



PRODUCT USER MANUAL

For Black Sea Biogeochemical Analysis and Forecasting Product

BLKSEA_ANALYSISFORECAST_BGC_007_010

Issue: 3.0

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RECORD TABLE

Issue	Date	§	Description of Change	Author	Validated By
1.0	19/04/2019	all	Initial version	R. Lecci, L. Vandenbulcke, M. Grégoire	
1.1	03/04/2020	all	General revision following the upgraded data quality into EIS 202007	R. Lecci, L. Vandenbulcke, M. Grégoire	C. Derval
2.0	29/11/2022	all	New product	R. Lecci, L. Vandenbulcke, M. Grégoire	Copernicus Marine Product management
3.0	30/11/2023	all	Upgraded product ;	R. Lecci, L. Vandenbulcke, M. Grégoire	

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GLOSSARY AND ABBREVIATIONS

Analysis (Numerical)	a detailed study of the state of the ocean done in Near real Time based on observations and numerical model. The operational prediction centre produces 3D time-space analysis systems. A long series of analyses is of great utility for studying the behavior of the ocean system.
BAMHBI	Biogeochemical Model for Hypoxic and Benthic Influenced areas (MAST / Université de Liège, Belgium)
BCs	Boundary Conditions
BLK	Black Sea
BFM	Biogeochemical Flux Model
CF	Climate Forecast (convention for NetCDF)
CHL	Chlorophyll
CMEMS	Copernicus Marine Environment Monitoring Service
CMS	Copernicus Marine Service
DIC	Dissolved Inorganic Carbon
DirectGetFile	Copernicus Marine service tool (FTP like) to download a NetCDF file
FAQ	Frequently Asked Question
Forecast (Numerical)	a computer forecast or prediction based on equations governing the motions and the forces affecting motion of fluids. The equations are based, or initialized, on specified ocean conditions at a certain place and time (NOAA Glossary).
FTP	File Transfer Protocol
GHER	Geo-Hydrodynamics Environmental Research laboratory of the Liege University (Belgium), and the synonym 3D circulation model
MFC	Monitoring and Forecasting Centre
NetCDF	Network Common Data Form

NOAA	National Oceanic and Atmospheric Administration
OCTAC	Ocean Colour Thematic Assembly Centre
OpenDAP	Open-Source Project for a Network Data Access Protocol. Protocol to download subset of data from a n-dimensional gridded dataset (i.e.: 4 dimensions: lon-lat, depth, time)
pCO ₂	partial pressure of carbon dioxide
PFT	Plankton Functional Types
pH	potential of Hydrogen
PU	Production Unit
Subsetter	Copernicus Marine service tool to download a NetCDF file of a selected geographical box using values of longitude and latitude, and time range
ULg MAST (ULg)	Université de Liège, Belgium Modelling for Aquatic SysTems research Unit
3DVAR	Three-Dimensional Variational

I INTRODUCTION

I.1 Summary

This document is the user manual for the Copernicus Marine analysis and forecast product **BLKSEA_ANALYSISFORECAST_BGC_007_010**. An archive of analysis over the last two years up to real-time is available on the Copernicus Marine server.

The product is composed by 3D daily and monthly mean concentration of chlorophyll, nitrate, phosphate, dissolved oxygen, phytoplankton carbon biomass, pH, dissolved inorganic carbon, net primary production and by 2D daily and monthly means of vertically integrated bottom oxygen concentration (for the shelf), surface partial pressure of CO₂ and surface flux of CO₂.

BLKSEA_ANALYSISFORECAST_BGC_007_010 product is organized in 14 datasets:

- 6 contain the monthly mean fields for all the variables
 - **cmems_mod_blk_bgc-bio_anfc_3km_P1M-m**
 - **cmems_mod_blk_bgc-car_anfc_3km_P1M-m**
 - **cmems_mod_blk_bgc-co2_anfc_3km_P1M-m**
 - **cmems_mod_blk_bgc-nut_anfc_3km_P1M-m**
 - **cmems_mod_blk_bgc-pft_anfc_3km_P1M-m**
 - **cmems_mod_blk_bgc-opt_anfc_3km_P1M-m**
- 6 contain the daily mean fields for all the variables
 - **cmems_mod_blk_bgc-bio_anfc_3km_P1D-m**
 - **cmems_mod_blk_bgc-car_anfc_3km_P1D-m**
 - **cmems_mod_blk_bgc-co2_anfc_3km_P1D-m**
 - **cmems_mod_blk_bgc-nut_anfc_3km_P1D-m**
 - **cmems_mod_blk_bgc-pft_anfc_3km_P1D-m**
 - **cmems_mod_blk_bgc-opt_anfc_3km_P1D-m**
- 1 contains the hourly mean fields for surface variables (i.e., air-sea CO₂ fluxes, pCO₂):
cmems_mod_blk_bgc-co2_anfc_3km_PT1H-m
- 1 contains the static fields for the system (coordinates, mask and bathymetry):
cmems_mod_blk_bgc_anfc_3km_static

The product is published on the Copernicus Marine dissemination server after automatic and

human quality controls. Product is available on-line and disseminated through the Copernicus Marine Information System. Files downloaded are in NetCDF format.

