MERCATOR OCEAN INTERNATIONAL

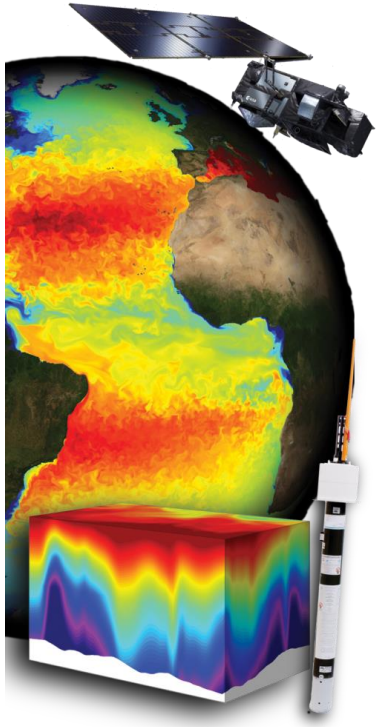
Observing System Evaluation and Design Using Ocean Monitoring and Forecasting Systems

Elisabeth Rémy, Yosuke Fujii and
the OSEval Task Team members

Observing System Evaluation and Design Using Ocean Monitoring and Forecasting Systems

GOV ocean monitoring and forecasting centers make heavy use of the ocean observing systems to serve a wide range of oceanic applications, from marine safety to seasonal forecasts.

The accuracy of the analysis and forecasts highly rely on the availability and quality of the in situ and satellite observations that are routinely assimilated.



To benefit the most from the observation to constrain model forecast requires:

- A good understanding of the observation content and errors (observations error, treatment, scales…),
- Regular assessment of the role of observations in constraining the ocean circulation.

-> discussions between ocean forecasting centers and data providers are important for a better use of the present observations, to demonstrate the value of the existing observing systems and to help designing a fit for purpose Global and Regional Ocean Observing Systems.

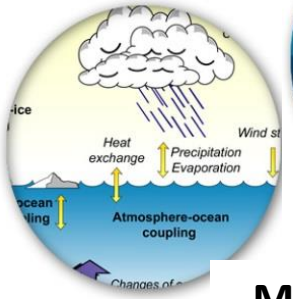
OSEVal Task Team

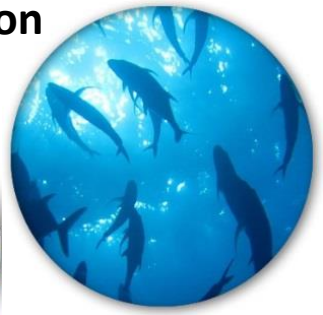
The GOV Observing System Evaluation Task Team (OSEval) provides a unique international framework to discuss impact of present and future ocean observations on operational monitoring and forecasting systems.

Data Assimilation TT

Coastal TT

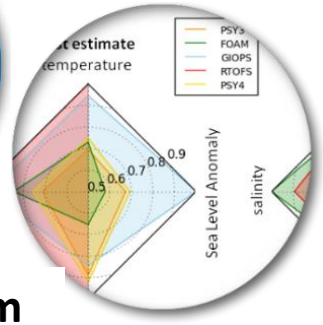
Coupled Prediction TT

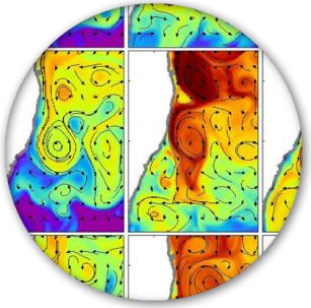




Marine Ecosystem Analysis and Prediction TT

Intercomparison and validation TT





OSEval TT

Co-chairs: Yosuke Fujii (JMA/MRI), Elisabeth Rémy (Mercator Ocean)

GOV OSEval Task Team activities and outcomes:

- Perform, collect and synthetize evaluation and design studies of GOOS and ROOS on GOV systems,
- Define best practices, transfer from research to operation new methodologies,
- Provide consistent and scientifically justified requirements and feedbacks to agencies in charge of Global and Regional Ocean Observing Systems

-> build up a positive feedback cycle between observational agencies and operational centers for better fit for purpose observing systems.

