PRODUCT USER MANUAL

For Global Biogeochemical Non assimilative Hindcast Product

GLOBAL_REANALYSIS_BIO_001_018

Issue: 4.1

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CHANGE RECORD

Issue	Date	§	Description of Change	Author	Validated By
1.0	13 May 2014	All	Creation of the document.	Perruche, C.	Drillet, Y.
2.0	15 December 2014	All	Updating the simulation time period 1998 -> **2013**	Perruche, C.	Drillet, Y.
2.1	17 dec 2014	All	MyOF modifications	Y. Drillet	Y. Drillet L. Crosnier
2.2	May 1 2015	all	Change format to fit CMEMS graphical rules		L. Crosnier
3.0	Jan 7 2016	All	Update of the simulation time period 1998 -> **2014**	C. Perruche M. Drevillon	Yann Drillet
3.1	Jan 7 2016	All	update server and webpage info	C. Perruche M. Drevillon	Yann Drillet
4.0	Sep 13 2016	All	Update of the simulation time period 1998 -> **2016**	C. Perruche M. Drevillon	Yann Drillet
4.1	July 16, 2018	I.1 & II.2.1	Remove wrong documentation references	J. Paul	

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GLOSSARY AND ABBREVIATIONS

DGF	Direct Get File. It is a CMEMS download mean. "Direct download" directly transfers the file as stored on the server. It is able to deliver compressed data and should be used if you wish to download larger datasets.
DU	Dissemination Unit. A Dissemination Unit is a kind of Production Unit, with the ability to disseminate its own products or other Production Unit's products to the rest of CMEMS Production Centres and to external Users.
EC	European Commission
FTP	File Transfer Protocol
GLO	Global Monitoring and Forecasting Centre
MFC	Monitoring and Forecasting Centre
CIS	CMEMS Information System
NetCDF	Network Common Data Form
PUM	Product User Manual
QUID	Quality Information Document
REA	Reanalysis (for Models)
SLA	Service Level Agreement
SSS	Sea Surface Salinity
SST	Sea Surface Temperature Thematic Assembly Centre

I EXECUTIVE SUMMARY

I.1 Description summary of Products covered by this document

This document describes the global ocean biogeochemical **non assimilative** hindcast simulation GLOBAL_REANALYSIS_BIO_001_018 (also called BIOMER_FREEGLORYS2V3). This simulation is based on the PISCES biogeochemical model and covers the ocean color era (1998 - 2016). It is forced offline at a daily frequency by global physical non assimilative hindcast simulation FREE-GLORYS2V3.

Note that the global physical simulation FREE-GLORYS2V3 is not available.

The GLOBAL_REANALYSIS_BIO_001_018 product contains several biogeochemical variables:

- Nitrate
- Phosphate
- Silicate
- Iron
- Dissolved oxygen
- Chlorophyll concentration
- Phytoplankton concentration in carbon
- Primary production

This product is delivered as monthly averages on the native tripolar grid (ORCA025) at ¼° resolution with 75 vertical levels.

I.2 History of changes

- On April 8 2015, new output files for year 2011 are added, superseding former output files for year 2011. Moreover, new output files for years 2012 and 2013 are added.
- On April 13 2016, a new output files for December 2013 is added, superseding former output file for December 2013. Moreover, new output files for year 2014 are added.
- On October 16 2017, new output files for years 2015 and 2016 are added

