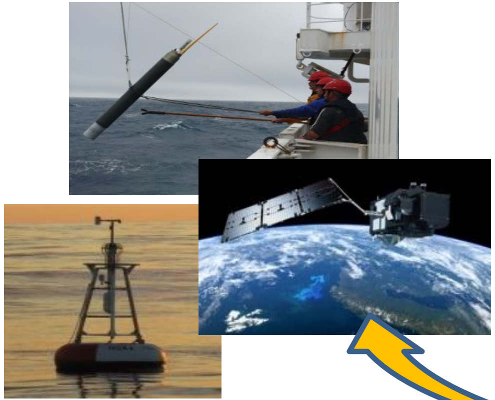
Impact of tropical Atlantic observations on ocean analysis and forecasts

Elisabeth Rémy, Jean-Michel Lellouche, Charly Regnier, Lynne Macarez (Mercator Ocean), Yosuke Fujii (JMA-MRI)

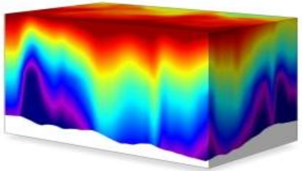
MERCATOR OCEAN INTERNATIONAL

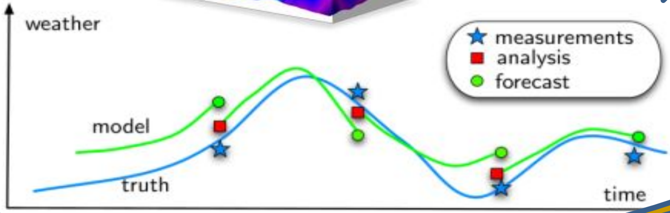
Ocean monitoring and prediction systems

Ocean observing systems

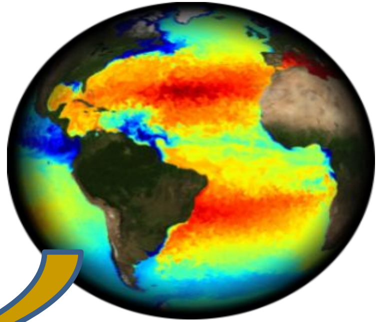


Data integration into model (physics and BGC)





Provision of Ocean, ice and BGC analysis and forecasts



Ocean analysis highly rely on observation availability and accuracy. An efficient assimilation of observation into forecasting model to better control the ocean circulation requires:

- a good knowlegde of the **<u>observed spatial and temporal scales</u>** **<u>by the different platforms</u>**
- a good knowledge of the **<u>observation accuracy and resolution</u>**
- a good knowledge of the **<u>model representativity</u>** of the observable processes

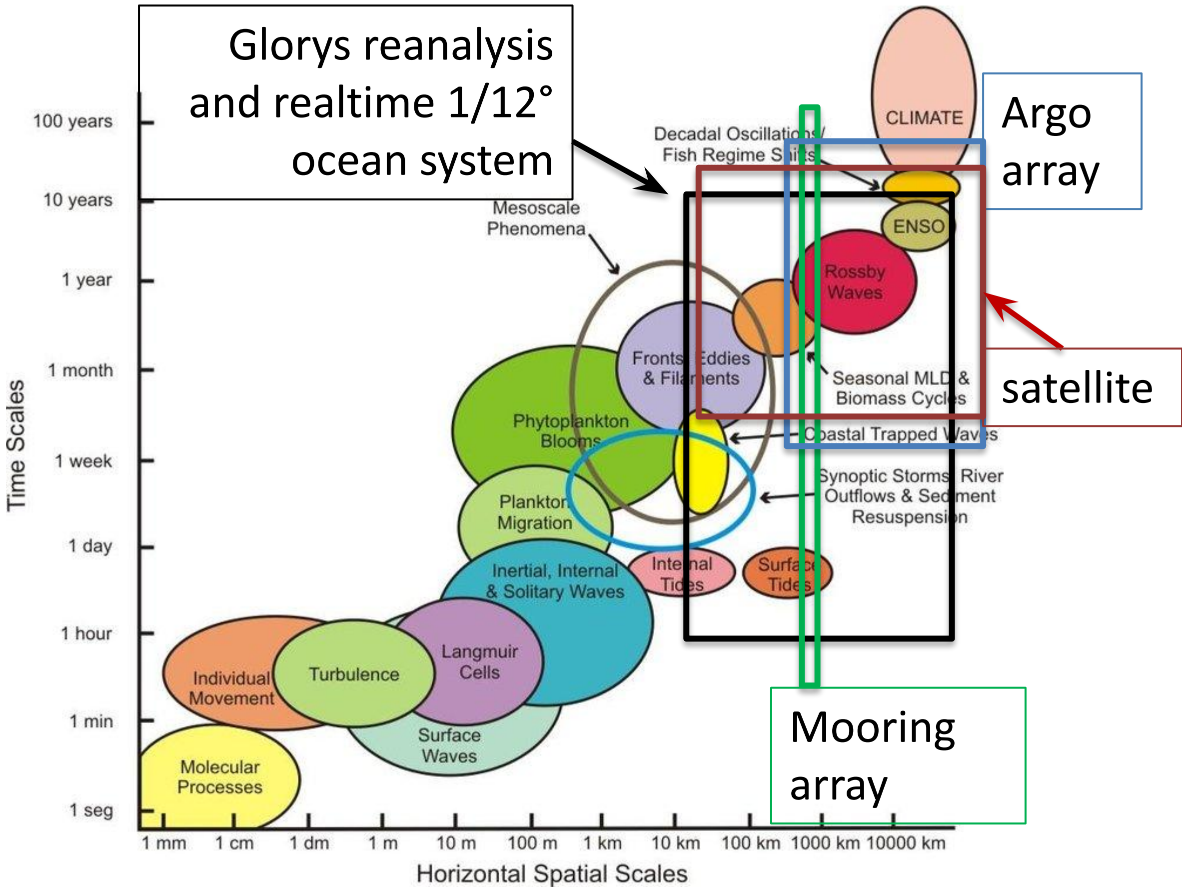
-> discussion between model and observation community for a better understanding of the observation content and accuracy.

Ocean processes and observing networks

The Mercator Ocean global system at 1/12° is able to represent the ocean variability from the diurnal cycle to the interannual variability.

