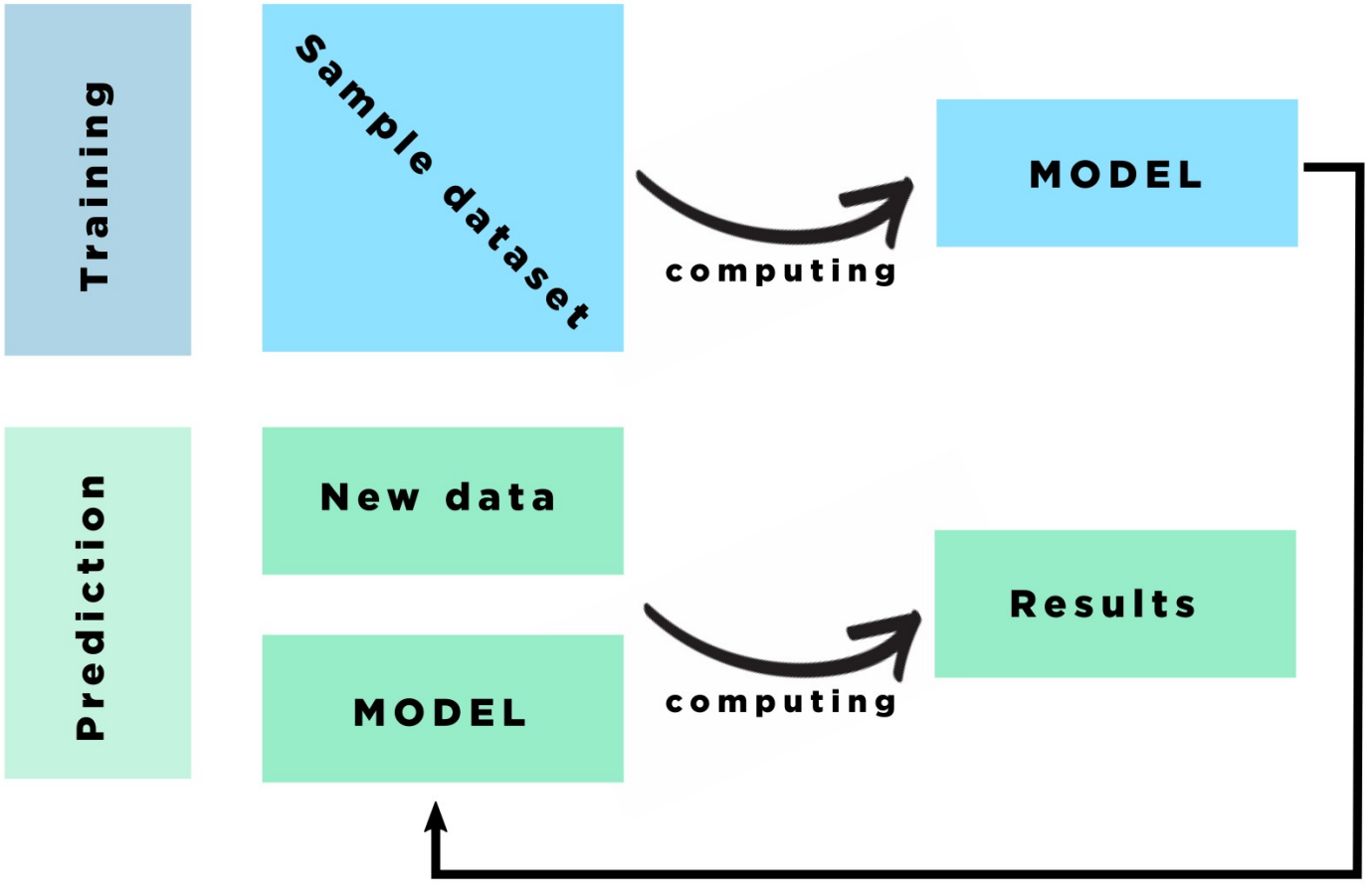
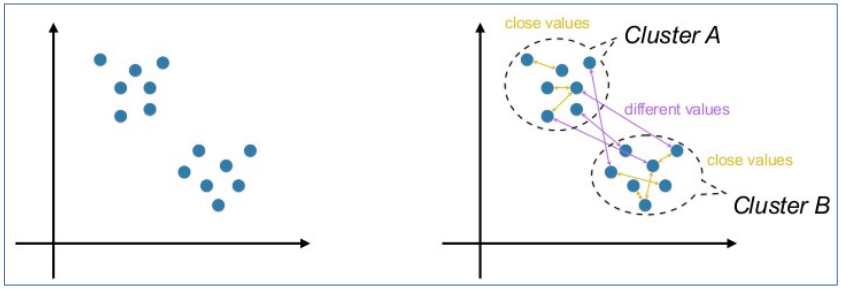
Machine learning in oceanography
2 examples at LOPS : PyxPCM & OSnet

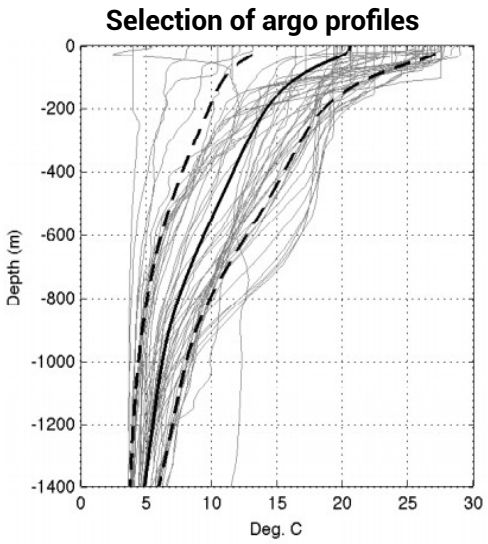
Balem K., Maze G., Tokunaga S.

