OGS Istituto Nazionale di Oceanografia e di Geofisica Sperimentale

Integration of BGC-Argo and the Mediterranean BGC forecast system: new developments of the oxygen data quality assessment and assimilation

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Framework: Integrating BGC-ARGO and Med-Bio forecasting model

Data: BGC-ARGO floats

- large n. of profiles

Tot 2015-2021
Chla > 6800
O2o > 9500
NO3 > 3300

Model: Med-BGC MFC

- NRT and RAN products

From Salon et al., 2019 [1]

OGSTM – transport model
[non linear free surface]

$$\left.\frac{\partial C}{\partial t}\right|_{tra} = -\boldsymbol{v}\cdot\nabla C + \nabla(K\nabla C)$$

BFM – biogeochemical model
[C, N, P, Si, O, chl cycles; 51 state variables; 4 phyto, 4 zoo, 1 bact, organic matter, carbonate system]

$$\left.\frac{\partial C}{\partial t}\right|_{bio} = \boldsymbol{R}_{bio}(C, T, PAR, wind)$$

3DVarBio – data assimilation
[variational scheme with decomposition of B, update of 4 phytoplankton]

$$J(C^a) = \tfrac{1}{2}(C^a - C^b)^T B^{-1}(C^a - C^b) + \tfrac{1}{2}(y - H(C^a))^T R^{-1}(y - H(C^a))$$

BGC-Argo dataset for **tuning** and **validation in biogeochemical models**, and in **data assimilation.**

In Med-BGC:

Chlorophyll and nitrate → validation and data assimilation
Oxygen → validation

CURRENT STATE NRT:

- **Float oxygen sensor drift** (0.9 ± 2.7 mmol/m³/yr) makes O2o data prone to uncertainties
- The **quality control (QC) procedures** on the oxygen:

  (A) must be **specific** [2-3] before RT data use for scientific purposes [4]

  (B) are **limited and automatic** (at surface, along the profiles and along floats trajectories)

  (C) no specific QC at depth [4]

Objective: The need for a specific RT pre-processing QC of oxygen data

1. **Propose a procedure** to RT **QC** the **BGC-Argo oxygen** data for model validation and **assimilation** in the **operational biogeochemical Copernicus Marine Service system**
2. **Test the assimilation** of quality-checked oxygen profiles into the Med-BGC model system

A pre-processing quality control procedure for model data assimilation

methods

1. Calculate the trend and remove it
2. Offset-check for validation and assimilation

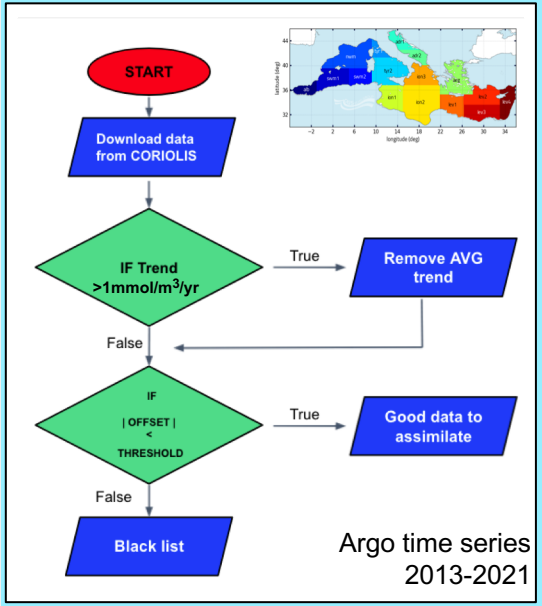
Trend analysis (1)

- **Length**: at least 1 year
- **Methods**: RANSAC and Theil Sen;
- **Depths**: 600, 800 m

Offset analysis (2)

Climatology: EMODnet
(*Buga et al. 2018); 16 sub-basins*
Offset formula= $[O_2]$ - $[O_2clim]$
Threshold: 2 * standard deviation (Clim.)

RT quality check Flowchart

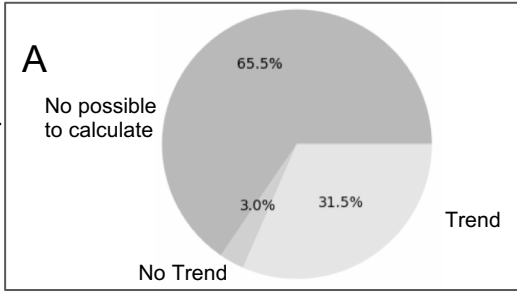


results

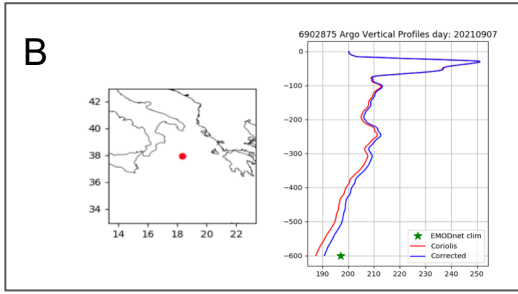
QC procedure have highlighted that:

A. Correction involves 30% of WMOs. The corrections up to 1.5% of oxy at 600m
B. Most of time the removal of the drift moves float values (**blue profile**) closer to climatological fields (**green star**).