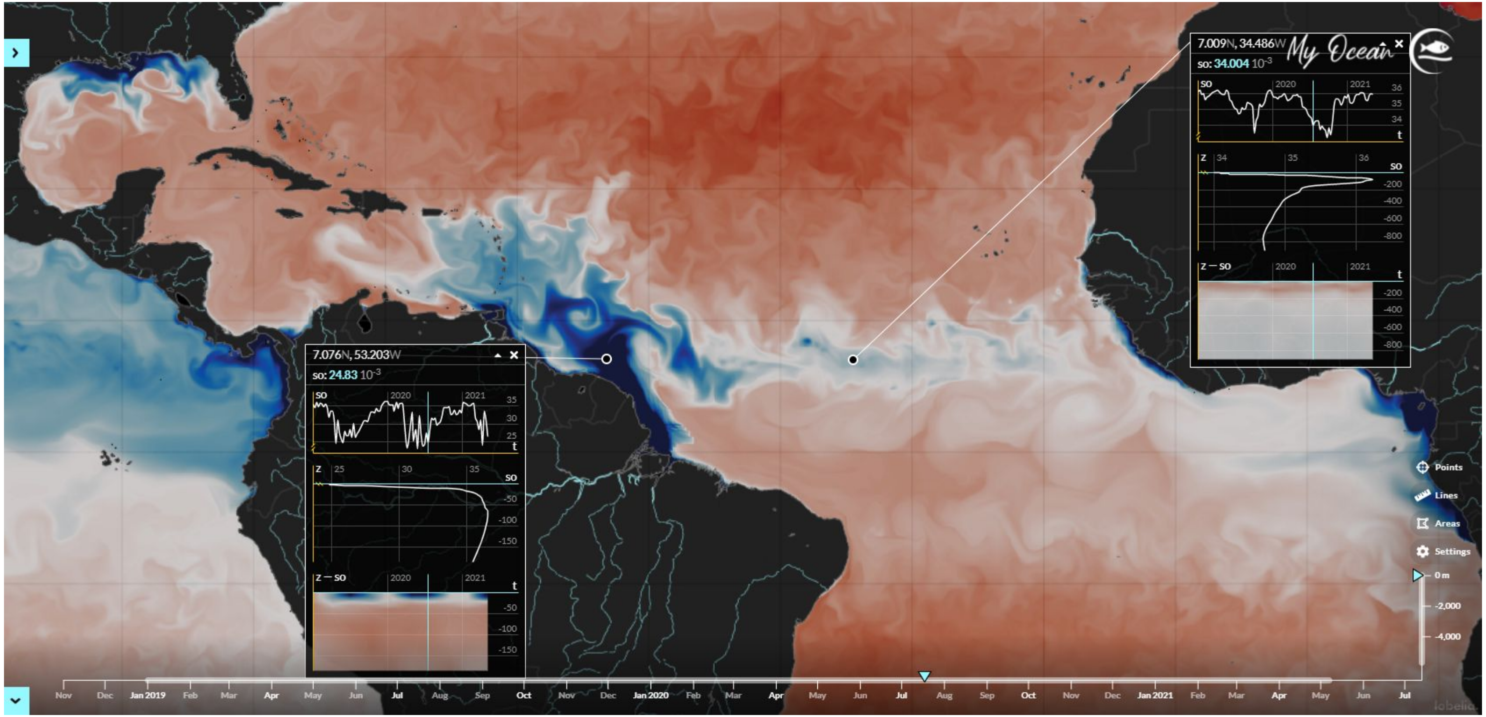
- The meso-scale representation depends on the latitude.
- Below one day, the rapid waves are filtered; no tide forcing in the model.

Assimilated observations help to constrain different scales and variables of the model forecast depending on the platform.



Accuracy of the 1/12° system in the Tropical Atlantic

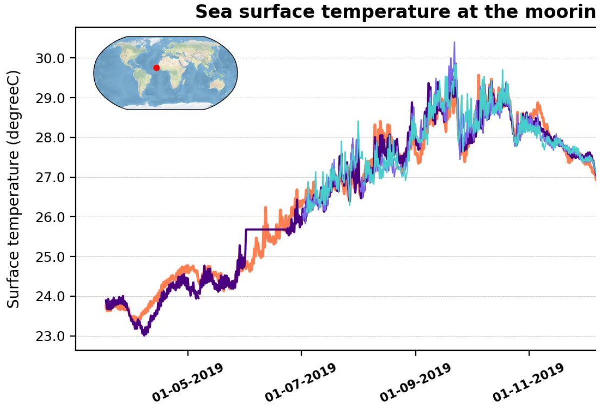
Ocean surface salinity in the real time 1/12° global system for July 7 2020.

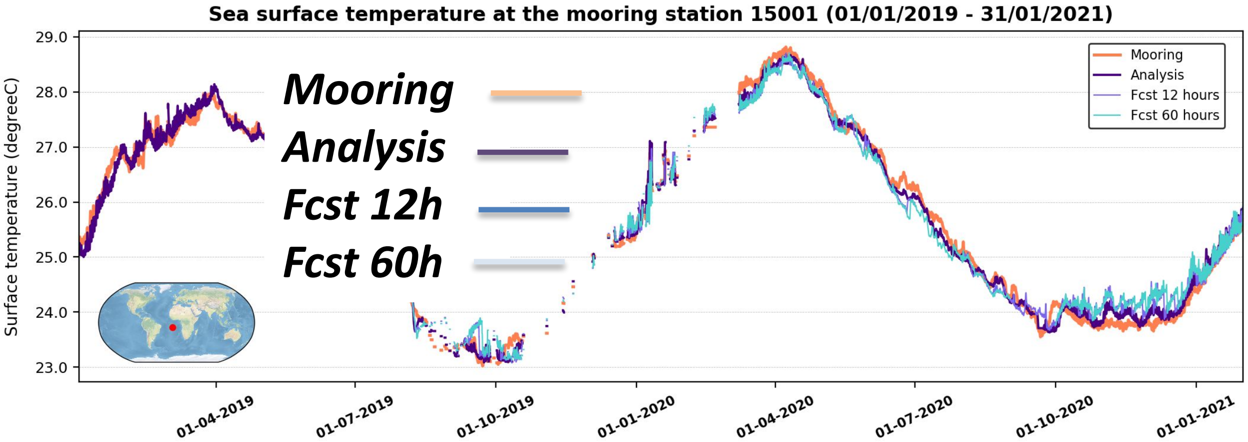


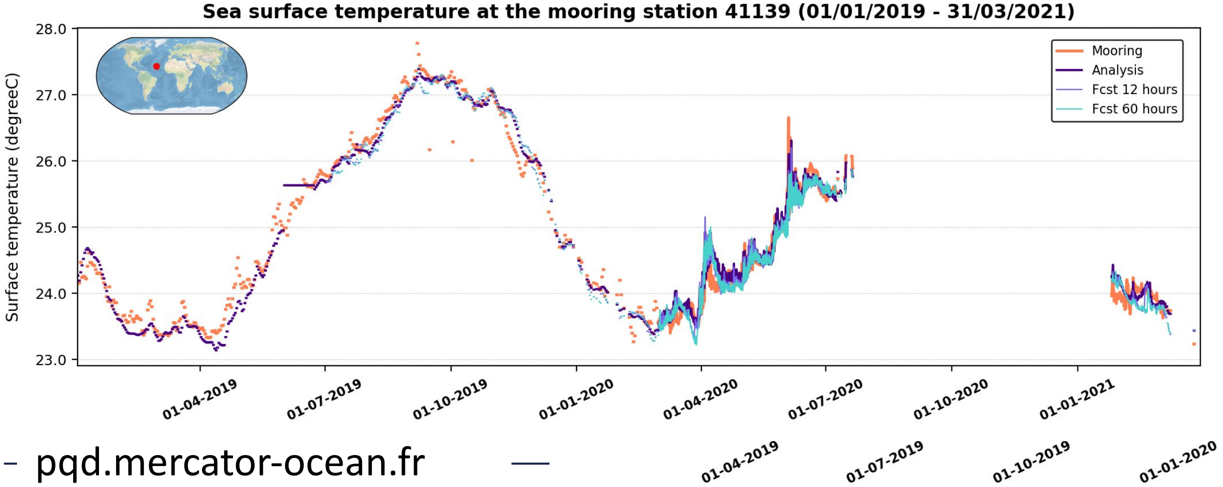
https://myocean.marine.copernicus.eu/ (https://tinyurl.com/ye5t5ccv)