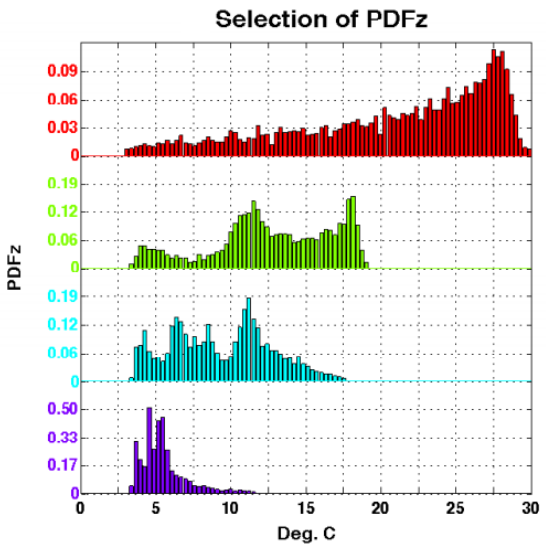

Training
Sample dataset
computing
MODEL
Prediction
New data
MODEL
computing
Results

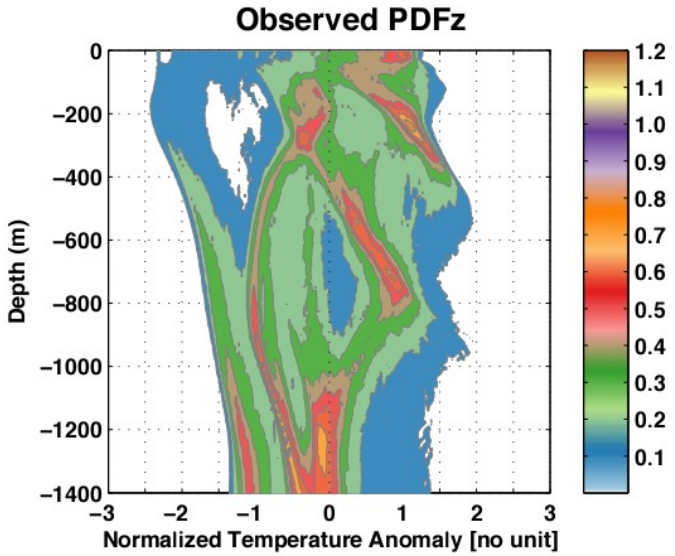
PyXpcm : Ocean Profile Classification Model for Xarray objects