A



B



New developments: Integration of BGC-Argo O_2 in Med-BGC forecast system

methods

Med-MFC

OGSTM-BFM-3DVarBio

Test (2017-2018)	Data assimilation
Hindcast	--
Multivar_RUN	Chl NO3 **O2o**

results

HC - Multi_RUN validation 2017-2018

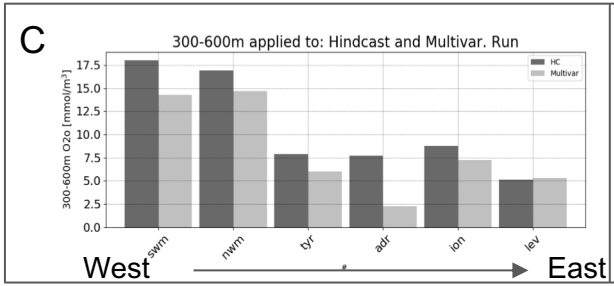
The total number of assimilated (corrected) O2o profiles are >2000 (~600)

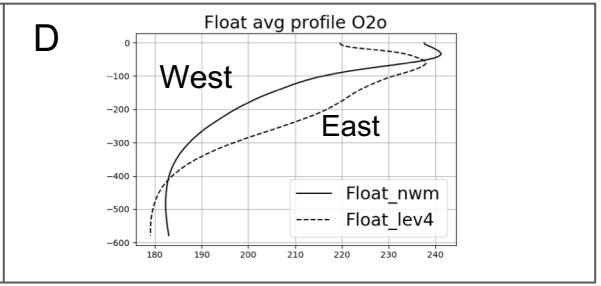
C. Level 1 skills metrics reveal an improvement in O2o Multivar with respect to HC

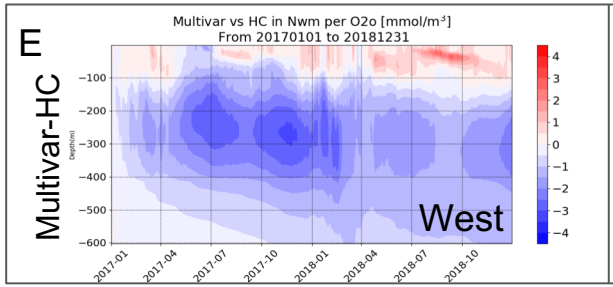
D-E **Surface**: Positive-negative correction → floats correct small scale variability

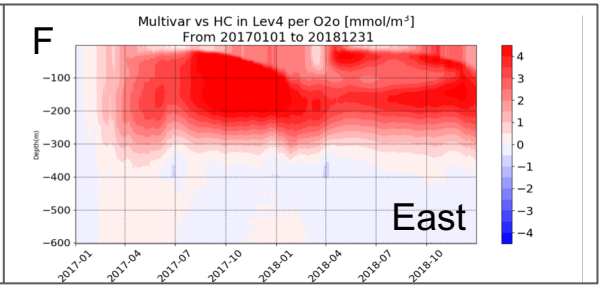
D-E **Deep Layer<100m**: negative correction West (possible resp. missing processes)

D-F **Subsurface<300m:** positive correction East at subsurface oxygen maximum (possible underestimation of primary prod)









Conclusions and references

- **QC of float oxygen successfully implemented**
- **Oxygen assimilation is feasible and effective**
- **Oxygen assimilation will be part of Med MFC product at new CMEMS release in November 2022**

(1) Salon, S., Cossarini, G., Bolzon, G., Feudale, L., Lazzari, P., Teruzzi, A., Solidoro, C., and Crise, A. (2019). Novel metrics based on Biogeochemical Argo data to improve the model uncertainty evaluation of the CMEMS Mediterranean marine ecosystem forecasts, Ocean Sci., 15, 997–1022, https://doi.org/10.5194/os-15-997-2019.