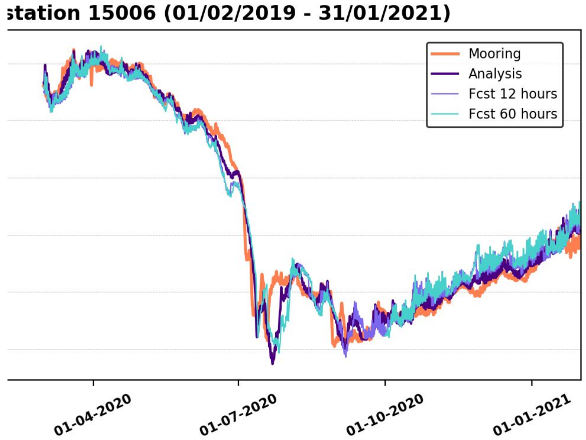
MERCATOR OCEAN INTERNATIONAL

Accuracy of the 1/12° system in the Tropical Atlantic





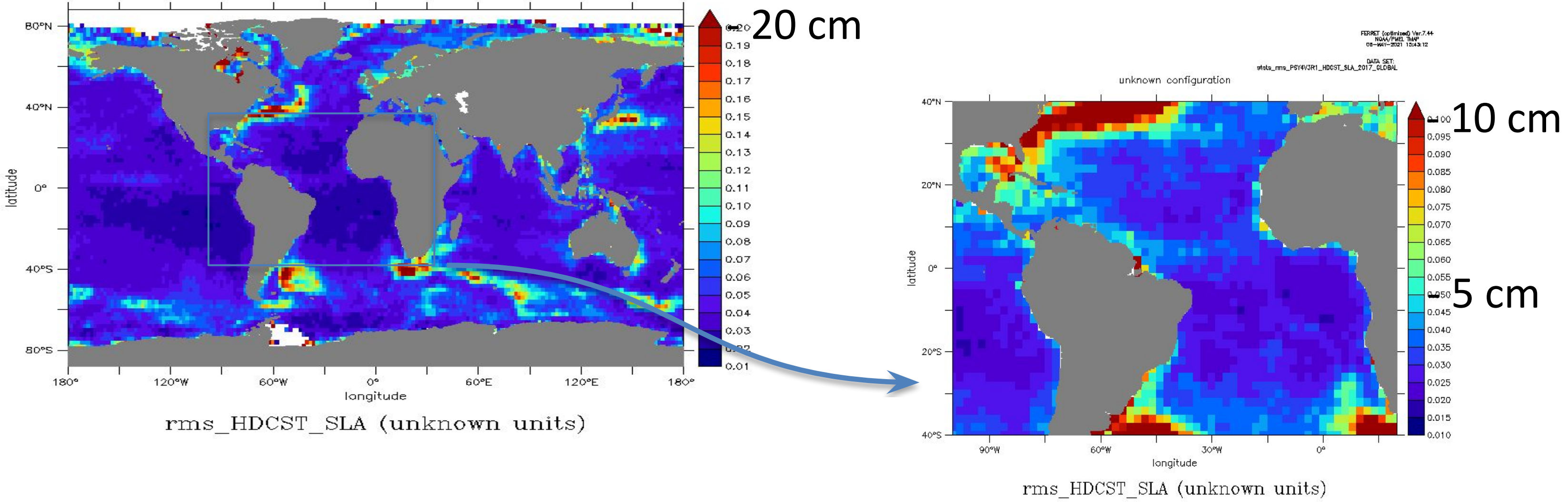




- pqd.mercator-ocean.fr

Accuracy of the 1/12° system in the Tropical Atlantic

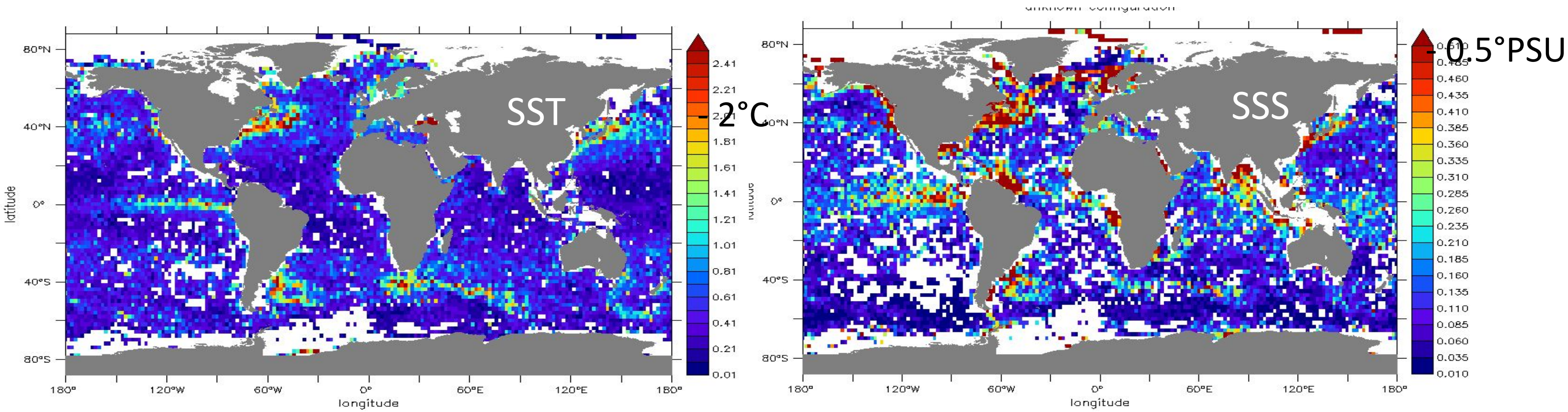
Comparison to along track Sea Level observations (2016)



- In the Tropical Atlantic, RMS misfit beetween the observed and analysed sea level is very small, around 3 cm, comparable to the observed SLA product accuracy (CMEMS/DUACS).
- Slightly higher misifits in coastal zones and in the Amazon outflow region.

Accuracy of the real time global 1/12° system

Comparison to in situ observations (2016)



Weekly RMS misfit between the 1/12° global system analysis and in situ observations (2°x2°maps): For temperature (left panel), salinity (right panel) in 2016 between the surface and 5 meter depth.