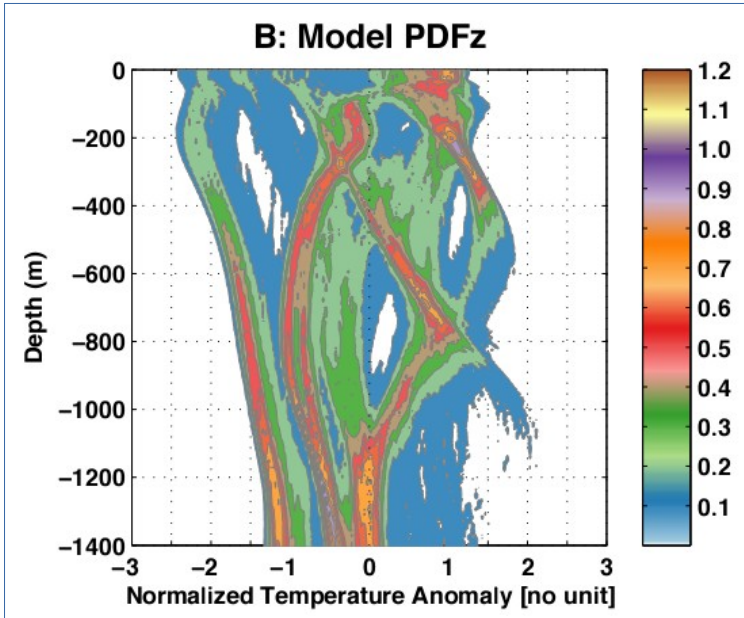


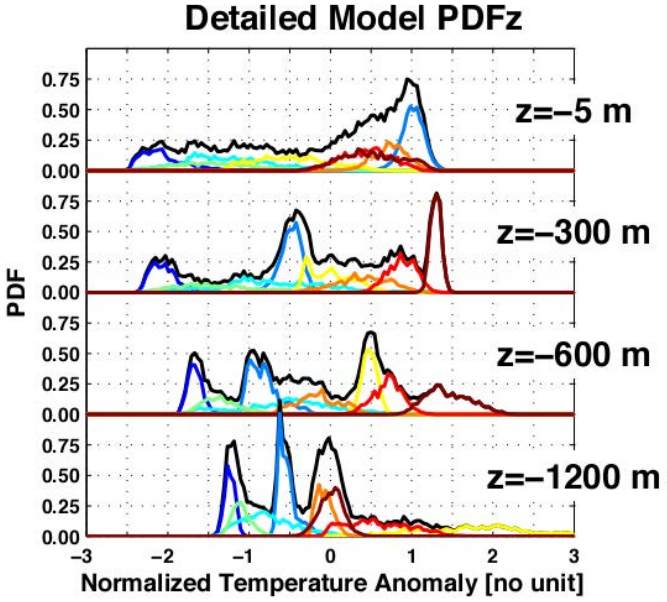
https://pyxpcm-dev.readthedocs.io



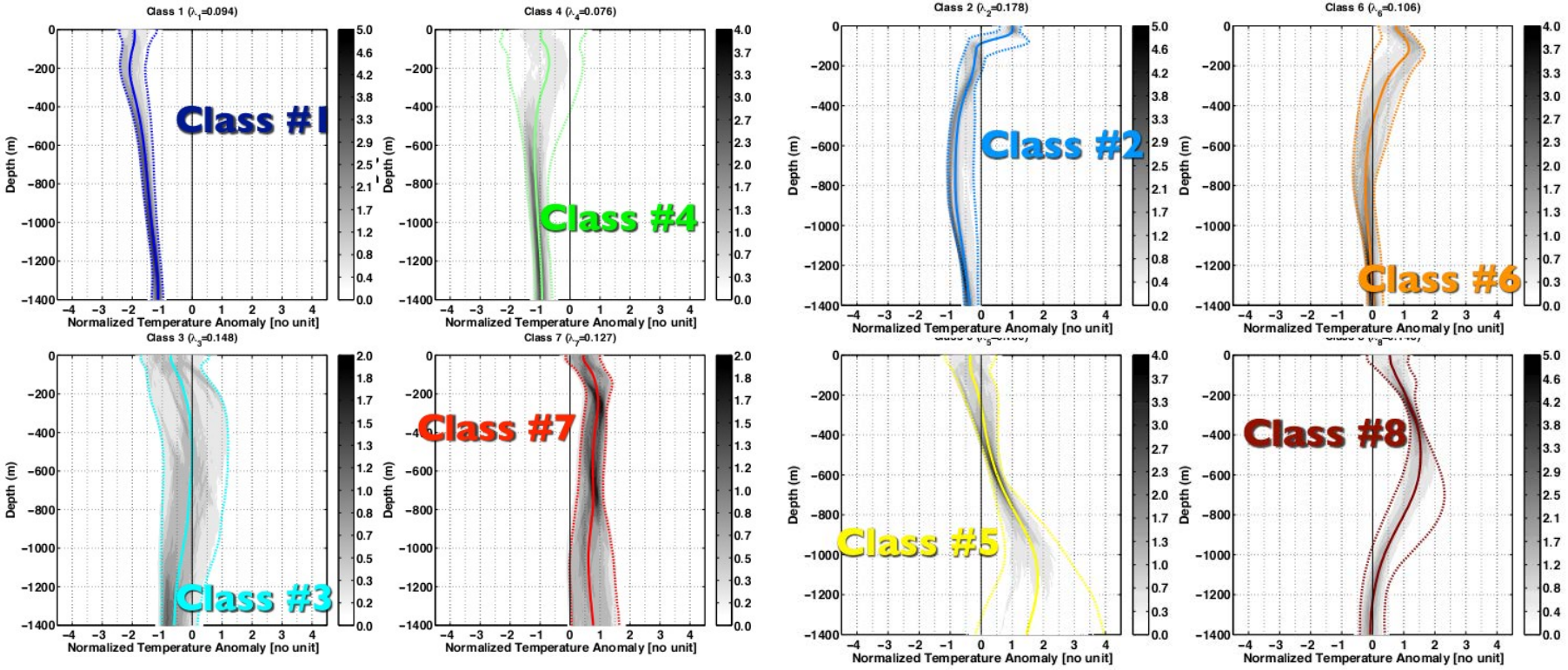


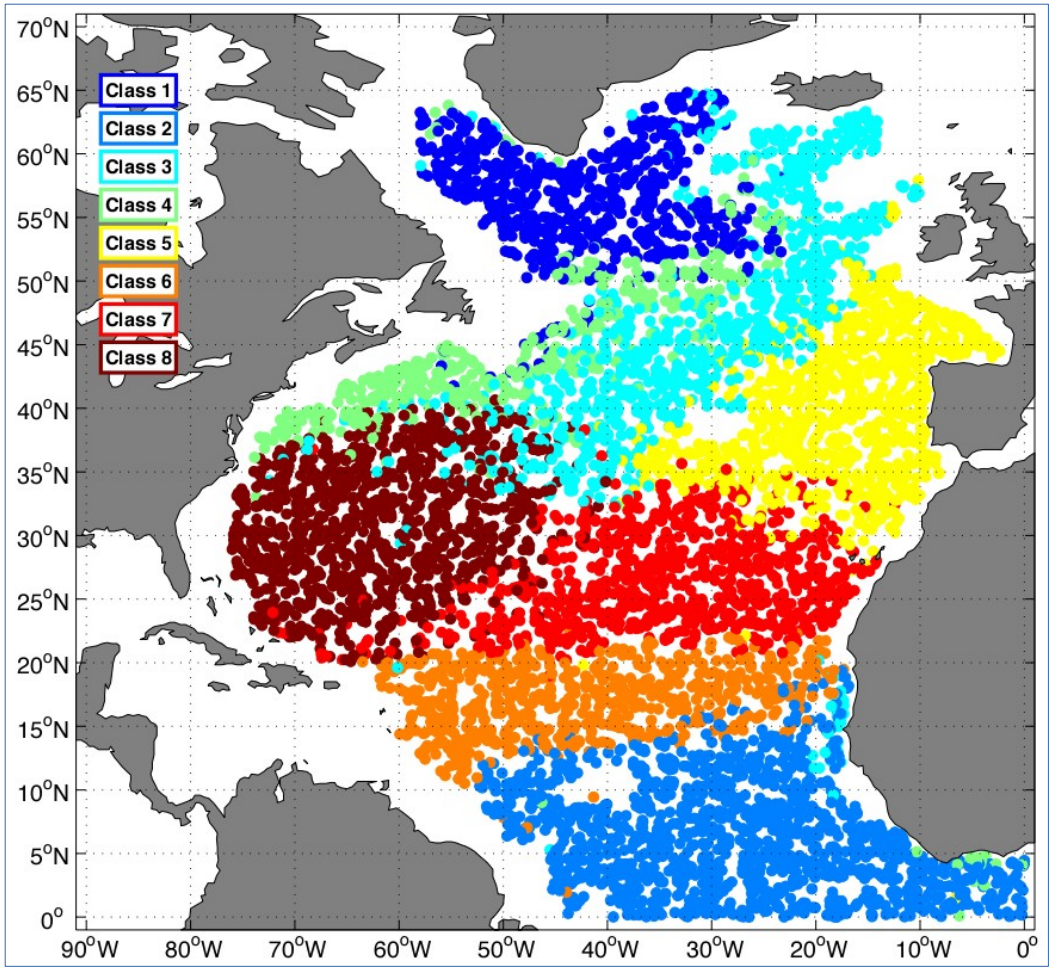






Maze, G., et al., Progress in Oceanography, 2017


Class 1 (λ1=0.094)
Class #1
Class 4 (λ4=0.076)
Class #4
Class 2 (λ2=0.178)
Class #2
Class 6 (λ6=0.106)
Class #6
Class 3 (λ3=0.148)
Class #3
Class 7 (λ7=0.127)
Class #7
Class #5
Class #8
Depth (m)
Normalized Temperature Anomaly [no unit]



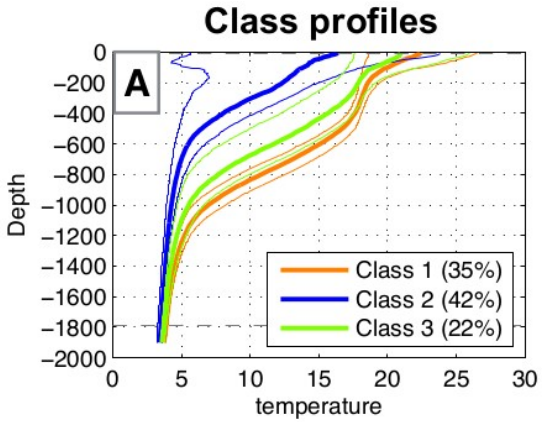
Maze, G., et al., Progress in Oceanography, 2017