(2) Takeshita, Y., Martz, T. R., Johnson, K. S., Plant, J. N., Gilbert, D., Riser, S. C., Neill, C., and Tilbrook, B. (2013). A climatology-based quality control procedure for profiling float oxygen data, J. Geophys. Res. Oceans, 118, 5640– 5650, doi:10.1002/jgrc.20399

(3) Bittig HC, Körtzinger A, Neill C, van Ooijen E, Plant JN, Hahn J, Johnson KS, Yang B and Emerson SR (2018). Oxygen Optode Sensors: Principle, Characterization, Calibration, and Application in the Ocean. Front. Mar. Sci. 4:429. doi: 10.3389/fmars.2017.00429

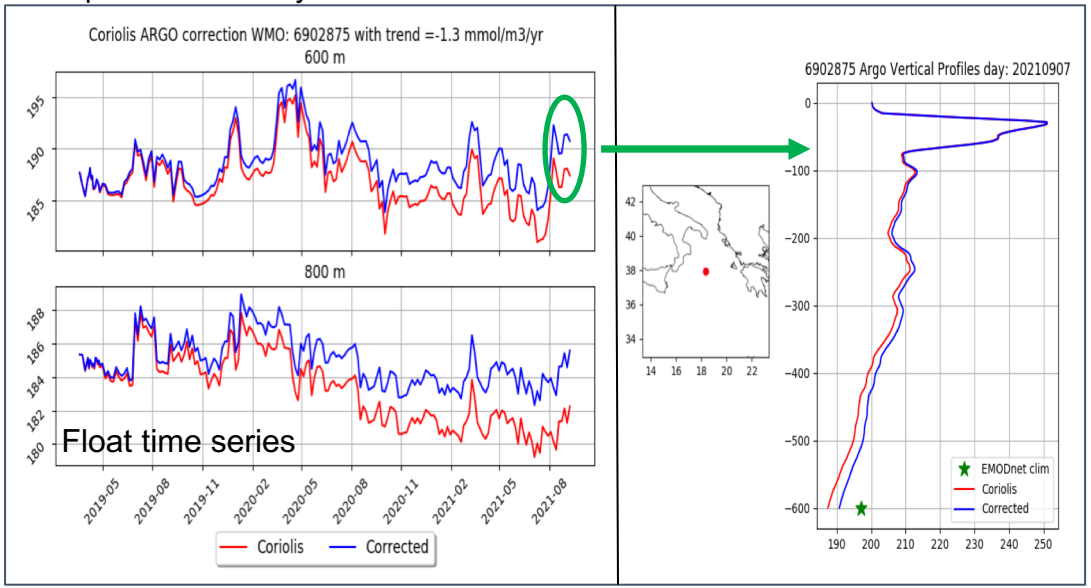
(4) Thierry Virginie, Bittig Henry, The Argo-Bgc Team (2021). Argo quality control manual for dissolved oxygen concentration. https://doi.org/10.13155/46542

Extra materials: QC pre-processing procedure

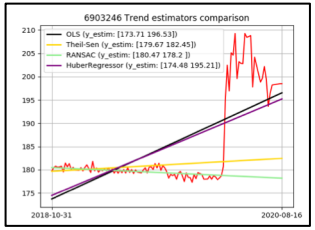
BGC availability 2017-2018
DOXY 2253
NITRATE 711
CHLA 1209

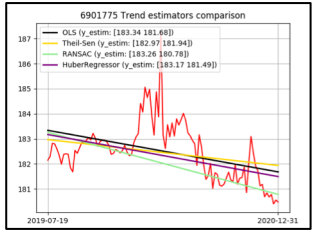
	tot	No trend	With trend	no possible calculation	Blacklist
O2o	>2000	61	642	1333	125

Example of trend analysis:

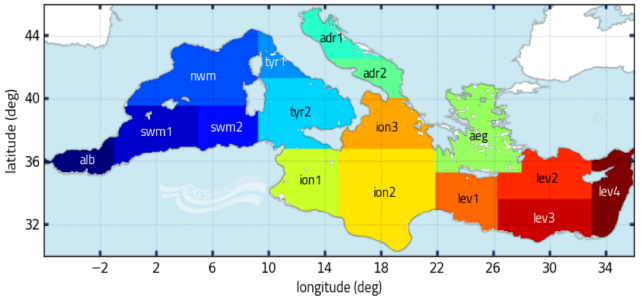


Example of statistical methods for trend calculation





Mediterranean Sea sub-basins



Extra materials: Mediterranean BGC forecast system

Subsurface Oxygen Maximum (SOM) comparison

	NWM (West)	LEV(East)
SOM (floats) [mmol/m^3]	30-50 m 243	50-60m 236
SOM (Mavropoulou 2020) [mmol/m^3]	50–70m or (**slightly higher**) >235	50–70m >235
SOM HC [mmol/m^3]	40m 238	60m 226
SOM Multivar [mmol/m^3]	40m 239	60m 230

Avg profiles of Hindcast, Multivar and BGC floats