II SYSTEM DESCRIPTION

II.1 Numerical Biogeochemical Model: PISCES

The biogeochemical model used is PISCES (Aumont, in prep). It is a model of intermediate complexity designed for global ocean applications (Aumont and Bopp, 2006) and is part of NEMO modeling platform. It has 24 prognostic variables and simulates biogeochemical cycles of oxygen, carbon and the main nutrients controlling phytoplankton growth (nitrate, ammonium, phosphate, silicic acid and iron). The model distinguishes four plankton functional types based on size: two phytoplankton groups (small = nanophytoplankton and large = diatoms) and two zooplankton groups (small = microzooplankton and large = mesozooplankton). Prognostic variables of phytoplankton are total biomass in C, Fe, Si (for diatoms) and chlorophyll and hence the Fe/C, Si/C, Chl/C ratios are variable. For zooplankton, all these ratios are constant and total biomass in C is the only prognostic variable. The bacterial pool is not modeled explicitly. PISCES distinguishes three non-living pools for organic carbon: small particulate organic carbon, big particulate organic carbon and semi-labile dissolved organic carbon. While the C/N/P composition of dissolved and particulate matter is tied to Redfield stoichiometry, the iron, silicon and carbonate contents of the particles are computed prognostically. Next to the three organic detrital pools, carbonate and biogenic siliceous particles are modeled. Besides, the model simulates dissolved inorganic carbon and total alkalinity. In PISCES, phosphate and nitrate + ammonium are linked by constant Redfield ratio (C/N/P = 122/16/1), but cycles of phosphorus and nitrogen are decoupled by nitrogen fixation and denitrification.

The distinction of two phytoplankton size classes, along with the description of multiple nutrient co-limitations allows the model to represent ocean productivity and biogeochemical cycles across major biogeographic ocean provinces (Longhurst, 1998). PISCES has been successfully used in a variety of biogeochemical studies (e.g. Bopp et al. 2005; Gehlen et al. 2006; 2007; Schneider et al. 2008; Steinacher et al. 2010; Tagliabue et al. 2010, Séférian et al, 2013). The biogeochemical model is initialized with World Ocean Atlas 2001 for nitrate, phosphate, oxygen and silicate (Conkright et al. 2002), with GLODAP climatology including anthropogenic CO2 for Dissolved Inorganic Carbon and Alkalinity (Key et al. 2004) and, in the absence of corresponding data products, with model fields for dissolved iron and dissolved organic carbon.

II.2 Forcings of the biogeochemical model

II.2.1 Ocean dynamical forcings

Biogeochemical model PISCES (NEMO3.5) is forced **offline** by daily fields of by the physical model NEMO (OPA module in the NEMO platform).. The main features of this dynamical ocean are:

- NEMO 3.1
- Atmospheric forcings from 3-hourly ERA-Interim reanalysis products, CORE bulk formulation
- Vertical diffusivity coefficient is computed by solving the TKE equation

- Tidal mixing is parameterized according to the works of Bessières et al. (2008) and Koch-Larrouy et al, (2006).
- Sea-Ice model: LIM2 with the Elastic-Viscous-Plastic rheology
- Initial conditions: Levitus 98 climatology for temperature and salinity, patched with PHC2.1 for the Arctic regions, and Medatlas for the Mediterranean Sea.

A special treatment is done on vertical diffusivity coefficient (Kz): the daily mean is done on Log10(Kz) after a filtering of enhanced convection (Kz increased artificially to 10 m2.s-1 when the water column is unstable). The purpose of this Log10 is to average the orders of magnitudes and to give more weight to small values of vertical diffusivity.

Daily ocean dynamical fields used to force PISCES are described more precisely in Table 1.

The two last years (2015-2016) of the biogeochemical simulation are forced by the new ocean physical hindcast FREE-GLORYS2V4. The ocean physical forcings are very similar (same code NEMO, same configuration). The main difference is that FREE-GLORYS2V4 starts from EN4 climatologies.

II.2.2 Atmospherical forcings

The atmospheric forcing fields are daily averages from ERA-Interim reanalysis product (CORE bulk formulation). The variable needed to force PISCES biogeochemical model are described in Table 1.

II.2.3 External sources of nutrients

Boundary fluxes account for nutrient supply from three different sources: Atmospheric deposition (Aumont et al., 2008), rivers for nutrients, dissolved inorganic carbon and alkalinity (Ludwig et al., 1996; Mayorga et al., 2010) and inputs of Fe from marine sediments. Nutrient and freshwater inflows by rivers are colocalized. River and dust inputs are balanced with sediment trapping of NO3, Si and Carbon. An annual and global value of atmospheric carbon dioxide is imposed at sea surface. More details are provided in Table 1.