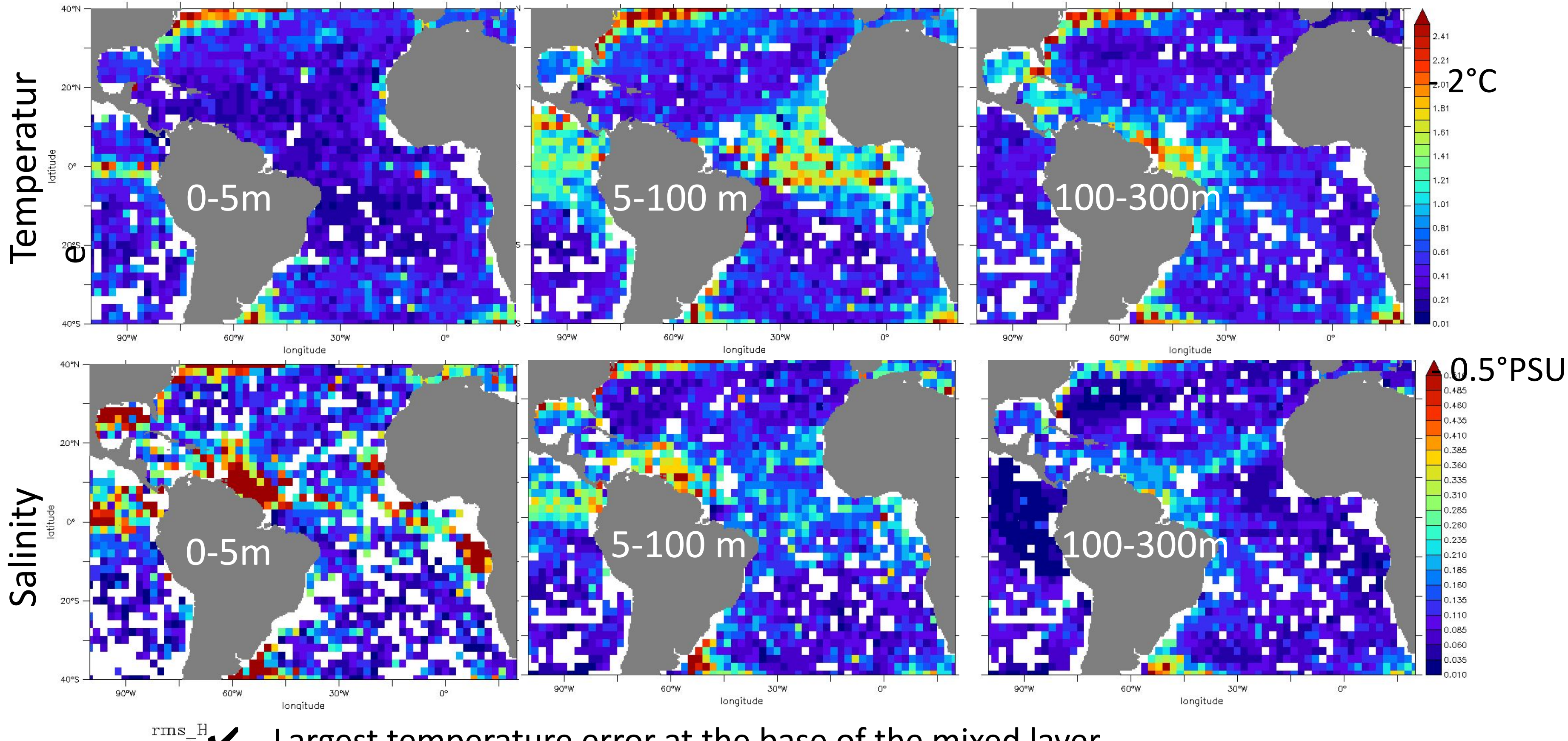
High surface temperature analysis error:

Western boundary currents, east tropical Pacific.

High surface salinity analysis error:

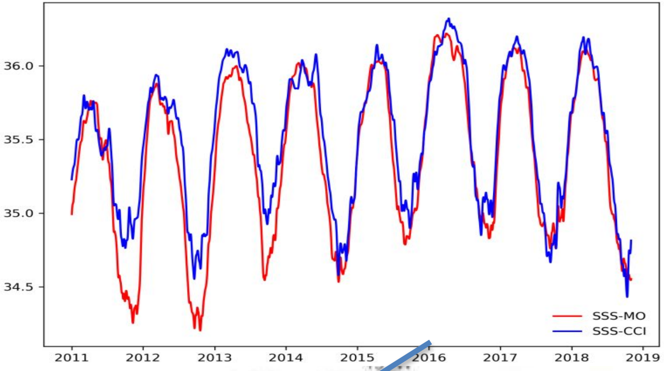
river plumes, tropical regions with high **precipitation (ITCZ-SPCZ**), **North Atlantic** (same patterns are found when comparing analysis to satellite SSS)

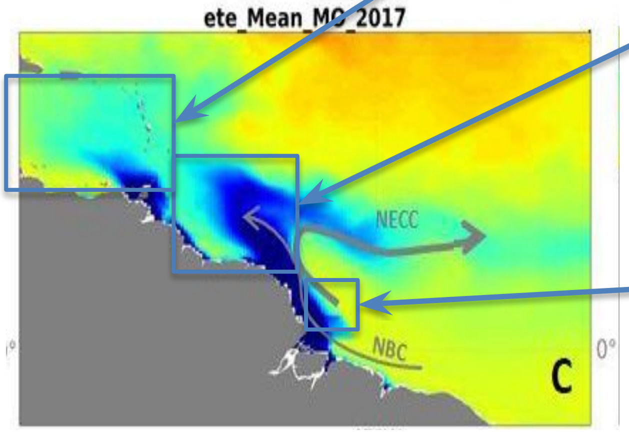
Accuracy of the 1/12° system in the Tropical Atlantic



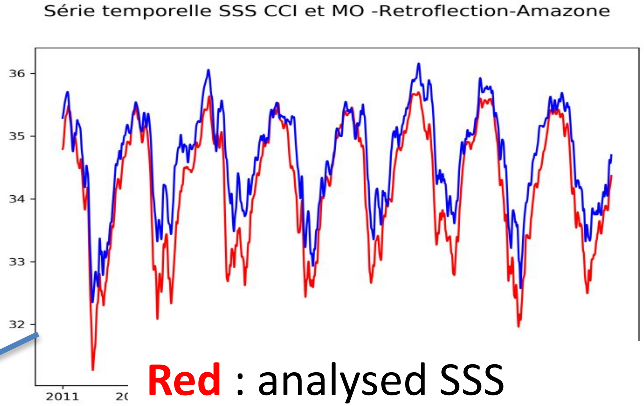
- ✔ Largest temperature error at the base of the mixed layer.
- ✔ Largest salinity error in river outflow regions, at the surface.

Accuracy of the 1/12° system in the Tropical Atlantic

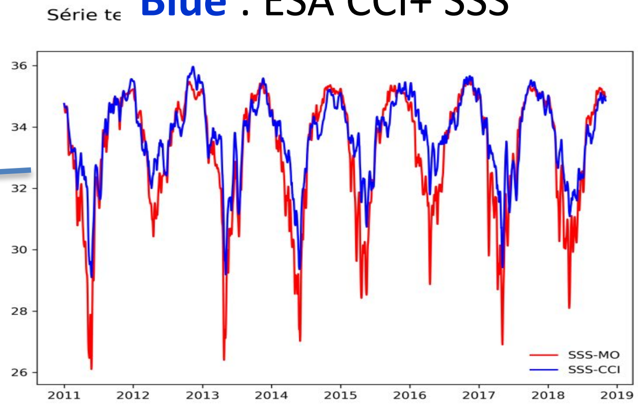




Mean SSS in Glo12 in summer 2017



Red : analysed SSS
Blue : ESA CCI+ SSS



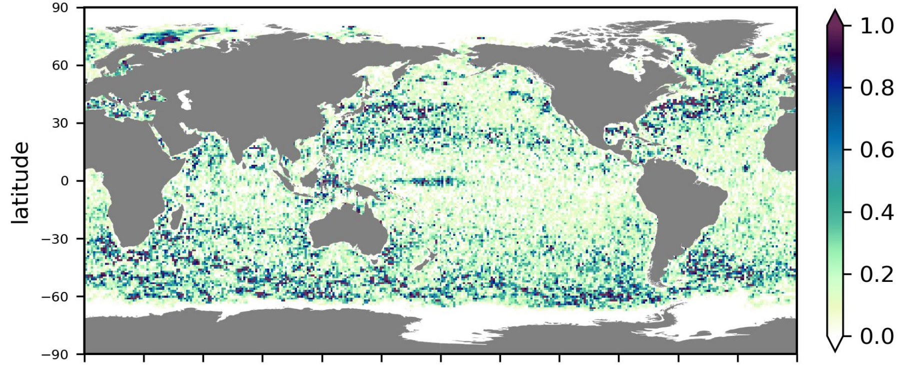
Evolution of the SSS in different subregions from 2011 to 2018

- Coherent seasonal and interannual variability between the 2 estimates
- Fresher values in Glo12 compared to ESA CCI SSS in autumn, when close to the river mouth.