Impact of the present altimeter constellation

Sea Level observations were one of the first global and regular observations available in NRT setting the basis for ocean monitoring systems at global scale.

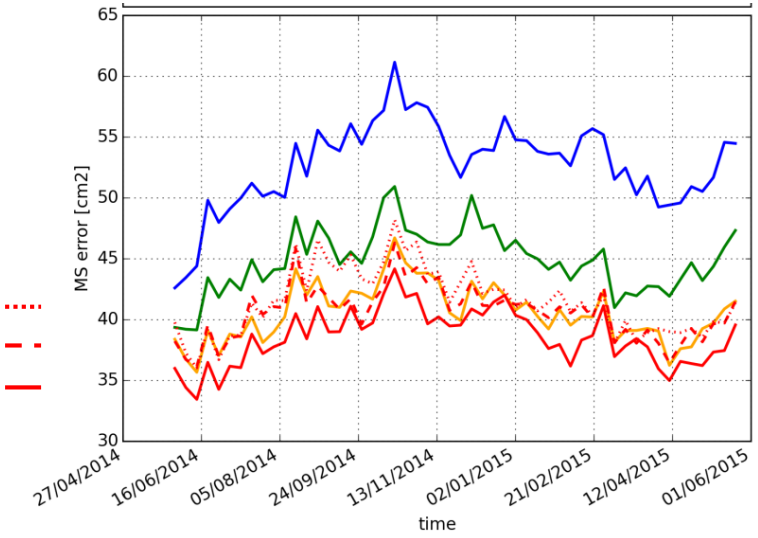
Many studies have addressed the impact of different parameters of the present altimetry constellation on GOV ocean monitoring and forecasting systems:

- Number of altimeters,
- complementarity with in situ T and S observations,…

Experiments assimilating 1 to 4 altimeters and different MDTs with the Mercator Ocean global ¼° system

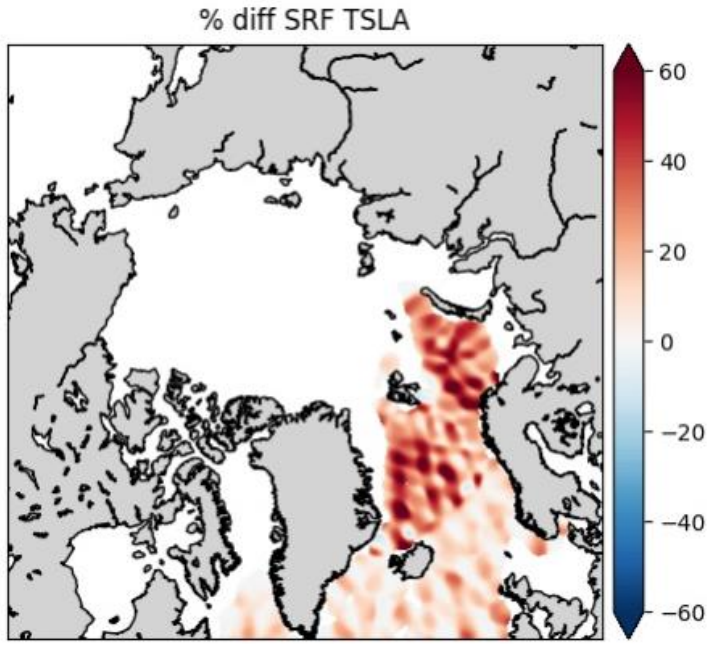
1 alt+MDTv3
2 alt+MDTv3
3 alt+MDTv3

4 alt+MDTv1 .....
4 alt+MDTv2 - -
4 alt+MDTv3 —



Observation - model SLA MS differences (cm²), M. Hamon, JAOT, 2019.

