- Global Reanalysis of Ocean bioGeochemistry :

GREEN Grog -

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and the GREEN Grog consortium

GREEN Grog

A new PPR associating :

- ✓ Mercator-Océan
- ✓ CLS, Acri-ST
- ✓ IFREMER, LSCE, LEGGE, LOV, LOCEAN, LEGOS, MARBEC
- ✓ 3 years of funding (2016-2019)

… building on and going beyond GREEN Mercator II

… contributing to H2020 AtlantOs

Long-term objective:

build the capacity at Mercator Océan for providing weekly to seasonal forecasts and multi-annual reanalysis of ocean biogeochemical state at regional and global scales

Scientific drivers:

+ Biogeochemical/ecological state estimation

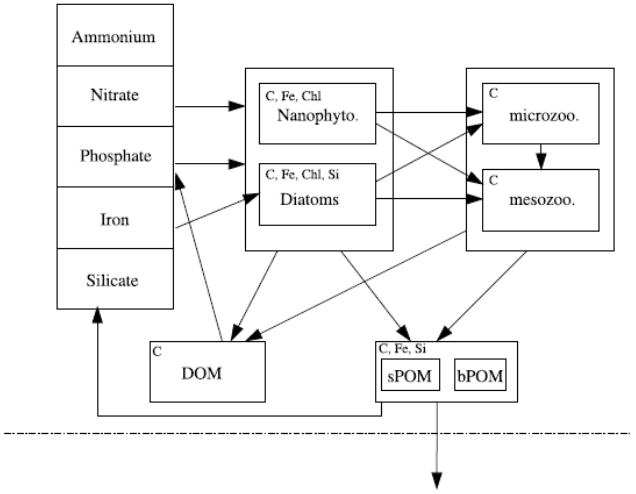
+ Monitoring ocean C uptake and CO_2 air/sea fluxes

+ Marine ecosystem management (fisheries) at weekly to seasonal time scales

+ Regional downscaling and coastal applications, management of living marine resources

Development of an “integrated system”:

- ✓ coupled biogeochemical ocean general circulation model
- ✓ data assimilation to constrain ocean physics and biogeochemistry
- ✓ data streams: assimilation & validation
  - physical: temperature, salinity, SSH
  - biological: chlorophyll, fluorescence
  - biogeochemical: nutrients, oxygen
    - various platforms: space born
      - in situ: ARGO, gliders, eulerian observatories, VOS, research ships

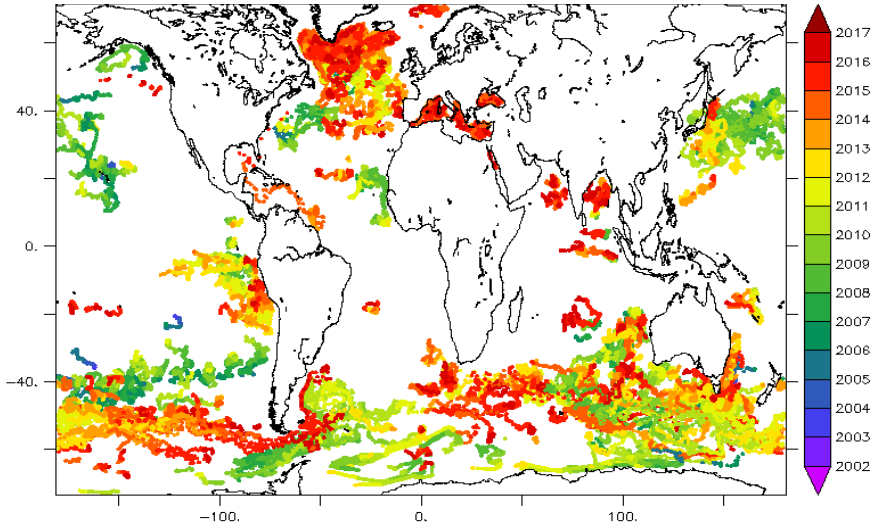


Aumont et al. (2015)