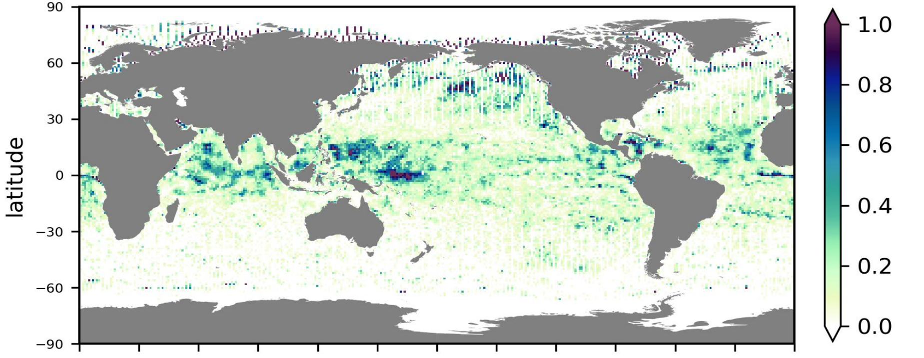
The freshwater flows closer to the coast in Glo12 than seen in ESA CCI SSS.

Influence of different type of observations on the 1/12° global analysis

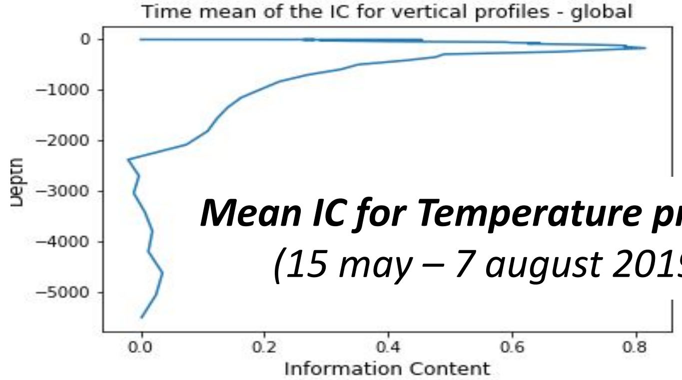
Information Content = DFS/Nb Obs - DFS approximated as proposed by C. Lupu et al. (2011)



Mean Sentinel3b IC *(15 may – 7 august 2019)*



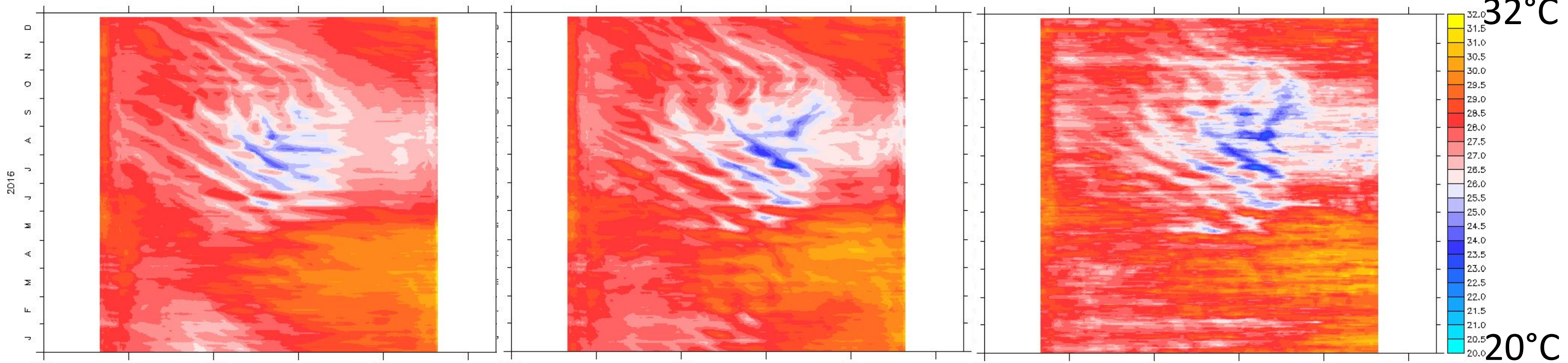
Mean SST IC *(15 may – 7 august 2019)*



Mean IC for Temperature profiles
(15 may – 7 august 2019)

- SST observations have more influence in the tropics and in the « summer hemisphere »,
- SLA observations are most used in turbulent regions,
- In situ observations at the thermocline depth have the largest impact.

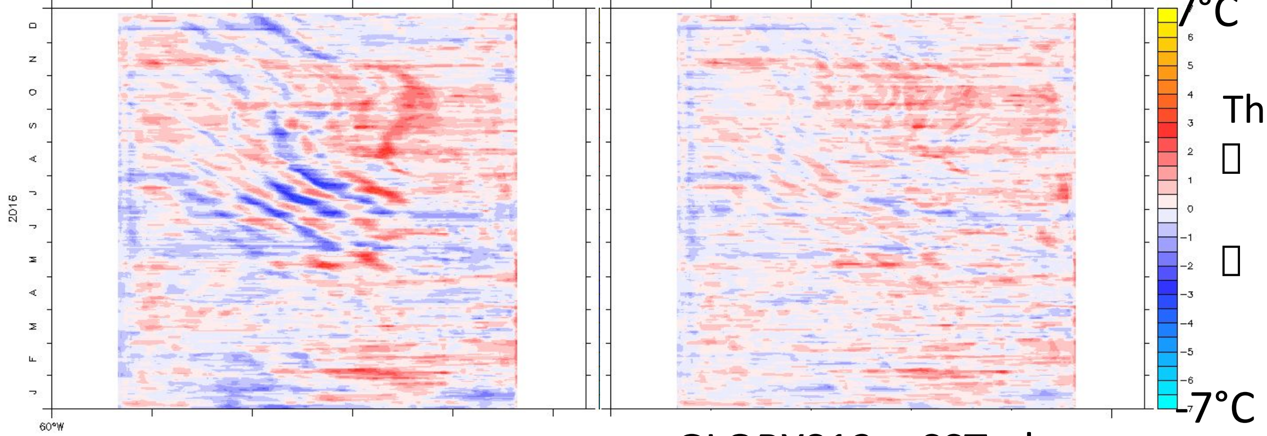
Evolution of the SST at 1N in the Tropical Atlantic in 2016



Free GLORYS12 (no DA)

GLORYS12 (with DA)

Satellite observations



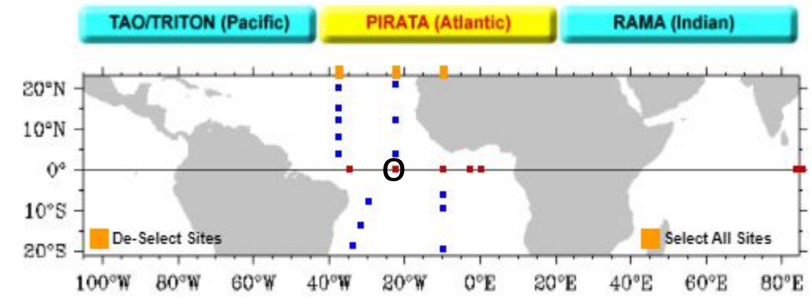
Free GLORYS12 – SST obs

GLORYS12 – SST obs

The data assimilation (DA) leads to:

- Change in the propagation of the tropical waves (TIW)
- Better agreement with the satellite observed SST.