Ensemble spread reduction due to S3A assimilation (31 Feb.-Mar. 6 2017) in the TOPAZ system

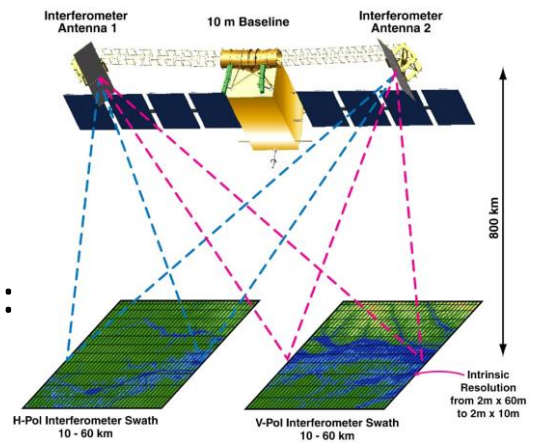


$$\mathrm{SRF} = \sqrt{\frac{\mathrm{tr}(\mathbf{H}\mathbf{P}^f\mathbf{H}^{\mathrm{T}}\mathbf{R}^{-1})}{\mathrm{tr}(\mathbf{H}\mathbf{P}^a\mathbf{H}^{\mathrm{T}}\mathbf{R}^{-1})}} - 1$$

L. Bertino, NERSC, MET Norway

Future large swath altimetry

A new concept for observing the sea surface height with large swath (around 100 km) altimeter(s) is emerging: SWOT science mission (CNES/NASA/Canada and UK space agencies), WiSA (ESA) and COMPIRA (JAXA).



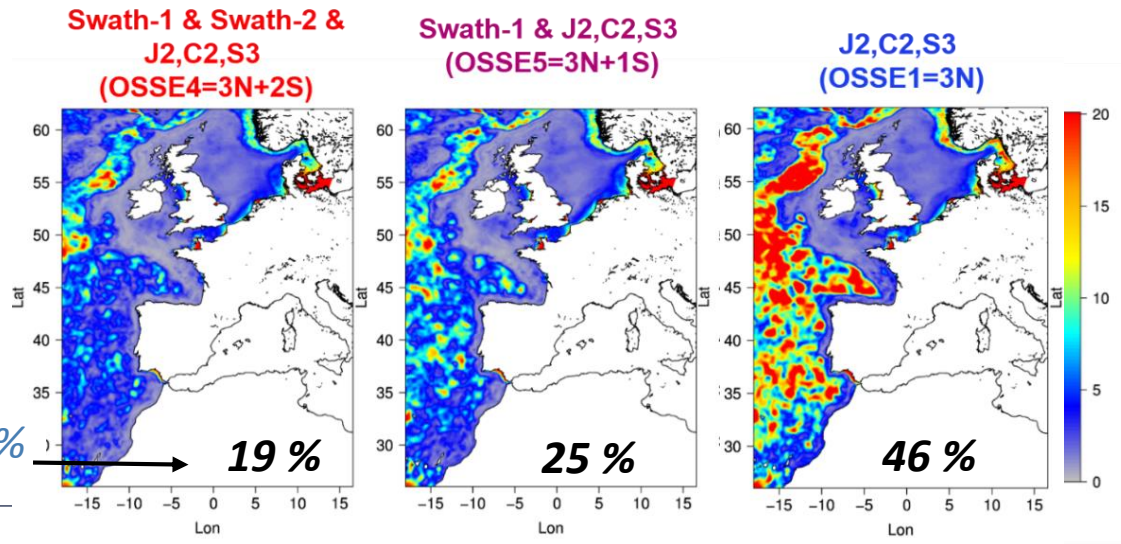
SWOT launch in 2021
http://swot.jpl.nasa.gov/

Simulated data assimilation experiments (OSSE) are conducted to prepare the forecasting systems and help designing a large swath altimeter constellation. They show:

- Improved estimation of the SSH and velocity fields compared to nadir altimetry,
- Model capacity to keep the information between revisiting time,
- Need of further developments to take into account complex and correlated observation/representativity errors in the Data Assimilation scheme.