Ocean dynamic forcings (daily)	• Ocean temperature • Ocean salinity • 3D velocity (U, V, W) • Turbulent diffusivity coefficient (average done on the Log10(Kz) and filtering) • Mixed Layer Depth (turbocline criterion) • Ice cover area fraction
Atmospheric forcings (daily)	• Net solar flux at the ocean surface • Net fresh water budget into ocean E-P • Wind speed at 10 m
External sources of	• Atmospheric deposition (dust) of phosphate, silicate and iron

nutrients	(monthly climatology): cf Aumont et al., 2008 • Rivers (monthly climatology): Non-redfieldian river inputs of NO3, PO4, Fe, Si, Dissolved Inorganic Carbon and Alkalinity (Ludwig, 1996; Mayorga et al., 2010). Rivers are colocalized with runoffs of the physical model. • Inputs from sediments: Inputs of Iron are parameterized with the variance of the bathymetry (Aumont, in prep) • Atmospheric CO2: Annual and global atmospheric CO2 value varying with anthropogenic emissions

Table 1: Forcings of PISCES model

II.3 Configuration

The horizontal grid is the standard ORCA025 tri-polar grid (1440 x 1021 grid points). The three poles are located over Antarctic, Central Asia and North Canada. The ¼ degree resolution corresponds to the equator. The vertical grid has 75 levels, with a resolution of 1 meter near the surface and 200 meters in the deep ocean.

Biogeochemical and physical simulations start at rest (cold start) in December 1991. The spin-up period consists of 5 years of interannual simulation between 1992 and 1997. The simulation period covers the ocean color era (1998 – 2013).

The main features of the biogeochemical simulation are summarized in Table 2.

Geographical coverage	Global Ocean (180°W-180°E; 77°S-90°N)
Grid and Resolutions	ORCA grid at 1/4°; 75 levels
Grid size	1442x1021x75 (partial steps)
Code and Version	NEMO3.5 – PISCES
Time period	1998 – 2013 (delivered in GLOBAL_REANALYSIS_BIO_001_018)
Spin-up	1992 – 1997 (not delivered in GLOBAL_REANALYSIS_BIO_001_018)
Assimilation	No
Mass conservation	River and dust inputs are balanced with sediment trapping of NO3, Si and Carbon
Initial conditions	WOA 2001 for NO3, O2, PO4 and Si GLODAP with anthropogenic part for DIC and Alkalinity A 3000-year PISCES run for DOC and Iron

Vertical mixing	TKE 1.5 closure scheme + Average on the Log10(Kz) and filtering of enhanced convection
Advection	MUSCL scheme
Tracer diffusion	Isopycnal Laplacian
Horizontal diffusion coefficient for tracers	aht0 = 300 m2/s
NetCDF convention	CF 1.5

Table 2: Main Characteristics of PISCES model simulation

II.4 Data Assimilation

No assimilation of data in this simulation

III PRODUCT DESCRIPTION

III.1 General Information

Product GLOBAL_REANALYSIS_BIO_001_018 produced by Mercator Ocean in Toulouse, France, is a global ocean biogeogeochemical non assimilative hindcast product at 1/4° over the period [15/01/1998;15/12/2013]. Outputs are delivered as monthly mean files with Netcdf format (CF/COARDS 1.5 convention) on the native tripolar grid (ORCA025) at ¼° resolution with 75 vertical levels.

III.2 Details of datasets

There are 8 different datasets:

- **Dataset1** dataset-global-nahindcast-bio-001-018-no3 containing : nitrate concentration
- **Dataset2** dataset-global-nahindcast-bio-001-018-po4 containing : phosphate concentration
- **Dataset3** dataset-global-nahindcast-bio-001-018-si containing : silicate concentration
- **Dataset4** dataset-global-nahindcast-bio-001-018-o2 containing : dissolved oxygen concentration
- **Dataset5** dataset-global-nahindcast-bio-001-018-fe containing : iron concentration
- **Dataset6** dataset-global-nahindcast-bio-001-018-chl containing : chlorophyll concentration
- **Dataset7** dataset-global-nahindcast-bio-001-018-phyc containing : carbon phytoplankton biomass
- **Dataset8** dataset-global-nahindcast-bio-001-018-pp containing : primary production