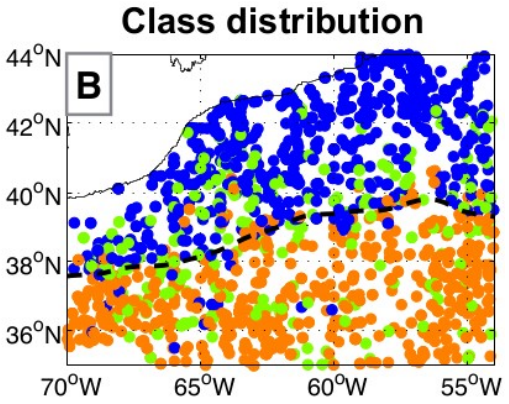
- Random sample of Argo temperature profiles in the North Atlantic

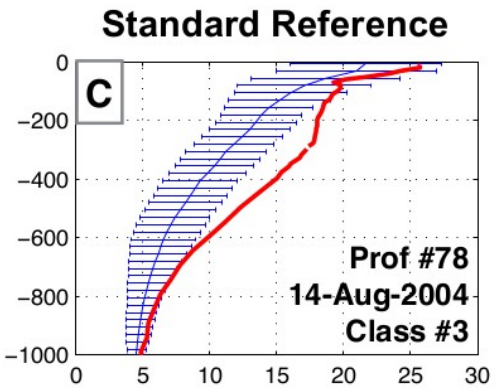
unsupervised classification

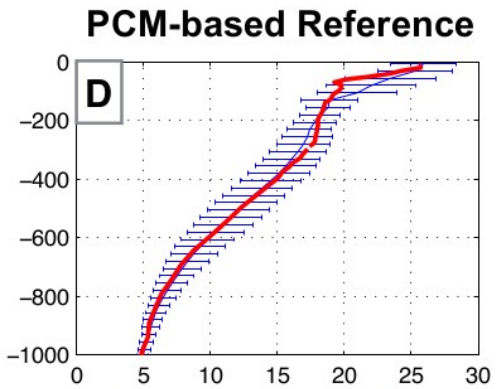
- Different groups of temperature profiles are identified automatically
- Which corresponds to coherent regions of the ocean

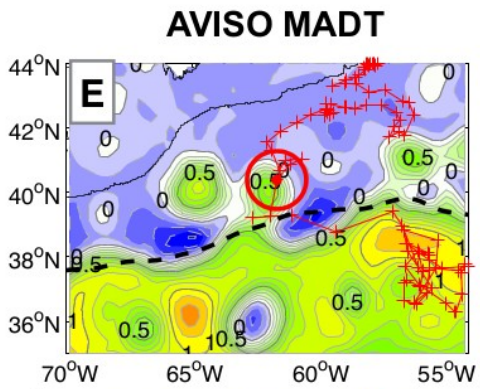
<u>Application example</u>
Delayed time validation of argo profiles near a front