SSH Error Variance in cm²

Error/NatRun variance in %



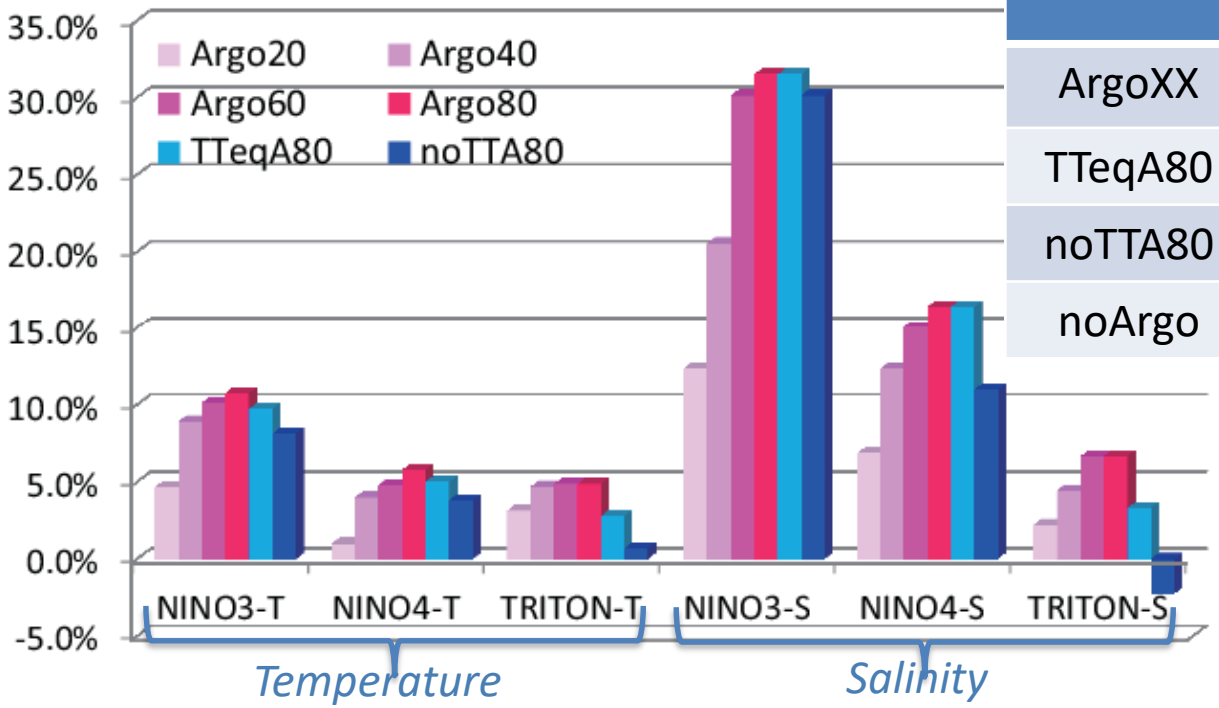
Observing System Simulation Experiments (OSSE) with the MO system, A. Bonaduce and M. Benkiran, Ocean Science, 2018.

Tropical Pacific Observing System

In the context of optimizing/redesigning the in situ Tropical Pacific Observing System (TPOS), data assimilation experiments were conducted to estimate the role of the different networks (moorings, Argo…).

Reduction of the mean 0-300m RMSE compared to the NoArgo experiment in %.

OSE with the JMA system, Y. Fujii



	TAO/TRITON	Argo
ArgoXX	ALL	XX%
TTeqA80	2˚S-2˚N alone	80%
noTTA80	None	80%
noArgo	ALL	None

RMSE are calculated with the 20% Argo data that are not assimilated.