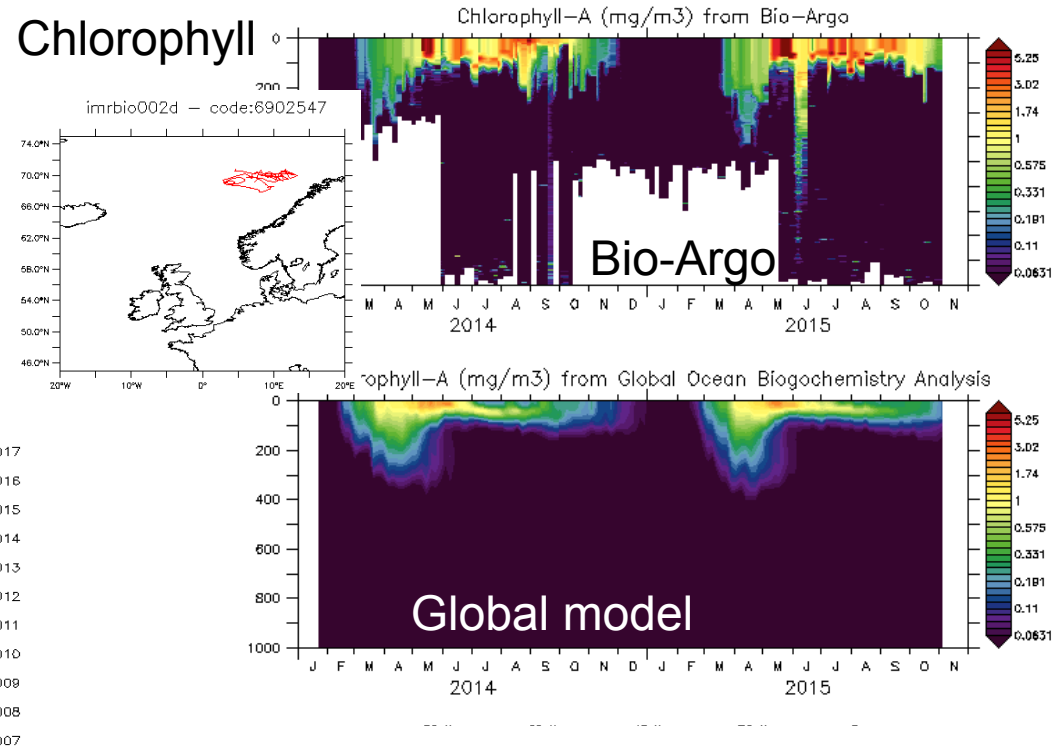
WP1: Observations

Bio-Argo: ~75 000 profils verticaux depuis 2002

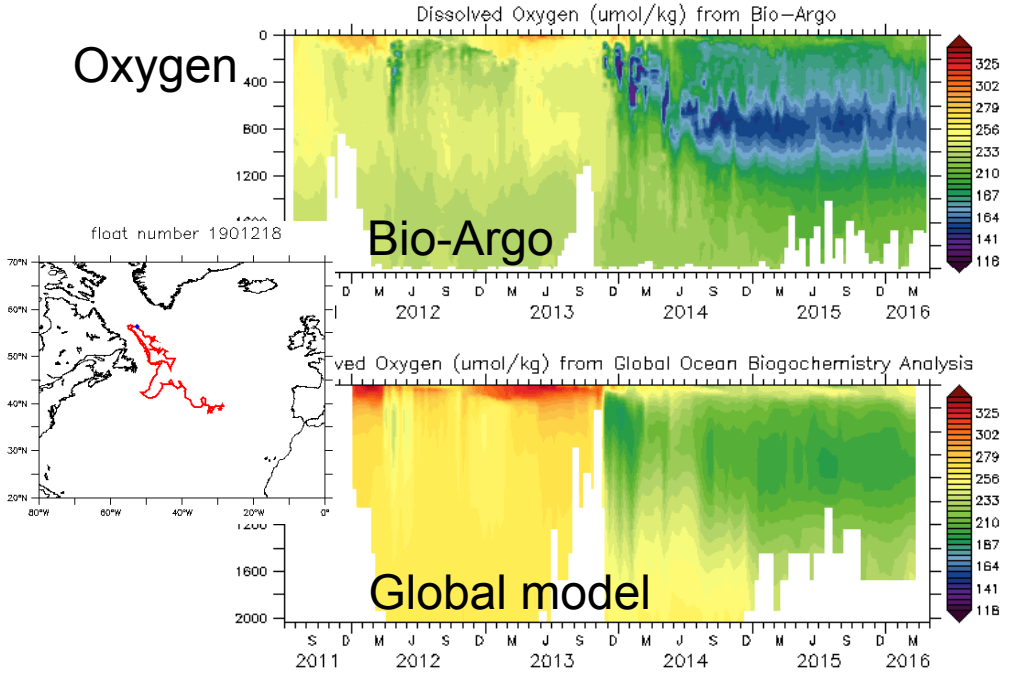
Year of Bio-Argo profiles on GDAC



Chlorophyll



Oxygen



L'apport de Bio-Argo:

→ Evaluation et améliorations des modèles

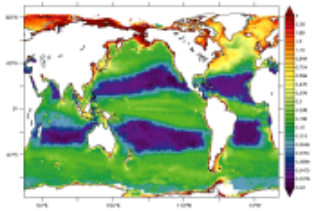
- cycle saisonnier: approfondissement de la MLD, bloom au printemps, max de sub-surface, DMC (Depth of Maximum Chloro)
- variations interannuelles
- Distribution spatiale: passage d'un régime à un autre, …

Copernicus Marine Environment Monitoring Services (CMEMS)

GLOBAL OCEAN BIOGEOCHEMISTRY ANALYSIS AND WEEKLY FORECAST

Numerical-model, Ocean-chlorophyll, Ocean-chemistry, Ocean-biology, Near-real-time, Global-ocean

GLOBAL_ANALYSIS_FORECAST_BIO_001_014

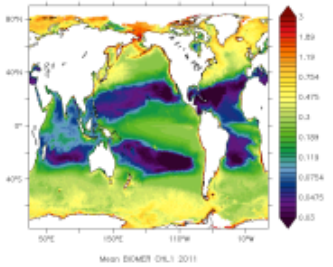


MORE INFO ADD TO CART

GLOBAL OCEAN BIOGEOCHEMISTRY NON ASSIMILATIVE HINDCAST (PISCES) (1998-2014)

Numerical-model, Ocean-chlorophyll, Ocean-chemistry, Ocean-biology, Multi-year, Global-ocean

GLOBAL_REANALYSIS_BIO_001_018



MORE INFO ADD TO CART

[O1] **GREEN Grog**: improve the quality of BGC products distributed by MO as part of CMEMS

WP2: Development of physical – biogeochemical models

2.1 Implementation and validation of online coarsening

2.2 Sensitivity to numerical schemes

2.3 Improvement of the NRT global forecasting system

Task 2.1: Implementation and validation of online coarsening

- **Implementation in NEMO 3.6 stable: still to validate implementation with different mpp splitting (in progress)**

- **Configurations set up for validation**
- 2 reference setup:

  ORCA 1/4-1/4 (eddy permitting) where physics and age tracer run both at ¼° resolution
  ORCA 3/4-3/4 where physics and age tracer run both at ¾° resolution

- Setup using the superparametrization:

  ORCA 1/4-3/4 (eddy permitting) where physics run at ¼° and age tracer at ¾° resolution

- **7 methods to coarsene KZ implemented and compared**

KZ_CRS = MIN(KZ)	KZ_CRS = weighted mean (KZ)	KZ_CRS = MAX(KZ)
KZ_CRS = MEDIANE(KZ)	KZ_CRS = 10**(weighted mean (LOG(KZ)))	
Coarsening via TKE	Effective KZ	

- **ORCA 1/4-3/4 compared to ORCA 1/4-1/4 and ORCA 3/4-3/4 after 60 days of simulation**

- **Need to finish implementation in NEMO_3.6 and to validate it on 30-year simulation (Erainterim period) with age tracer on the extended eORCA grid.**

- **See poster: Super parameterization of ocean dynamics for tracer transport models**

WP2: Development of physical – biogeochemical models

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=> poster by El Moussaoui et al. "An overview of BIOgeochemical MERcator (BIOMER) operational system: recent developments & perspectives development of physical – biogeochemical models"

[O2] : extending the set of stochastic perturbations implemented in the modeling system to improve simulated uncertainties over different regions and at depth

[O3] : develop and implement core ensemble modeling and assimilation algorithms for biogeochemical near-real-time applications and reanalysis at Mercator Océan

[O4] : develop an analysis scheme enabling the assimilation of vertical profiles of measured fluorescence, oxygen and nutrient concentrations

WP3: Development and implementation of assimilation systems

3.1 Ensemble coupled NEMO/PISCES modelling system

3.2 Development of an operational ocean color data analysis scheme

3.3 Development of a combined in situ/space data analysis scheme

3.4 Evaluation of assimilative system developments

WP3: Development and implementation of assimilation systems

Système probabiliste *(Task 3.1)*

AR(1) *(Brankart et al, 2015)*

→ **Processus aléatoires**
$\xi(t) \in N(0, \sigma)$

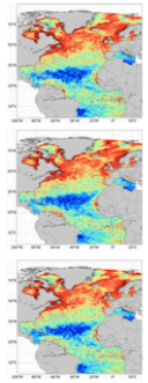
NEMO-NATL025
+ (online)
PISCES *(Aumont et al, 2015)*