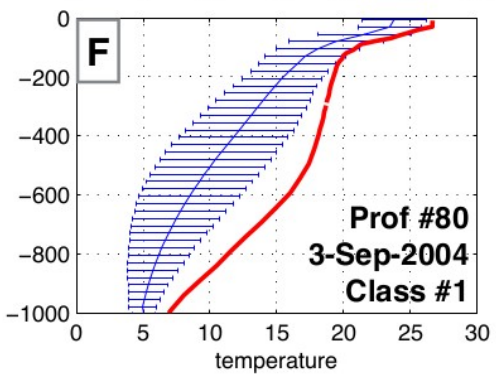


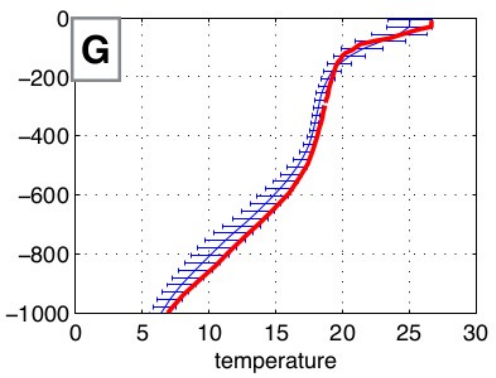


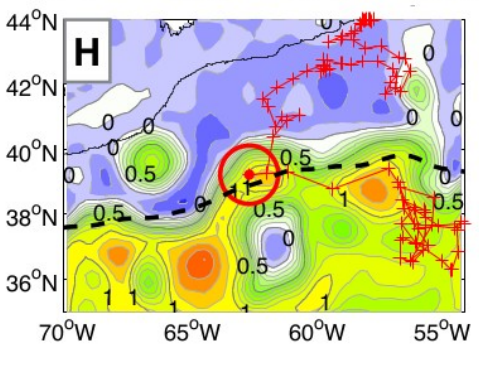




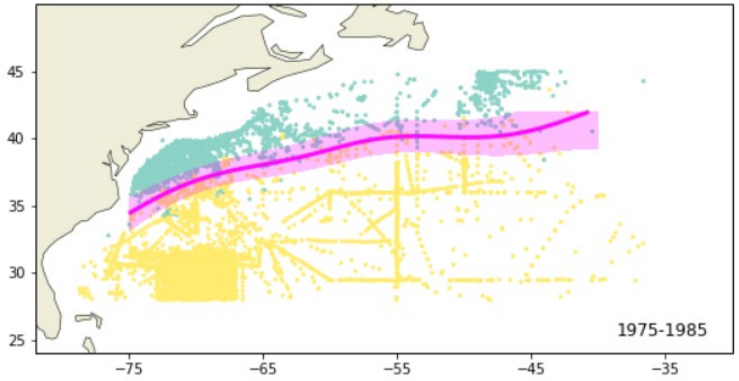




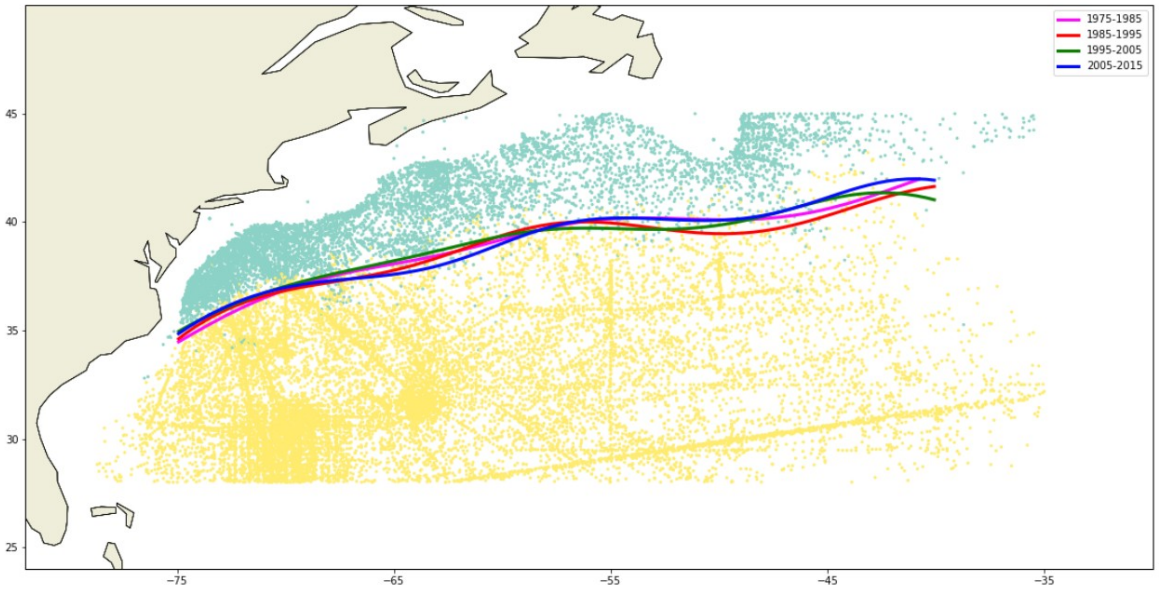




Maze, G., Mercier, H., Mercator Ocean Journal 55, 2017



SVM prediction (predict the separation between clusters) in the gulfstream :
Model trained with full CORA dataset and SVM predicted per decade.



Balem, K., Maze, G., 2019

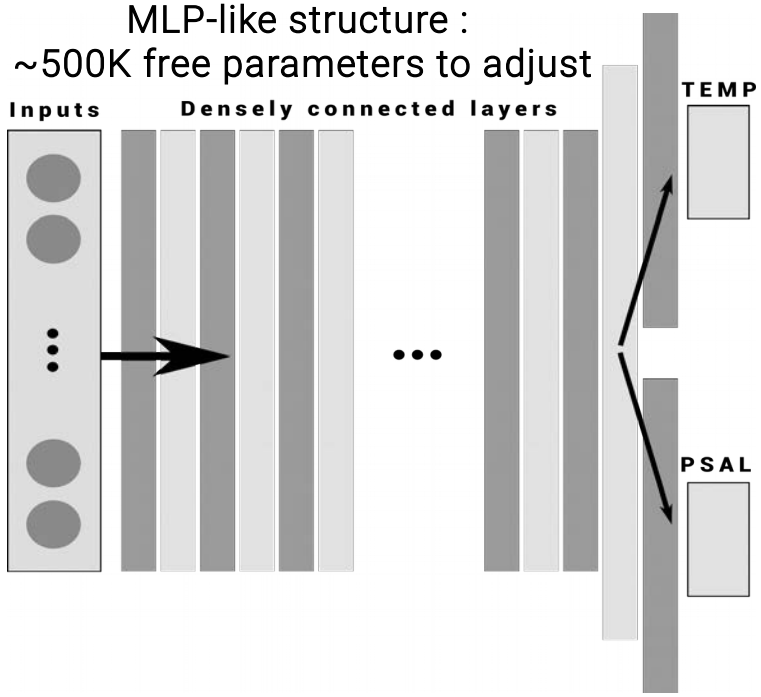
OSnet
(from “ocean state neural network”) : a multi-layer perceptron for predicting ocean thermo-halinity

The data

- 15 years worth of ARGO data quality controlled for research (2001 - 2016).
- For each ARGO profile, the sea level anomaly is interpolated from Aviso.
- 255 million measurements (5 fold cross-validation)