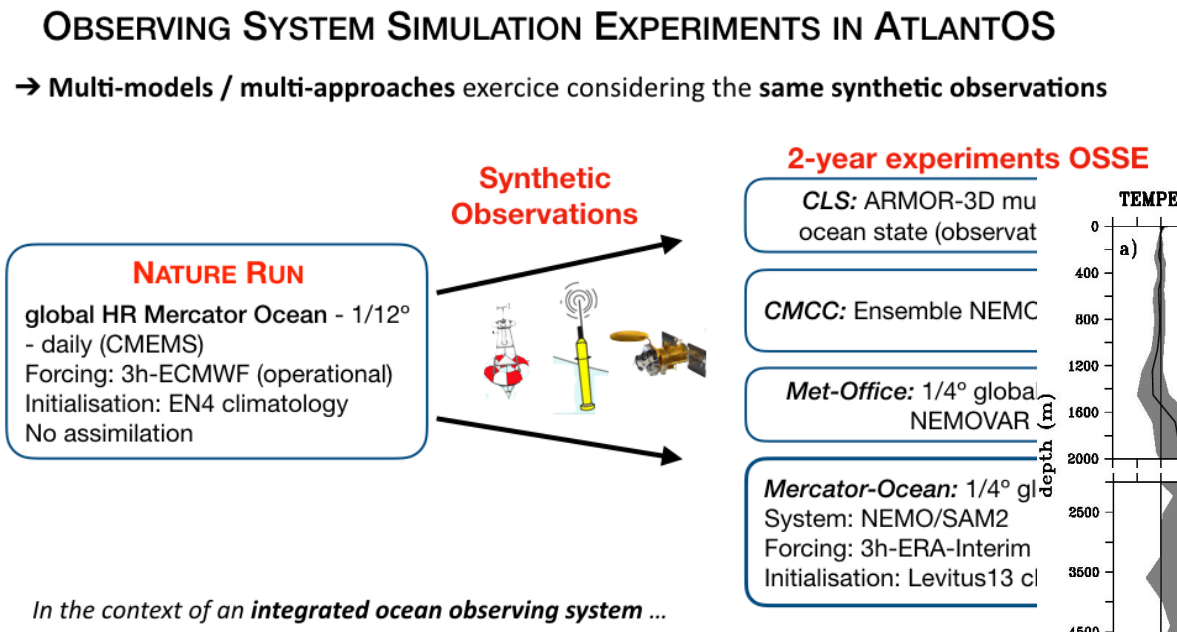
- The impact of Argo gets larger with the number of Argo floats assimilated,
- Impact of buoys are relatively large in the TRITON area.

-> the absence of TRITON buoys is likely to affect the accuracy of analysis fields in the JMA system.

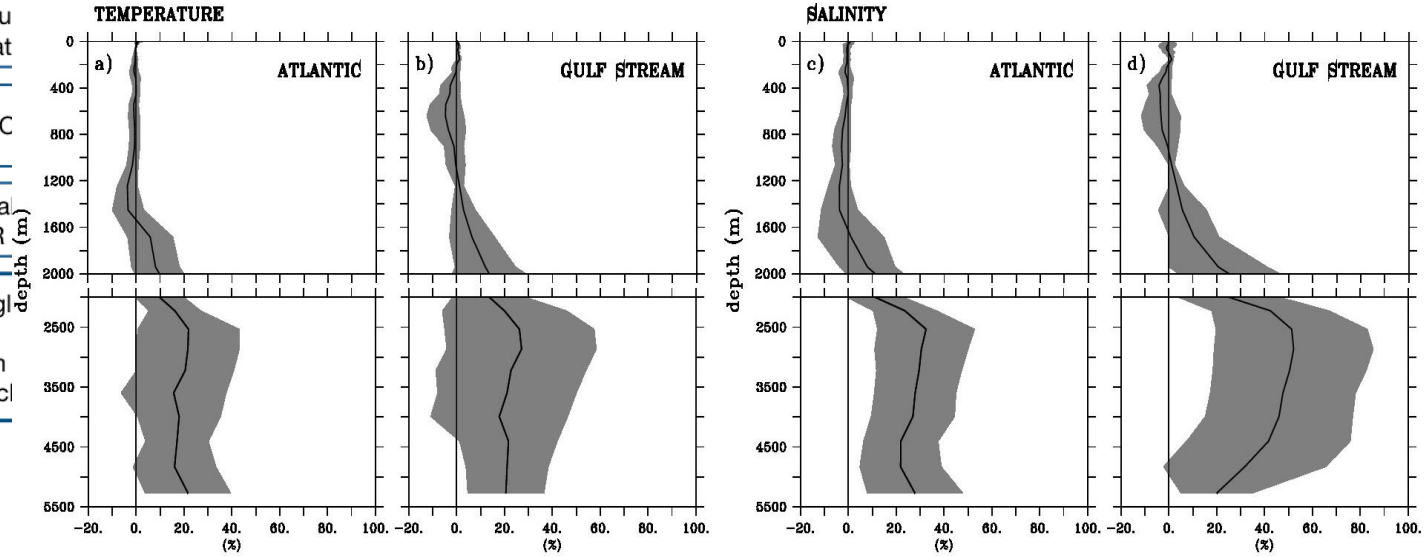
In situ Atlantic Observing System

The AtlantOS H2020 European project (2015-2019) aimed at Optimising and Enhancing the Integrated Atlantic Ocean Observing Systems.