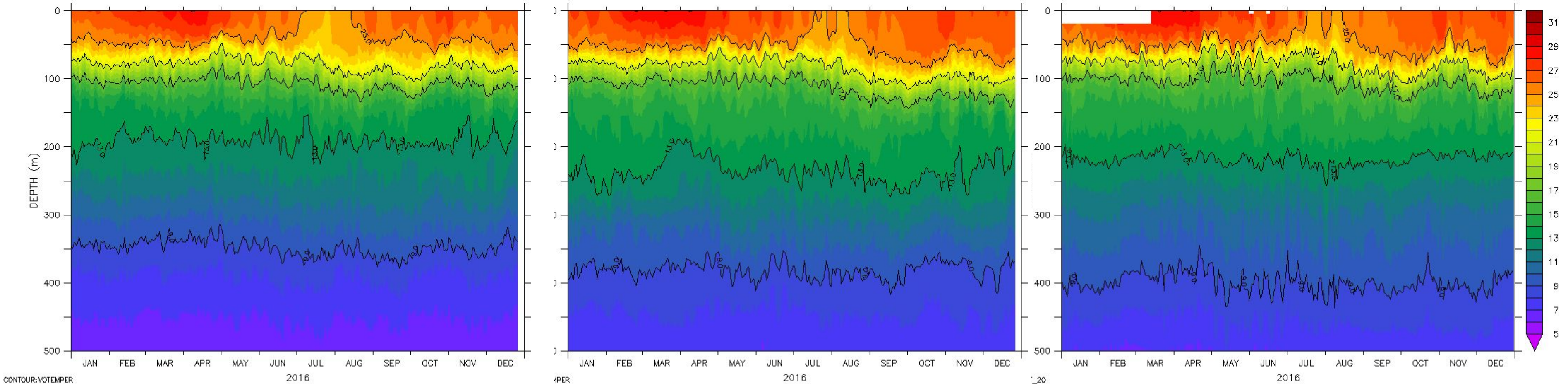
Impact of observations on ocean analysis in the Tropical Atlantic



Temperature evolution at mooring location (23W-Eq):

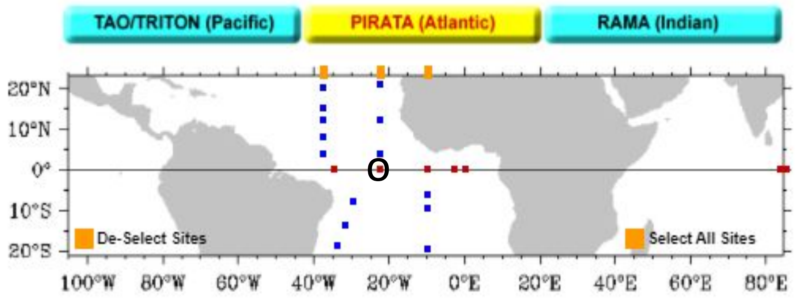
- Data assimilation improves the intraseasonal variability,
- Without DA, the model **strongly** (2 to 3°C) drifts at depth.

Temperature evolution at 23°W-0°N in 2016



Free GLORYS12 (no DA) *GLORYS12 (with DA)* *Mooring observations*

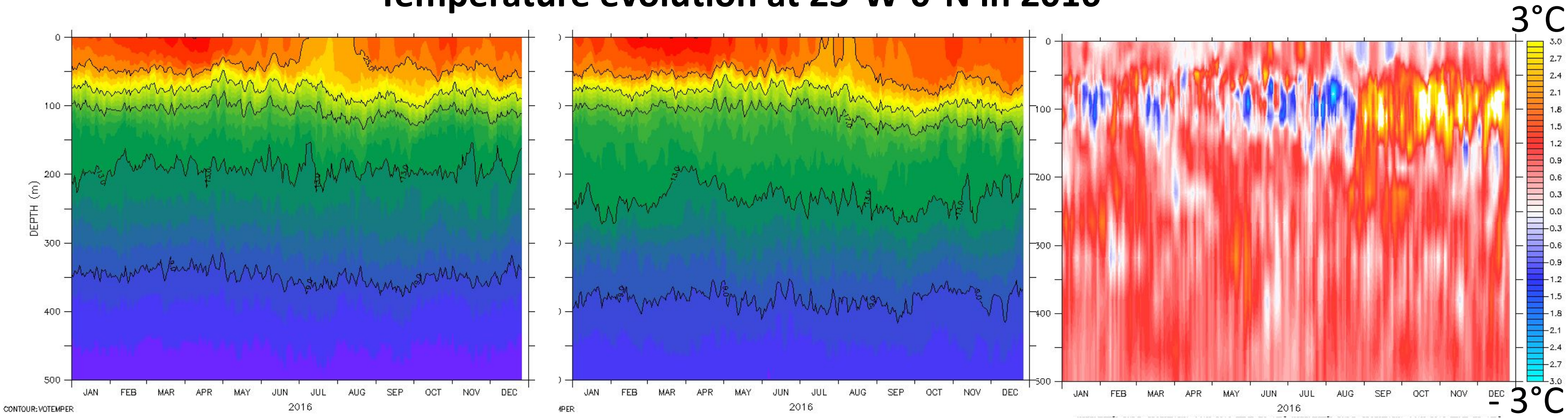
Impact of observations on ocean analysis in the Tropical Atlantic



Temperature evolution at mooring location (23W-Eq):

- Data assimilation improves the intraseasonal variability,
- Without DA, the model **strongly** (2 to 3°C) drifts after several years of integration

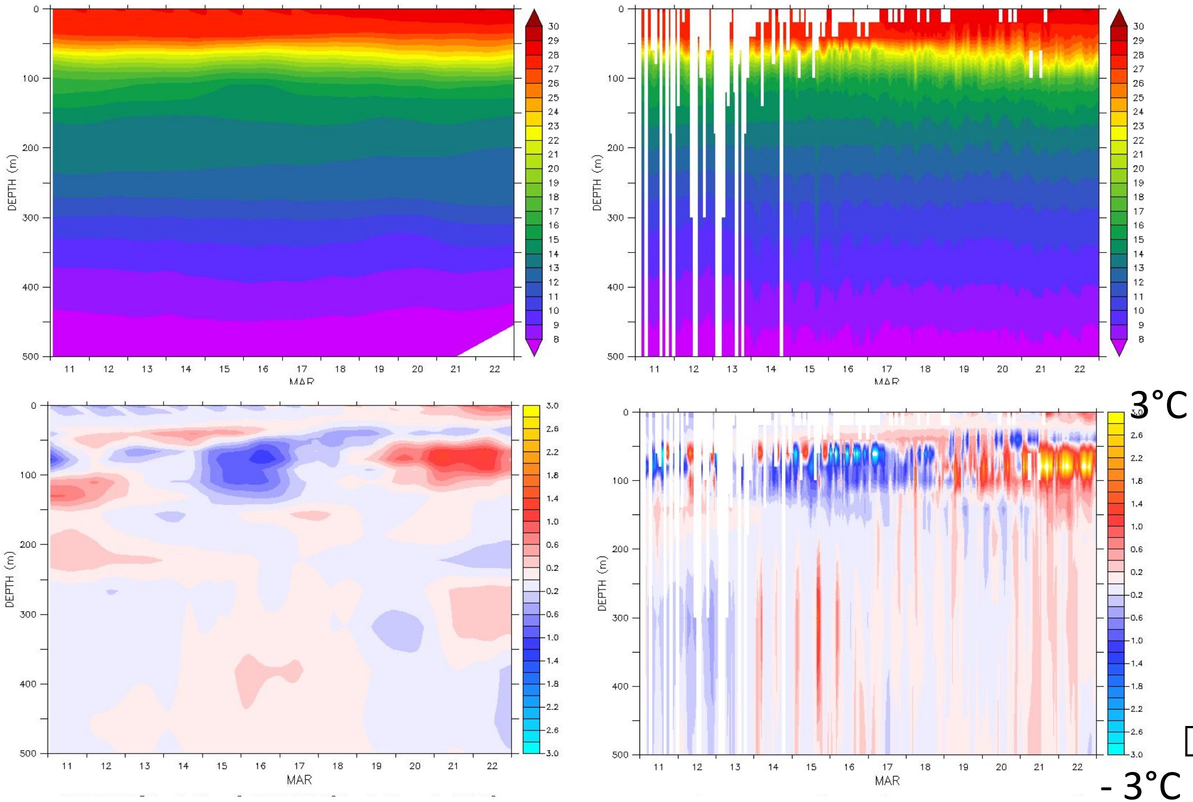
Temperature evolution at 23°W-0°N in 2016