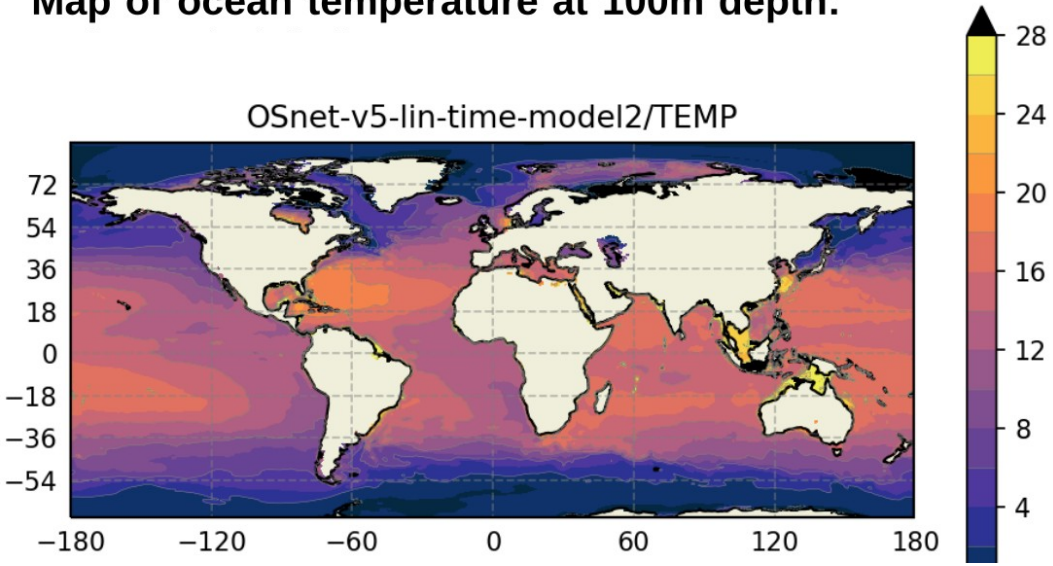
$$(T,S) = f(lat, lon, t, z, sla)$$

MLP-like structure :
~500K free parameters to adjust

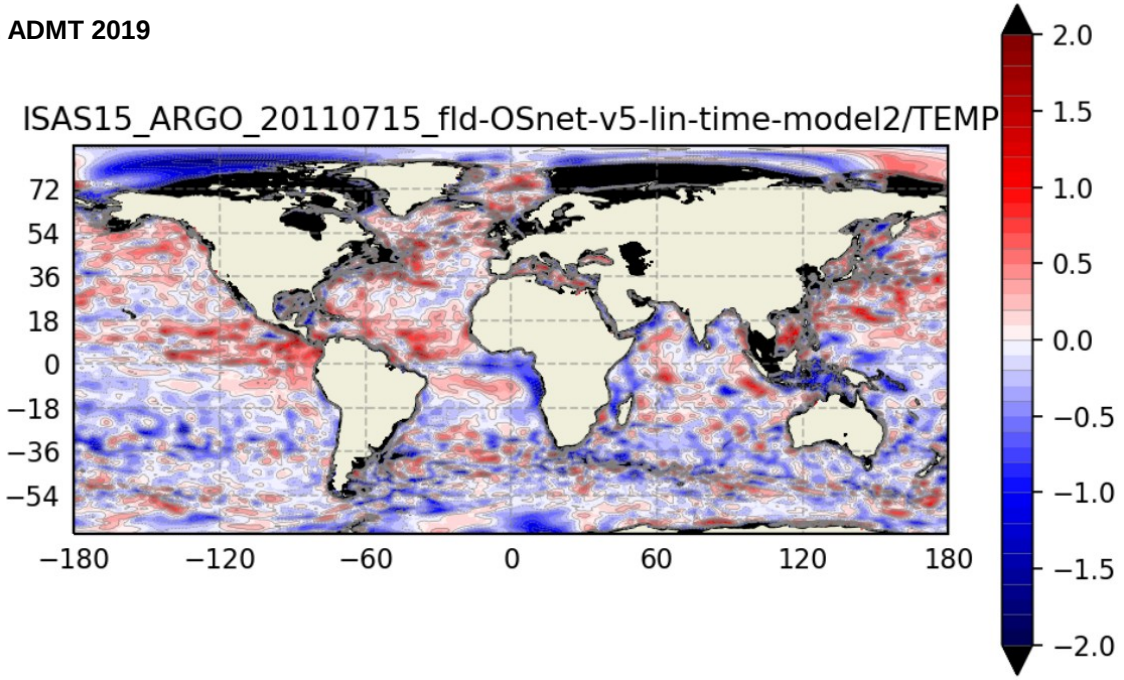


Inputs
Longitude
Latitude
Pressure
Date
Sea level anomaly
...

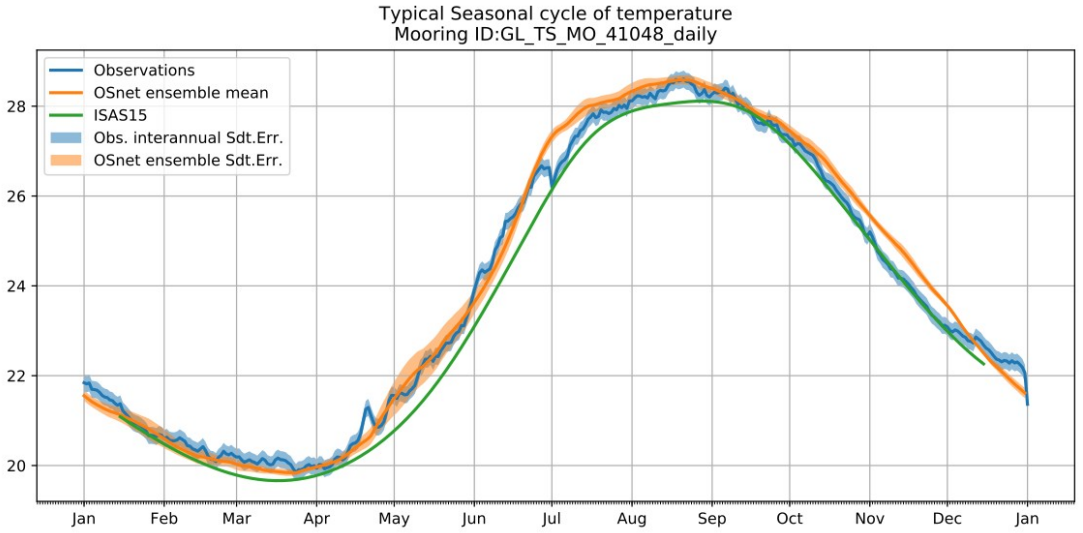
Map of ocean temperature at 100m depth:



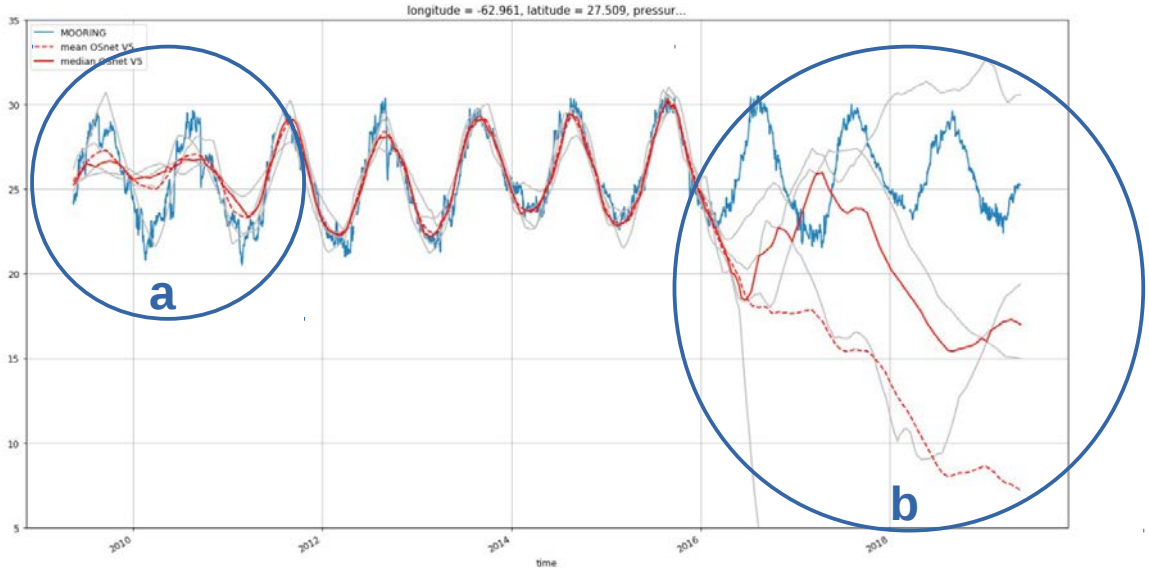
S. Tokunaga, G. Maze, ADMT 2019



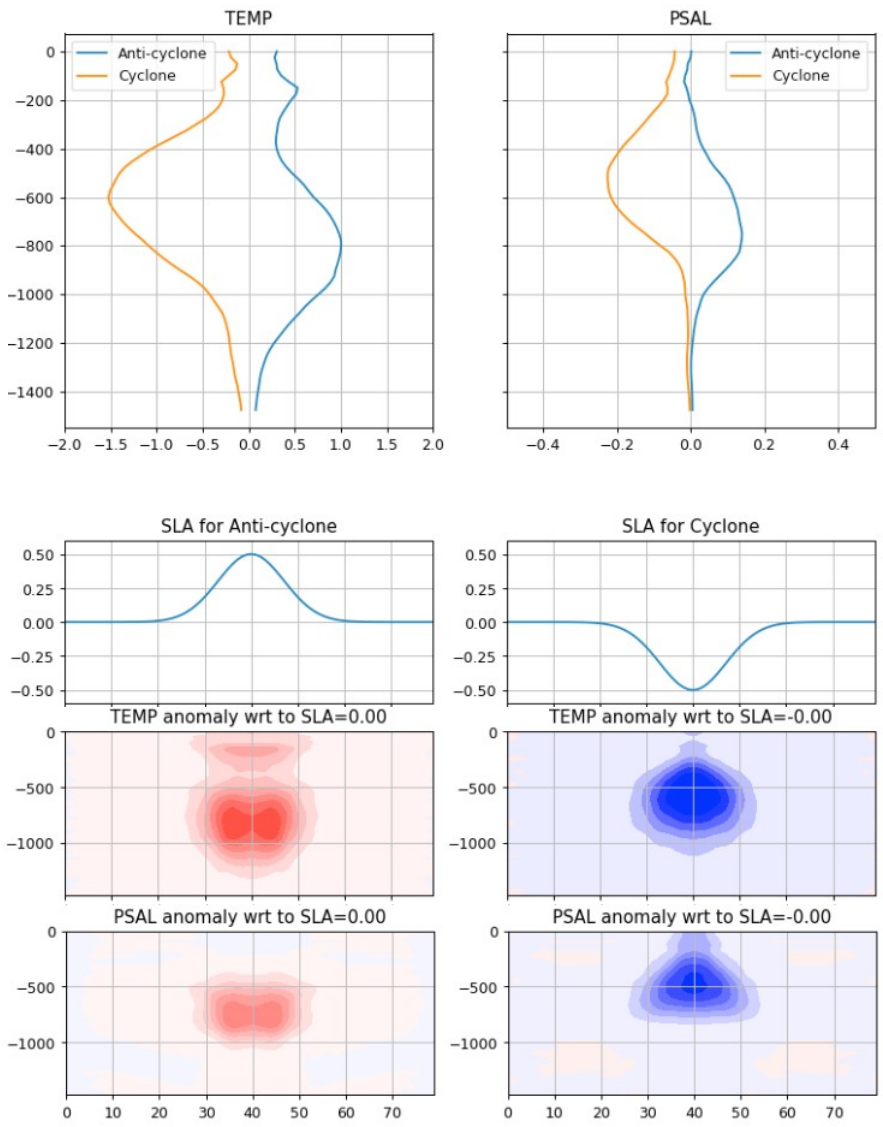
Example of a time series and a seasonal cycle (predicted in locations of fixed moorings for comparison)