Coordinated OSSE experiments were conducted with four European monitoring systems to help designing the extension of different physical in situ networks.



Top-to-bottom profiles of MSE reduction for the DEEP experiment as compared with the BACKBONE experiment: mean profile and ensemble spread.

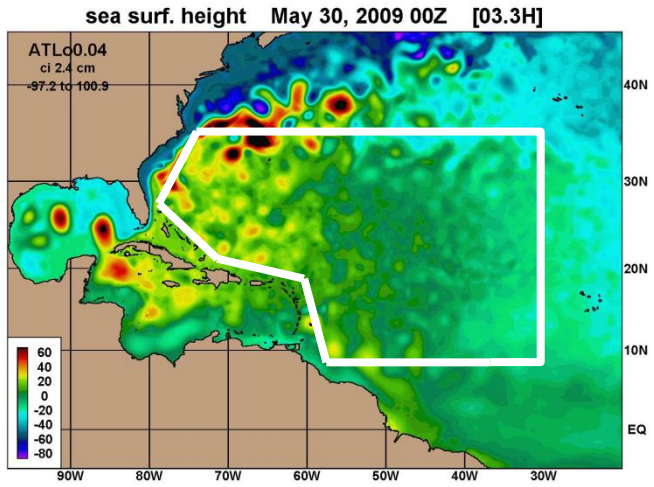


Gasparin et al.: Requirements for an integrated in situ Atlantic Ocean Observing System from coordinated Observing System Simulation Experiments, Frontiers in Marine Sciences, 2019.

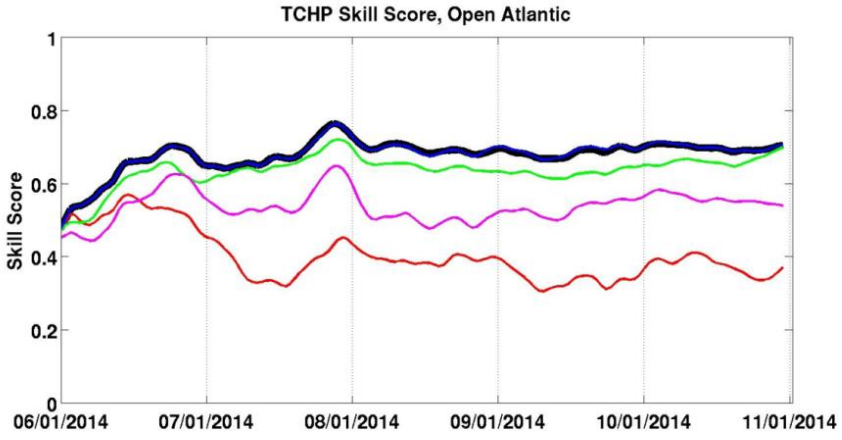
Impact of different GOOS components on weather indices

Evaluation of the Existing Ocean Observing System Components on **reducing errors in Tropical Cyclone Heat Potential** (TCHP).

OSSE with the HYCOM model during the 2014 Hurricane season



TCHP Skill score, Open Atlantic



Control (assim. Of all obs.)
deny XBT
deny Argo floats
deny all SST
deny altimetry

(Halliwell, 2017 OSEval meeting pres.)

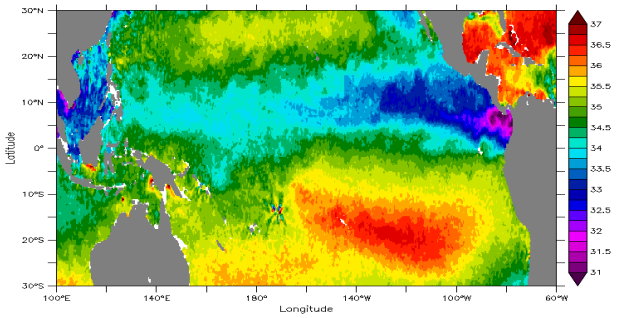
- Satellite altimetry provides the greatest positive impact, followed by Argo floats and SST measurements from both satellite and in-situ systems.

