats profiles down to 4000 m depth** instead of 2000m gives comparable results than if all are going down to 4000m. This is consistent with the fact that we found a low temporal variability but significant bias in some regions.

- Increasing the depth of Argo floats **profiles down to 6000 m** instead of 2000m **for only 1/9** : analysis in progress.

- The actual variability at depth **might be much smaller than the simulated model errors**, and there could be some issues detecting and controlling it.

Those conclusions are based on model simulation only.

Recommendations from Argo OSE/OSSE at Mercator Ocean

For Argo in situ observations, our system reacts as expected:

- Ø The ¼° ocean forecast and analysis system is sensitive to the density change of the current Argo array,
- Ø Extending to depth the float profiles should allow the reduction of deep biases. A work has to be done to understand the small uniform bias appearing at depth.

Recommendations:

- Ø The Argo array should be at least maintained at its present level of coverage and data quality.
- Ø Deep ocean measurements are strongly required in data assimilative system. They are also crucial for model initialization (climatology), model validation and in situ/altimetry complementarity (contribution of the dynamic height deep ocean steric variability to SSH variability) .

  Deep argo measurement with a coarse resolution seems to be enough to constrain the deep bias of the ¼° ocean system.

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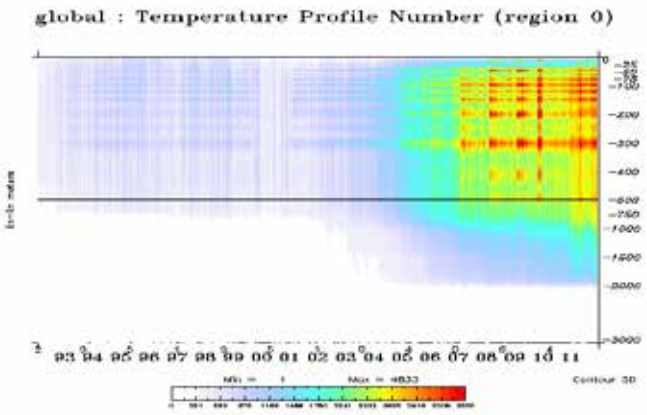
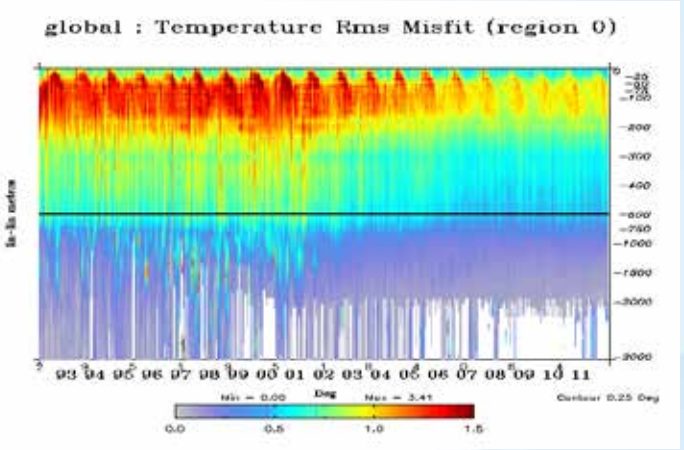
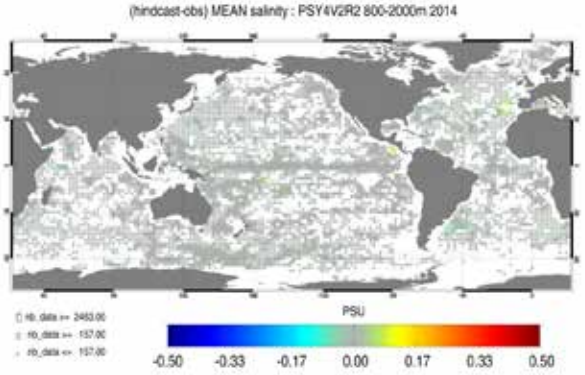
Model and analysis validation

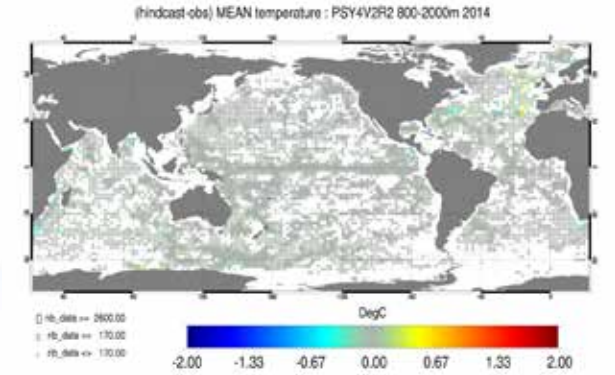
Glorys2v3: global number of in situ data and RMS innovations