The analysis and forecasting system is described in the Quality Information Document (QUID).

Disclaimer: The quality of the product may vary during the proposed time series depending on the possible update of the system.

Information on operational issues on products and services can be found on our [User Notification Service](#). If you have any questions, please [contact us](#).

I.2 History of changes

Date	Description
03.04.2020	Data assimilation improvement
29.11.2022	New product
30.11.2023	Upgraded datasets

II DESCRIPTION OF THE PRODUCT SPECIFICATION

II.1 General Information

Product line	BLKSEA_ANALYSISFORECAST_BGC_007_010	
Geographical coverage	27.25°E - 41.10°E; 40.50°N - 47.00°N	
Variables	Nitrate Phosphate Phytoplankton Carbon Biomass Chlorophyll Net Primary Production Dissolved Oxygen pH Dissolved Inorganic Carbon Alkalinity Surface partial pressure of CO ₂ Surface CO ₂ flux Photosynthetical-Active Radiation and Attenuation coefficient	
Product Type	Analysis	Forecast
Update frequency	Weekly	Daily
Available time series	-2Y + 10 days forecast	
Target delivery time	On Tuesday at 17:00 UTC	Daily at 17:00 UTC
Temporal resolution	cmems_mod_blk_bgc-bio_anfc_3km_P1M-m, cmems_mod_blk_bgc-car_anfc_3km_P1M-m, cmems_mod_blk_bgc-co2_anfc_3km_P1M-m, cmems_mod_blk_bgc-nut_anfc_3km_P1M-m, cmems_mod_blk_bgc-pft_anfc_3km_P1M-m, cmems_mod_blk_bgc-opt_anfc_3km_P1M-m : monthly mean cmems_mod_blk_bgc-bio_anfc_3km_P1D-m, cmems_mod_blk_bgc-car_anfc_3km_P1D-m, cmems_mod_blk_bgc-co2_anfc_3km_P1D-m, cmems_mod_blk_bgc-nut_anfc_3km_P1D-m, cmems_mod_blk_bgc-	

	pft_anfc_3km_P1D-m, cmems_mod_blk_bgc-opt_anfc_3km_P1D-m : daily mean cmems_mod_blk_bgc-co2_anfc_3km_PT1H-m: hourly mean
Horizontal resolution	~2.5 km (1/40°)
Number of vertical levels	59
Format	NetCDF CF1.0
Delivery mechanisms	Subsetter and FTP

Table 1: BLK-MFC Real Time product

The runtime schedule:

The BLK-MFC BGC production follows a split temporal scheme: a weekly assimilation/analysis and a daily forecast.

An analysis is produced weekly on Tuesdays and is valid for the preceding 10 days. It is based on a Singular Evolutive Extended Kalman Filter (SEEK) scheme and utilizes available observations up to the valid date. The analysis is used to initialize a 1-day hindcast and 10-day forecast.

II.2 Details of datasets

BLACKSEA_ANALYSISFORECAST_BGC_007_010
Datasets: • cmems_mod_blk_bgc-bio_anfc_3km_P1M-m • cmems_mod_blk_bgc-car_anfc_3km_P1M-m • cmems_mod_blk_bgc-co2_anfc_3km_P1M-m • cmems_mod_blk_bgc-nut_anfc_3km_P1M-m • cmems_mod_blk_bgc-pft_anfc_3km_P1M-m • cmems_mod_blk_bgc-opt_anfc_3km_P1M-m contain the 3D monthly mean fields for all the variables • cmems_mod_blk_bgc-bio_anfc_3km_P1D-m • cmems_mod_blk_bgc-car_anfc_3km_P1D-m • cmems_mod_blk_bgc-co2_anfc_3km_P1D-m • cmems_mod_blk_bgc-nut_anfc_3km_P1D-m • cmems_mod_blk_bgc-pft_anfc_3km_P1D-m • cmems_mod_blk_bgc-opt_anfc_3km_P1D-m contain the 3D daily mean fields for all the variables

- **cmems_mod_blk_bgc-co2_anfc_3km_PT1H-m**

contain the 2D hourly mean fields for the surface variables

- **cmems_mod_blk_bgc_anfc_3km_static**

contains the static fields for the system: coordinates, mean sea surface level, mask, and bathymetry

Variables name in the NetCDF file and Unit: Long_name & Standard_name

no3 [mmol m-3]

Nitrate

mole_concentration_of_nitrate_in_sea_water

po4 [mmol m-3]

Phosphate

mole_concentration_of_phosphate_in_sea_water

phyc [mmol m-3]

Phytoplankton Carbon Biomass

mole_concentration_of_phytoplankton_expressed_as_carbon_in_sea_water

chl [mg m-3]

Chlorophyll

mass_concentration_of_chlorophyll_a_in_sea_water

nppv [mg m-3 day-1]

Primary Production

net_primary_production_of_biomass_expressed_as_carbon_per_unit_volume_in_sea_water

o2 [mmol m-3]