Halliwell, Jr., G. R., et al.: North Atlantic Ocean OSSE System: Evaluation of Operational Ocean Observing System Components and Supplemental Seasonal Observations for Improving Coupled Tropical Cyclone Prediction. J. Oper. Oceanogr., 2017.

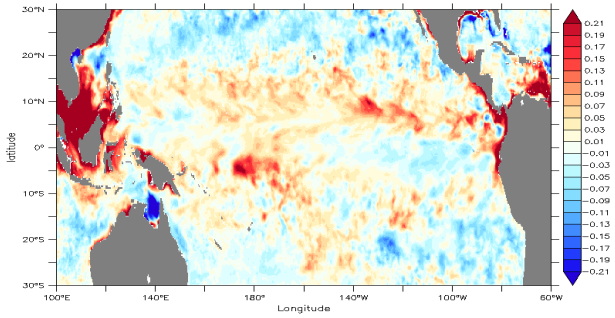
Sea Surface Salinity impact assessement

Observing System Experiments (OSE) were designed to prepare and assess the impact of satellite SSS assimilation with a focus on the Tropical Pacific Ocean during the 2015 El Nino event in two different operational ocean monitoring systems (Met Office and Mercator Ocean). They show:

- SMOS SSS data assimilation leads to a reduction of the SSS error (compared to in situ SSS) in the Tropical Pacific region,
- Bias correction on the SSS observations was required in both systems to benefit from SSS assimilation.



SMOS LOCEAN data



Mean 2015 SMOS exp. – NoSMOS SSS

https://www.godae-oceanview.org/projects/smos-nino15/

The benefit of assimilating SSS from space was also shown on ENSO Predictions from the NASA GMAO Seasonal Forecast System.
The combination of Aquarius and SMAP data assimilation produces best El Nino forecasts.
(*see E. Hackert presentation*)

Challenges

Downstream applications require from GOV ocean forecasting centers to provide higher spatial and temporal information, closer to the coast. In response, model increased spatial resolution, including higher frequency processes (tides, atmospheric pressure forcing, coastal configuration…)
-> need of controlling a broader range of ocean processes from large to meso/submesocale scale, from the open ocean to the coast in the model forecasts.
-> complex observation errors to take into account in the data assimilation scheme.

Observing System Evaluation are requiring dedicated experiments with large and complex systems with a careful analysis to get reliable conclusion.
Multi system approaches give more robust conclusions but requires strong effort to setup and analyse the experiments in a common framework.
Efforts should be done for evaluating and **designing** observation networks for:

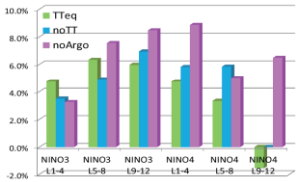
- The **coastal** regions,
- The **deep** ocean,
- The **polar** regions,
- **BGC and ecosystems.**

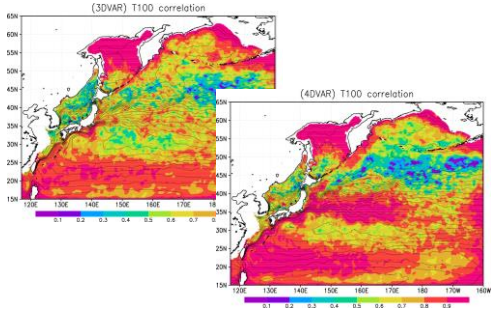
This involves different GOV Task Teams.

The link with the observation agencies should be reinforce.