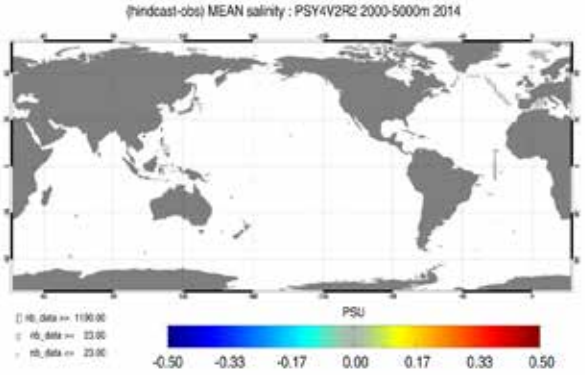


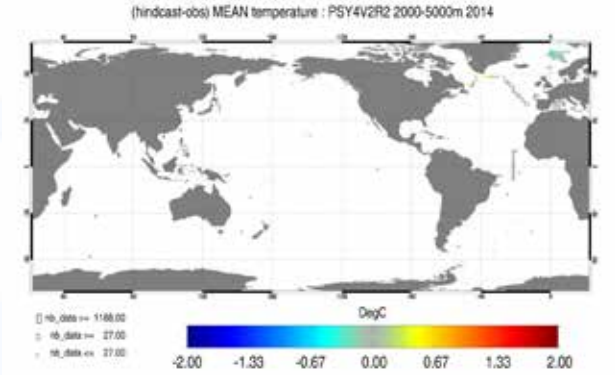


Real time production validation:
Observation misfit statistics
800m-2000m
And
2000m-5000m









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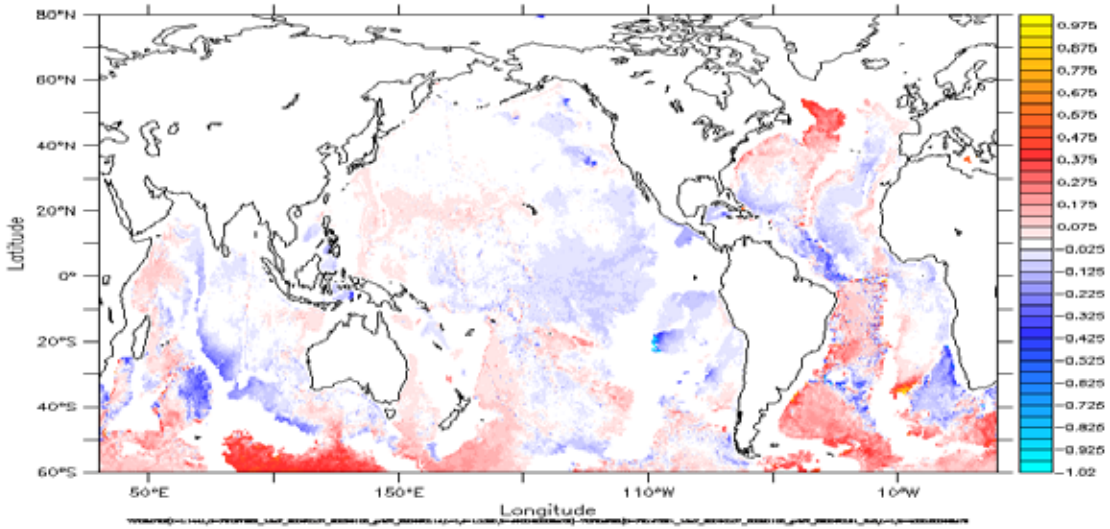
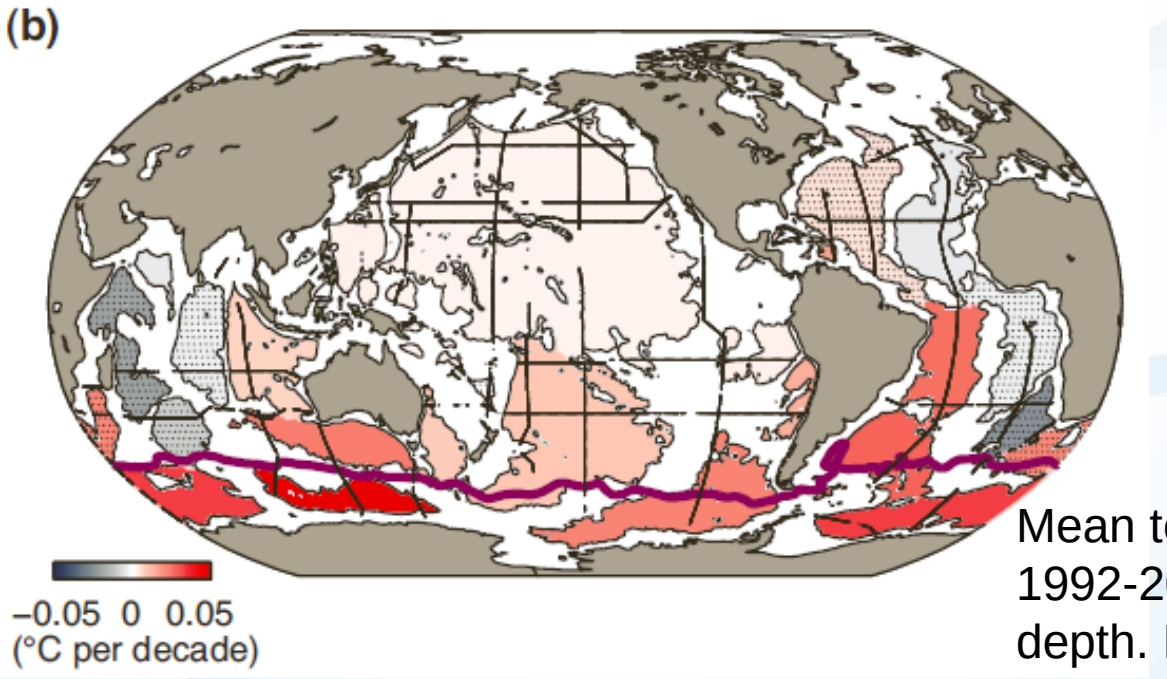


-1.0

0.0

-1.0°C

Diff temperature differences below 4000m between RunNoDeep – RunTruth in january 2009.



Mean temperature trend 1992-2005, below 4000m depth. From IPCC, AR5

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