+

Paramétrisations Stochastiques

- Échelles non résolues
- Paramètres de PISCES

Ensemble a priori



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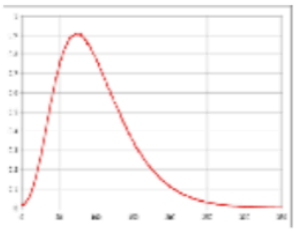

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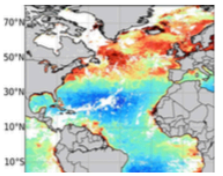
Observations

- **SeaWIFS**

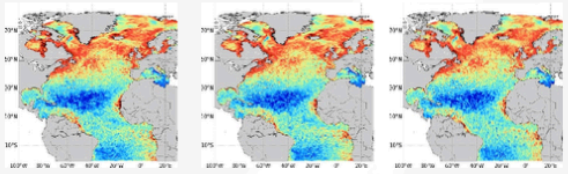


- **ARGO...etc**

+

Analyse **multivariée** de **rang réduit** (ETKF)
+
Anamorphose
(Béal et al, 2013)
+
Localisation spatiale

Ensemble analysé



Objectif Green Grog :

Système d'assimilation *(Task 3.2)*

(cf. présentation Garnier Florent session Assimilation).

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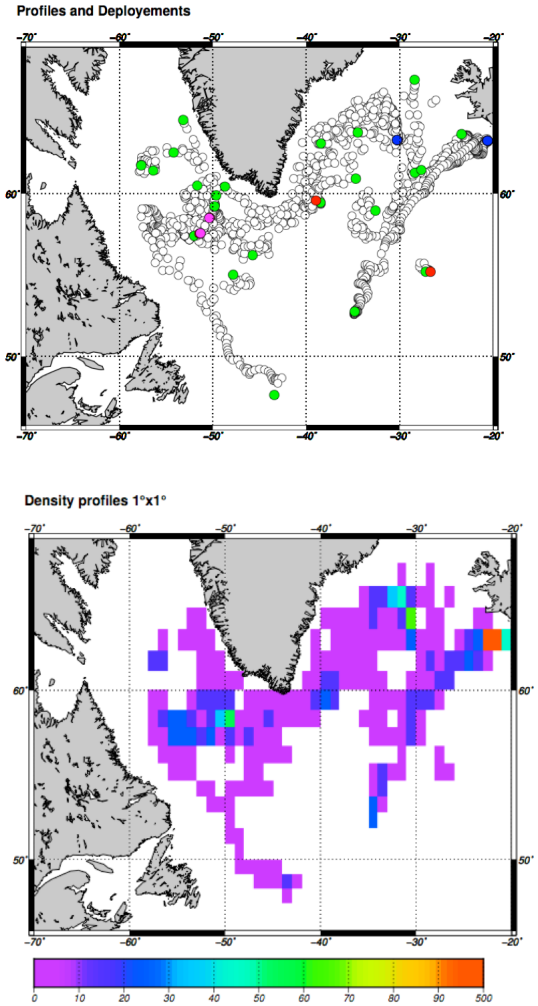
WP4: Production of simulations

Table 1: Global reference simulations produced during the project

#	Spatial resolution		Data assimilation		PHYS/BGC coupling	Period	Year of production	Producing center
	PHYS	BGC	PHYS	BGC				
1	1/4°	3/4°	no	no	online coarsening	1979-2015	2016	Mercator Océan
2	1/12°	1/4°	no	no	online coarsening	1979-2015	2017	Mercator Océan
3	1/4°	1/4°	yes	no	offline	2007-2015	2017	Mercator Océan
4	1/12°	1/4°	yes	no	offline	2007-2015	2017	Mercator Océan
5	1/12°	1/4°	no	no	offline	2007-2015	2017	Mercator Océan
6	1/4°	3/4°	yes	yes	online coarsening	2007-2015	2018	Mercator Océan



Top panel: remOcean NAtl Bio-Argo deployments and profiles. Bottom Panel: density of biogeochemical profiles (reprints from EU FP7 project "OSS2015" deliverable n. D43.3).