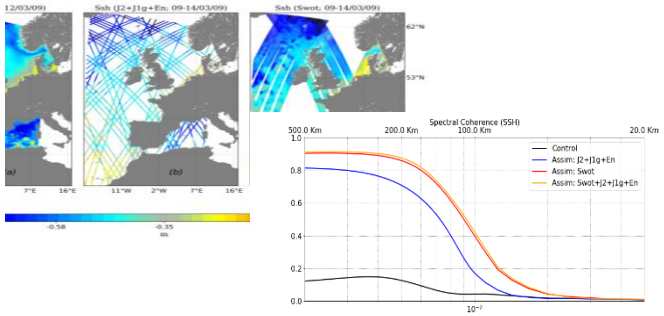
Contents of OceanObs'19 CWP on OS-Eval

TPOS and Argo

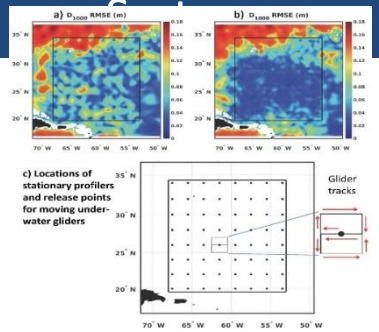




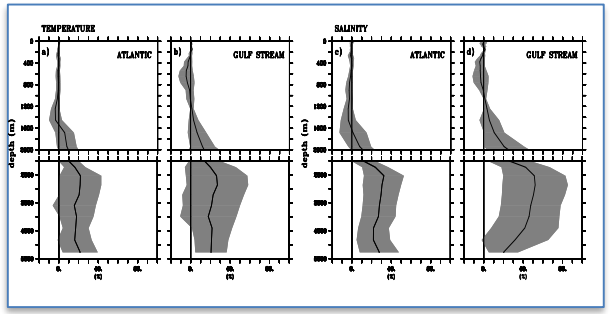
SWOT



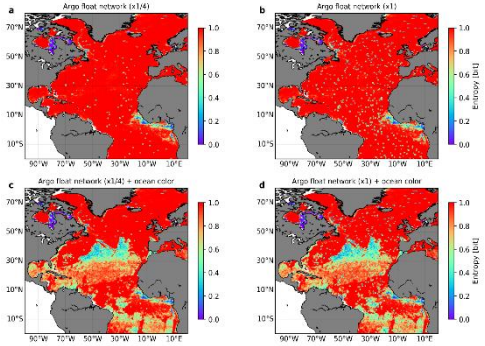
Coastal Obs



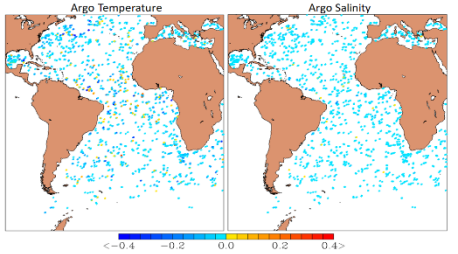
Atlant-OS

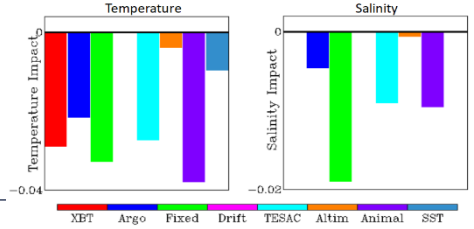


BGC Argo

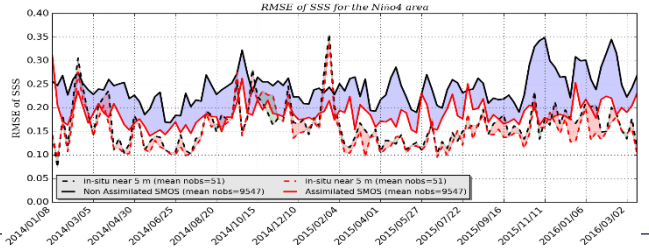


Adjoint Sensitivity

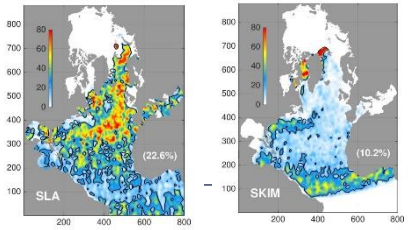




SMOS-NINO2015



SKIM



Fujii et al, in revision, Frontiers