S. Tokunaga, G. Maze, ADMT 2019

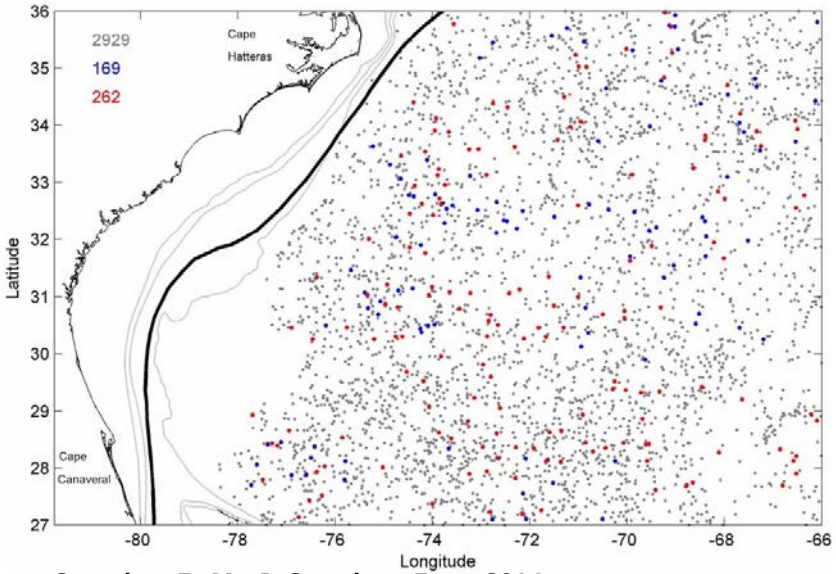


Lack of data (a), and no more data (b) in the training dataset

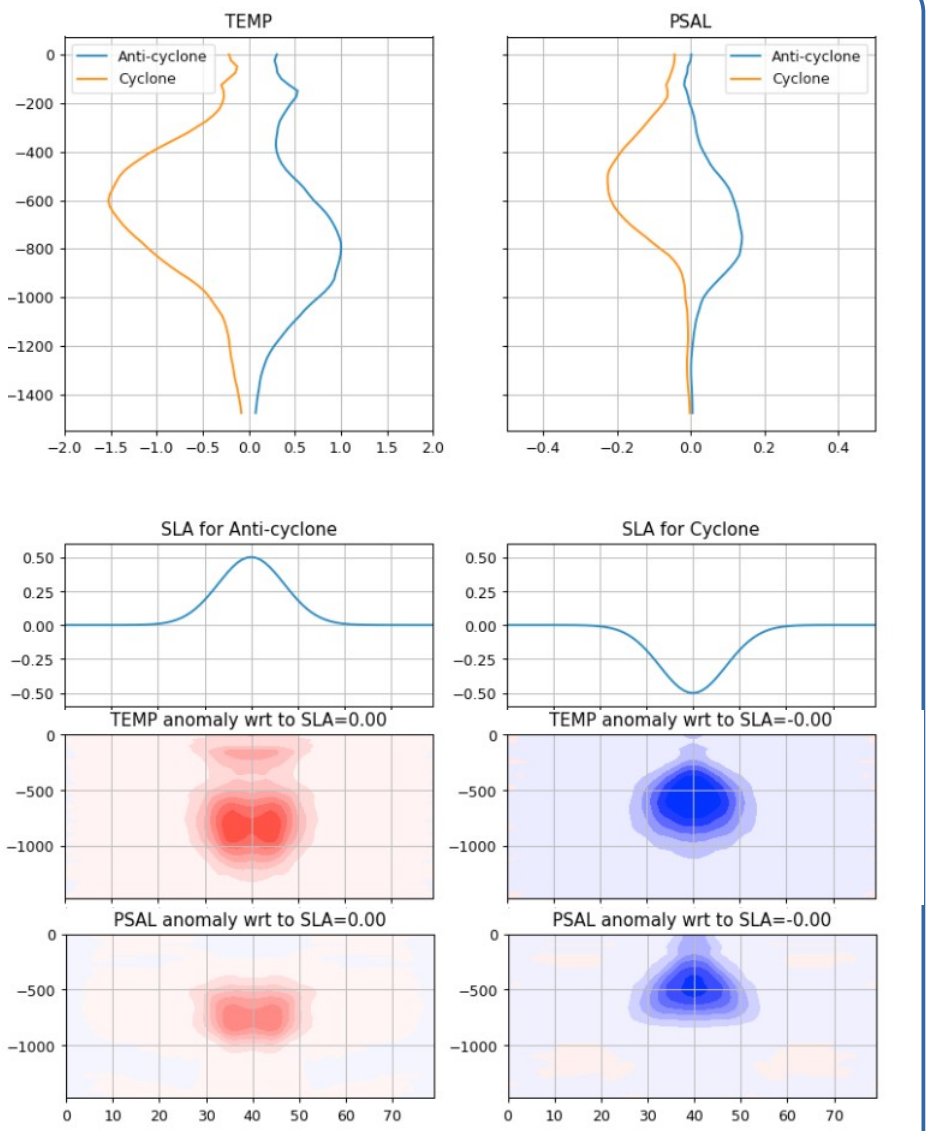


S. Tokunaga, G. Maze, ADMT 2019

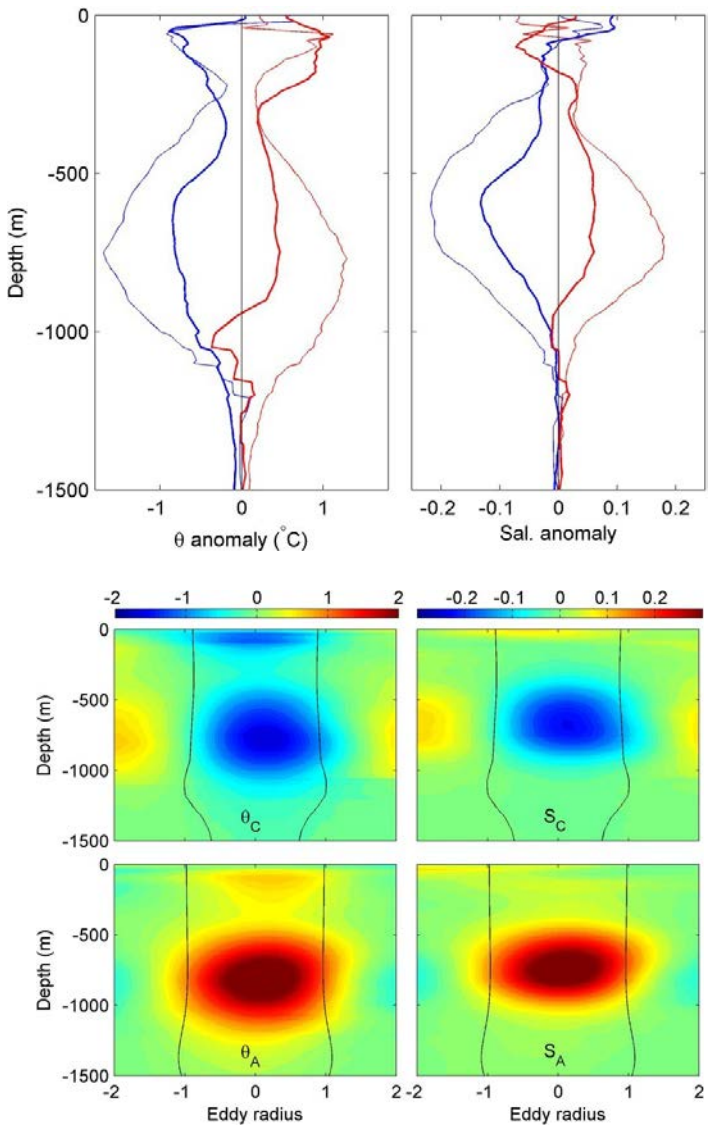
Effect of altimetry :
OSnet simulates vertical turbulence by predicting temperature and salinity for multiple case of sea level anomaly.



Castelao, R. M., J. Geophys. Res., 2014



S. Tokunaga, G. Maze, ADMT 2019



Castelao, R. M., J. Geophys. Res., 2014

Thank you