WP5: Impact studies

[O5] **GREEN Grog**: contribute to the design of the integrated Atlantic observing system by conducting Observing System Simulation Experiments (OSSEs)

=> make use of coupled physical-biogeochemical models for an improved representation of space-time variability of monitored essential ocean variables, and data assimilation to optimally merge observed and modeled data streams

WP6: Model output evaluation and skill assessment

WP7: Valorisation

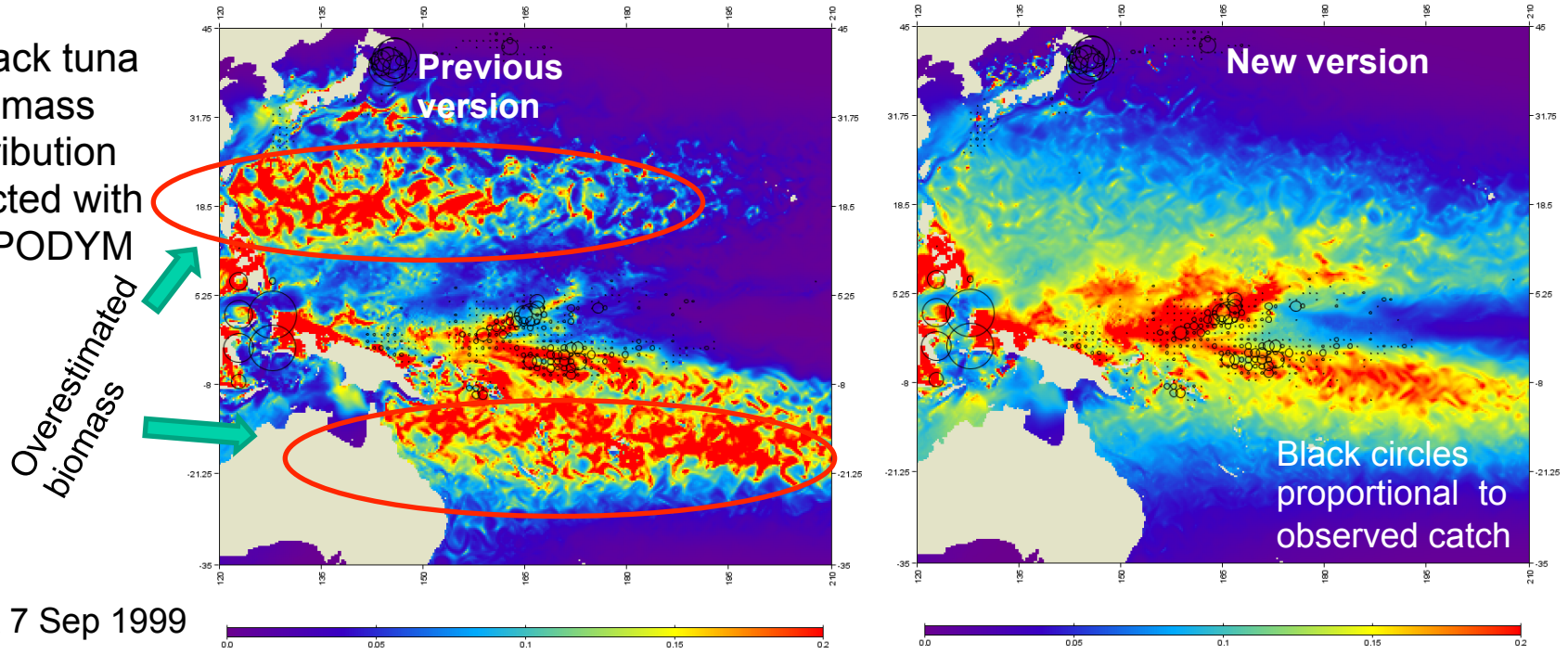
7.1 Provide initial and boundary conditions for coupled physical/biogeochemical simulations at the regional scale

7.2 Provide physical and biogeochemical forcing fields to the mid- and higher-trophic level models SEAPODYM and APECOSM7.3

WP7: **Task 7.2: provide physical - biogeochemical forcing fields to the mid- and higher-trophic level models SEAPODYM and APECOSM**

First experiments using model output from GMII, revealed a large bias in circulation along the Equator. These fields needed to be corrected prior to their use as forcing for SEAPODYM. This has a strong impact on the results based on parameter optimisation with catch data (Max. Likelihood Estimation).

Skipjack tuna biomass distribution predicted with SEAPODYM



New simulations will be used with these models and evaluated through predicted and observed densities of mid- and upper trophic levels

National context :

- ✓ *prospective de l'océanographie opérationnelle*

European level:

- ✓ *Copernicus*
- ✓ *H2020 AtlantOs*

International level:

- ✓ *Biogeochemical ARGO*
- ✓ *GODAE Ocean View (Marine Ecosystem Analysis & prediction)*