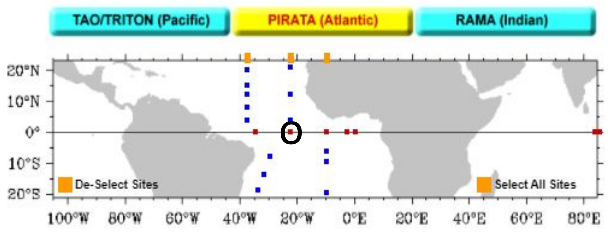
Free GLORYS12 (no DA) *GLORYS12 (with DA)* *G12 – Free G12*

Impact of observations on ocean analysis in the Tropical Atlantic

<u>Absolute and Temperature</u> <u>anomaly</u> evolution at 23°W – 0°N, 11 to 22 March 2017



Global 1/12° system *PIRATA observations*



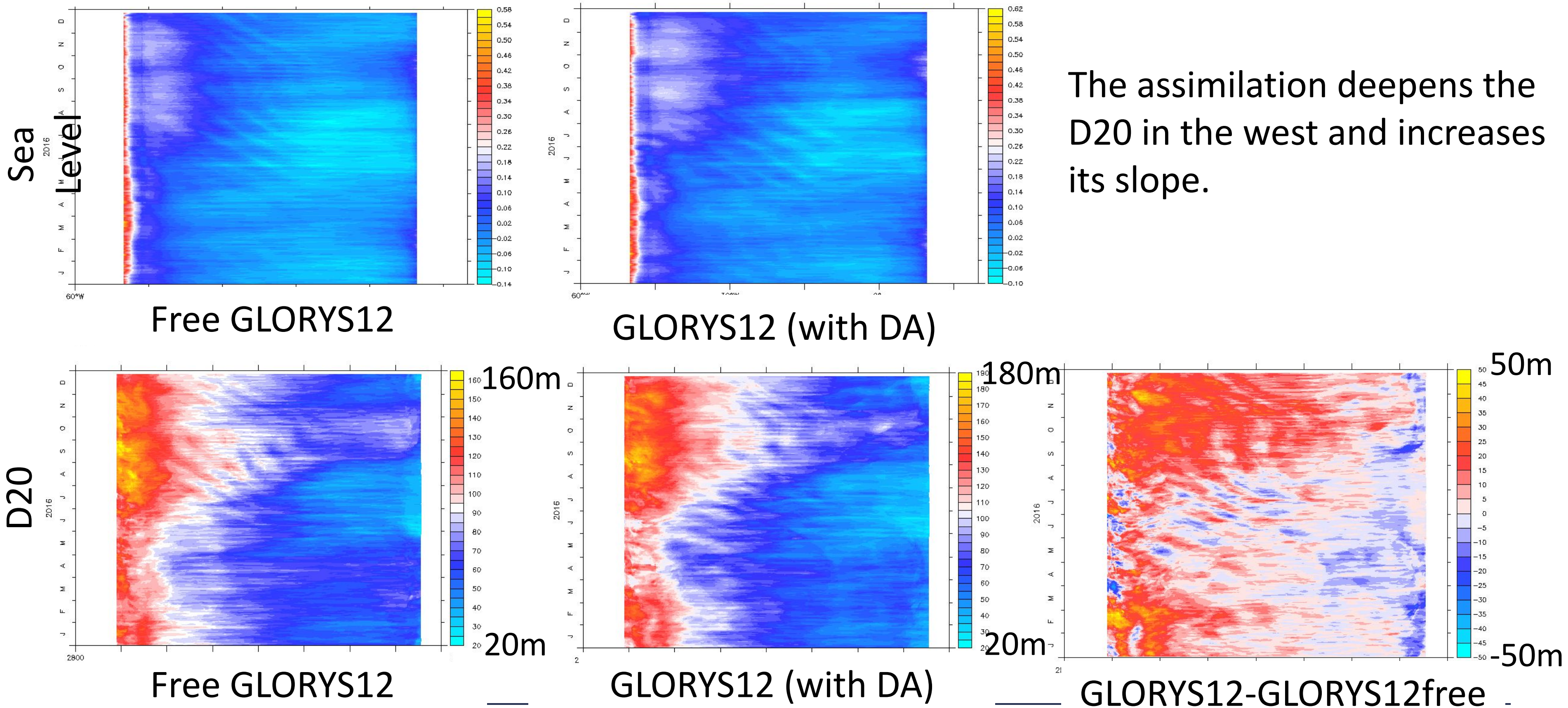
- Below 1 day, the model does not show the high frequency variability seen in the observations (10 mn).
- New NEMO ocean model version with atmospheric pressure forcing, <u>tide</u>, explicit resolution of the sea surface evolution will increase the energy at HF

⇒ data assimilation strategy will have to be updated.

Evolution of the SSH and the D20 at 1°N in 2016

Evolution of the Sea Level (top) and the depth of the 20° isotherm

The assimilation deepens the D20 in the west and increases its slope.

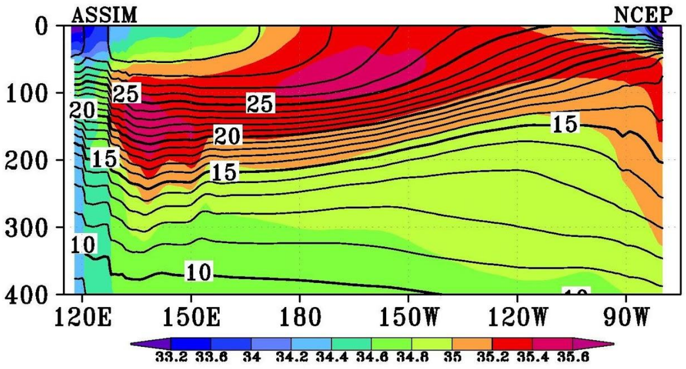


Impact of atmospheric forcings

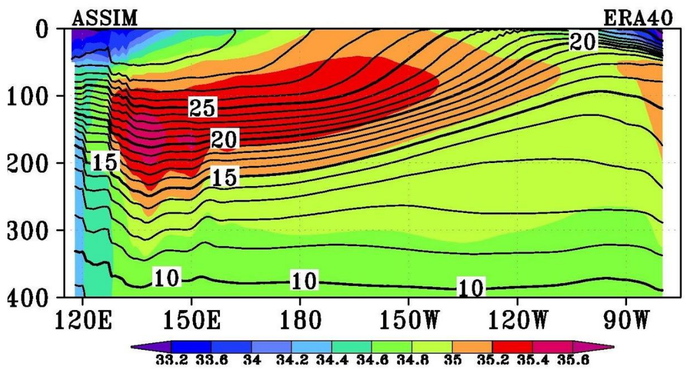
Forecast error can come from Initial Ocean Conditions but also “boundary” conditions such as atmospheric forcing, runoff and mode parametrization.

Large **impact of atmospheric forcing** on the ocean forecasts and analysis: Atmospheric surface fields may be needed to be controlled within the data assimilation process even in ocean only analysis system.