III.3 Details of variables and units

- NO3: Mole Concentration of Nitrate in Sea Water ($mmol.m^{-3}$)
- PO4: Mole Concentration of Phosphate in Sea Water ($mmol.m^{-3}$)
- Si: Mole Concentration of Silicate in Sea Water ($mmol.m^{-3}$)
- O2: Mole Concentration of Dissolved Oxygen in Sea Water ($mmol.m^{-3}$)
- Fe: Mole Concentration of Iron in Sea Water ($mmol.m^{-3}$)
- CHL: Mass Concentration of Chlorophyll in Sea Water ($mmol.m^{-3}$)
- PHYC: Mole Concentration of Phytoplankton expressed as carbon in sea water ($mmol.m^{-3}$)
- PP: Net Primary Production of Biomass expressed as carbon per unit volume in sea water ($g.m^{-3}$/day)

III.4 Grid Characteristics and Geographical Projection

Product is delivered on a curvilinear grid with a 1/4° horizontal resolution (~25km at the equator). Two netcdf files describing the grid are available on CMEMS FTP: GLO-MFC_001_018_coordinates.nc and GLO-MFC_001_018_mask_bathy.nc

IV PRODUCT DISTRIBUTION

IV.1 Which Download mechanism is available for this product?

The download mechanisms available for this product are:

- Subsetter
- DirectGetFile
- CMEMS FTP

IV.2 How to Download this product?

You first need to register. Please find the registration steps on our website:

http://marine.copernicus.eu/web/34-products-and-services-faq.php#1

Once registered, the CMEMS FAQ http://marine.copernicus.eu/web/34-products-and-services-faq.php will guide you on how to download a product through the CMEMS Web Portal Subsetter , DirectGetfile and FTP Services.

IV.3 How to write and run a script to download this product?

FAQ#4 will guide you on how to proceed:

http://marine.copernicus.eu/web/34-products-and-services-faq.php#4

V FILES NOMENCLATURE AND FORMAT

The nomenclature of the downloaded files differs on the basis of the chosen download mechanism Subsetter, Directgetfile or CMEMS FTP services.

V.1 Nomenclature of files when downloaded through the Subsetter Service

GLOBAL_REANALYSIS_BIO_001_018 files nomenclature when downloaded through the CMEMS Web Portal Subsetter is based on product dataset name and a numerical reference related to the request date on the MIS.

The scheme is: **datasetname_nnnnnnnnnnnn.nc**

where :

. datasetname is a character string within one of the following:

- dataset-global-nahindcast-bio-001-018-no3
- dataset-global-nahindcast-bio-001-018-po4
- dataset-global-nahindcast-bio-001-018-si
- dataset-global-nahindcast-bio-001-018-o2
- dataset-global-nahindcast-bio-001-018-fe
- dataset-global-nahindcast-bio-001-018-chl
- dataset-global-nahindcast-bio-001-018-phyc
- dataset-global-nahindcast-bio-001-018-pp

. nnnnnnnnnnnn: 13 digit integer corresponding to the current time (download time) in milliseconds

since January 1, 1970 midnight UTC.

.nc: standard NetCDF filename extension.

Example:

dataset-global-nahindcast-bio-001-018-no3_1303461772348.nc

V.2 Nomenclature of files when downloaded through the Directgetfile and CMEMS FTP Services

GLOBAL_REANALYSIS_BIO_001_018 files nomenclature when downloaded through the CMEMS Web Portal Directgetfile is based as follows:

BIOMER_FREEGLORYS2V3_{valid_date}_R{bul_date}_grid{variable_name}.nc

where

- **valid_date** YYYYMMDD is the validity day of the data in the file

· **bul_date** YYYYMMDD is the bulletin date the product was produced

· **variable_name** : name of the biogeochemical variable

V.3 Land mask and missing values

Land mask are equal to "_FillValue" (see variable attribute on NetCDF file). There are no missing values.