NCEP-R1



ERA-40



Difference of the T and S fields in the equatorial Pacific vertical session in an old version of JMA’s ocean reanalysis due to the difference of atmospheric forcings

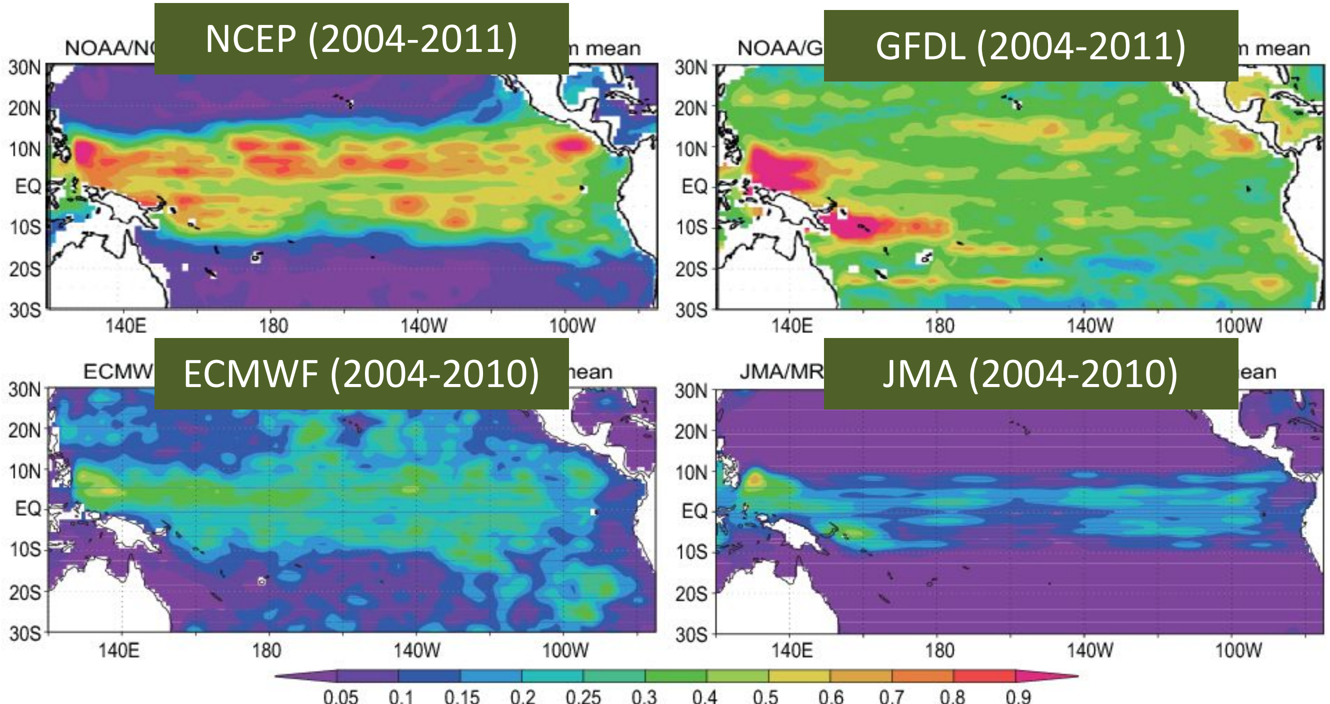
Multi system OSE: Tropical Mooring impact (TPOS)

Multi-system efforts are indispensable to get reliable evaluation since the impact of observation highly depends on the system (different model and data assimilation methods).

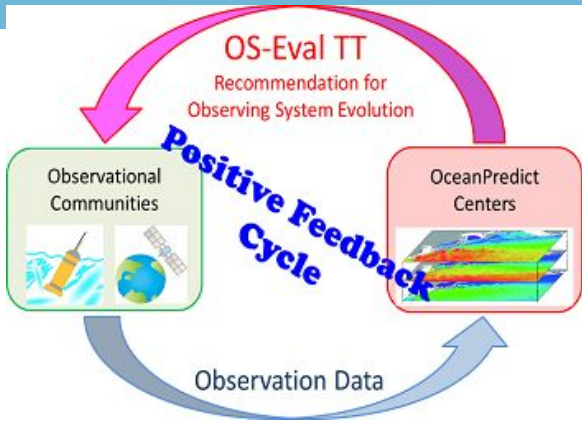
There is considerable dependency in the seasonal forecasts (mainly due to large systematic biases)

0-300m averaged RMSD of temperature (˚C) between the regular ODA runs and OSE without assimilating tropical mooring buoys

From Fujii et al., 2015 QJRMS



SynObs project proposed for the UN decade



<u>Synergistic Ocean Observations for Ocean and Coupled Predictions</u>

proposed by the OSEval OceanPredict Task Team (Yosuke Fujii et al.)
This project will be part of the ForeSea programme (OceanPredict) and is also linked to the ObsCoDe programme (GOOS).

Main project goals:

- Extract the **maximum benefit from the combination among various observation platforms**, typically between satellite and in situ observation data, and between open ocean and coastal sea observing systems, in monitoring and predictions of the ocean state using numerical ocean (and coupled) prediction systems.

- Identify the optimal combination of different ocean observation platforms, and develop assimilation methods with which we can draw synergistic effects from the combination. We may also plan a collocated satellite-in situ observation campaign.

The project will include studies for various scales and various areas, such as coastal and open ocean studies, studies of polar regions, weather and climate coupled prediction studies.

Conclusion

Data assimilation of SST, SLA and in situ observations (Argo, mooring, XBT/CDT, sea mammals, TSG in DT, …) **strongly improves the ocean mean and variability compared to a free simulation**.

In the Tropical Atlantic:

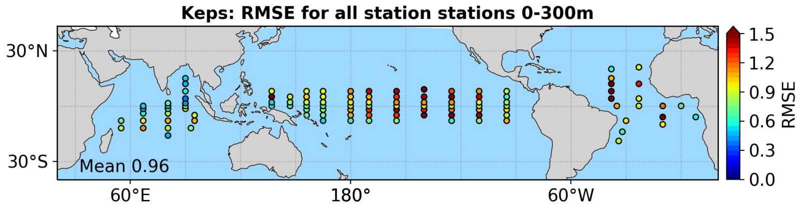
- Interannual to seasonal ocean variability is well reproduced by the 1/12° system,
- The largest temperature error are at the mixed layer base,
- There is still large salinity error in river outflow regions, in the future satellite SSS assimilation will help to reduce the forecast error.
- The data assimilation increments in the Tropics exhibit higher values around mooring locations but this seems to not lead to spurious pattern in the analysis.

Ongoing work on spectral analysis of GLORYS12 and GLORYS12free in the Tropics to better undersand the model representativity and the impact of the data assimilation on distinct scales / processes (Ananya Karmakar, post doc IRD-LEGOS/Mercator Ocean).

Perspectives

Evolution of the data assimilation and model

- Apply/improve the multi scale analysis in the tropics **to benefit from large scale information from the mooring array** and smaller scale information from higher resolution SST and SLA observations.
- In the future, the model forecast will contain more energy at higher frequency higher than a day: the data assimilation strategy will need to be updated (*same question as for the future SWOT altimetry mission: filtering of the HF variability in obs and model?).*
- To improve the surface ocean estimate in the Tropics, correction of the atmospheric fields may be required.
- Ongoing work on vertical mixing scheme with mooring observations used to validate those different evolutions.



Observation impact experiments dedicated to tropical mooring and Argo floats

Specific data assimilation experiments are planned in the framework of the EuroSea H2020 project and the OSEval Ocean Predict Task Team.