V.4 File Format: Netcdf

The products are stored using the NetCDF-CF format version 3.0.

NetCDF (network Common Data Form) is an interface for array-oriented data access and a library that provides an implementation of the interface. The netCDF library also defines a machine-independent format for representing scientific data. Together, the interface, library, and format support the creation, access, and sharing of scientific data. The netCDF software was developed at the Unidata Program Center in Boulder, Colorado. The netCDF libraries define a machine-independent format for representing scientific data.

Please see Unidata netCDF pages for more information, and to retrieve netCDF software package.

NetCDF data is:

* Self-Describing. A netCDF file includes information about the data it contains.

* Architecture-independent. A netCDF file is represented in a form that can be accessed by computers with different ways of storing integers, characters, and floating-point numbers.

* Direct-access. A small subset of a large dataset may be accessed efficiently, without first reading through all the preceding data.

* Appendable. Data can be appended to a netCDF dataset along one dimension without copying the dataset or redefining its structure. The structure of a netCDF dataset can be changed, though this sometimes causes the dataset to be copied.

* Sharable. One writer and multiple readers may simultaneously access the same netCDF file.

V.5 Structure and semantic of NetCDF maps files

netcdf BIOMER_FREEGLORYS2V3_19981115_R20140410_gridCHL {

dimensions:

x = 1442 ;

y = 1021 ;

deptht = 75 ;

time_counter = 1 ;

variables:

float nav_lon(y, x) ;

nav_lon:add_offset = 0.f ;

nav_lon:scale_factor = 1.f ;

nav_lon:units = "degrees_east" ;

nav_lon:unit_long = "Degrees East" ;

nav_lon:long_name = "Longitude" ;

nav_lon:standard_name = "longitude" ;

float nav_lat(y, x) ;

nav_lat:add_offset = 0.f ;

nav_lat:scale_factor = 1.f ;

nav_lat:units = "degrees_north" ;

nav_lat:unit_long = "Degrees North" ;

nav_lat:long_name = "Latitude" ;

nav_lat:standard_name = "latitude" ;

float deptht(deptht) ;

deptht:long_name = "Depth" ;

deptht:units = "m" ;

deptht:positive = "down" ;

deptht:unit_long = "Meters" ;

deptht:standard_name = "depth" ;

double time_counter(time_counter) ;

time_counter:standard_name = "time" ;

time_counter:long_name = "Time axis" ;

time_counter:title = "Time" ;

time_counter:calendar = "gregorian" ;

time_counter:units = "seconds since 1900-01-01 00:00:00" ;

time_counter:time_origin = "1900-01-01 00:00:00" ;

time_counter:unit_long = "seconds since 1900-01-01 00:00:00" ;

int x(x) ;

x:standard_name = "projection_x_coordinate" ;

x:units = "1" ;

int y(y) ;

y:standard_name = "projection_y_coordinate" ;

y:units = "1" ;

float CHL(time_counter, depptht, y, x) ;

CHL:units = "mg.m-3" ;

CHL:missing_value = 9.96921e+36f ;

CHL:valid_min = 0.f ;

CHL:valid_max = 100.f ;

CHL:long_name = "Mass Concentration of Chlorophyll in Sea Water" ;

CHL:short_name = "CHL" ;

CHL:online_operation = "average" ;

CHL:scale_factor = 1.f ;

CHL:add_offset = 0.f ;

CHL:savelog10 = 0.f ;

CHL:_FillValue = 9.96921e+36f ;

CHL:unit_long = "milligram of chlorophyll per cubic meter" ;

CHL:standard_name = "mass_concentration_of_chlorophyll_in_sea_water" ;

// global attributes:

:file_name = "BIOMER_FREEGLORYS2V3_19981115_R20140410_gridCHL.nc" ;

:TimeStamp = "2014-APR-07 10:59:40 GMT+0200" ;

:references = "http://www.mercator-ocean.fr" ;

:Conventions = "CF-1.5" ;

:comment = "Chlorophyll = Diatoms CHL + Nano CHL" ;

}

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