Dissolved oxygen

mole_concentration_of_dissolved_molecular_oxygen_in_sea_water

o2b [mmol m-3]

Dissolved Oxygen on the shelf bottom

mole_concentration_of_dissolved_molecular_oxygen_in_sea_water

ph [1]

Ocean pH

sea_water_ph_reported_on_total_scale

dissic [mol m-3]

Dissolved Inorganic Carbon

mole_concentration_of_dissolved_inorganic_carbon_in_sea_water

talk [mol m-3]

Alkalinity

sea_water_alkalinity_expressed_as_mole_equivalent

spco2 [Pa]

Surface partial pressure of CO2

surface_partial_pressure_of_carbon_dioxide_in_sea_water

fpcO2 [kg m-2 s-1]

Surface CO2 flux

surface_downward_mass_flux_of_carbon_dioxide_expressed_as_carbon

light [W m-2]

Immerged incoming photosynthetic active radiation

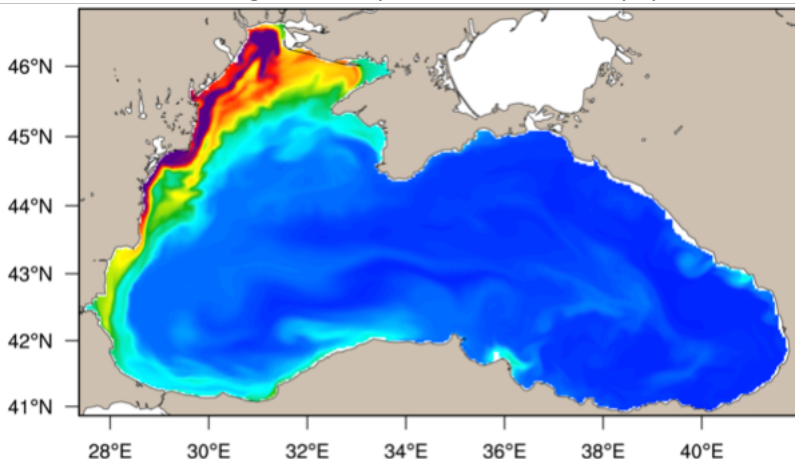
downwelling_photosynthetic_photon_flux_in_sea_water

kd [m-1]

Light attenuation volume_attenuation_coefficient_of_downwelling_radiative_flux_in_sea_water
e1t [m] Cell dimension along X axis
e2t [m] Cell dimension along Y axis
e3t [m] Cell dimension along Z axis cell_thickness
mask [1] Land-sea mask: 1 = sea ; 0 = land sea_binary_mask
deptho [m] Bathymetry sea_floor_depth_below_geoid
deptho_lev [1] Model level number at sea floor model_level_number_at_sea_floor

Table 2: list of the datasets and variable names and unit for the BLKSEA_ANALYSISFORECAST_BGC_007_010 product

II.3 Production System Description

Domain Resolution and grid Geographic coverage	BLKSEA (27.25°E - 41.10°E; 40.50°N - 47.00°N) ~2.5km; regular grid; 591 x 261 This product covers the Black Sea, the horizontal resolution is 1/40 (approx 2.5 km), the vertical grid is composed of 59 unevenly spaced levels. 
Model Version Production unit Period of validation	▪ nemo_bamhbi ▪ ULg, Belgium ▪ 01.01.2021–31.12.2022

Vertical grid	The product is delivered at the model's native grid, with up to 59 vertical levels: levels [m]: 0.25, 0.77, 1.32, 1.89, 2.49, 3.12, 3.80, 4.54, 5.33, 6.20, 7.15, 8.20, 9.37, 10.68, 12.16, 13.82, 15.72, 17.89, 20.38, 23.23, 26.53, 30.34, 34.76, 39.88, 45.83, 52.75, 60.79, 70.14, 81.01, 93.63, 108.27, 125.23, 144.83, 167.43, 193.41, 223.17, 257.14, 295.75, 339.40, 388.52, 443.45, 504.52, 571.99, 646.03, 726.73, 814.09, 908.02, 1008.35, 1114.81, 1227.10, 1344.84, 1467.64, 1595.06, 1726.70, 1862.12, 2000.92, 2142.72, 2287.16, 2433.67
Atmospheric forcing	ECMWF atmospheric forcing at 1/10 degrees: 6-hourly analysis; 1 hour for the first 3 days of forecast, 3 hours for the following 3 days of forecast and 6 hours for the last 4 days of forecast
Boundary forcing	The ocean model NEMO 4.2 is using conservations laws at the Bosphorus open boundary. The barotropic flux is computed based on the sea surface elevation at the Bosphorus mouth; the temperature and salinity of the incoming temperature follow respectively a zero-gradient approach and the salt-conservation law. In NEMO-BAMHBI, the biogeochemical tracer concentrations in the incoming water are either specified or follow a zero-gradient approach.
Assimilation scheme	fixed-base SEEK
Assimilated observations	surface chlorophyll
Initial conditions (spin-up process)	Physical fields: NEMO-BAMHBI model outputs (previous version) Biogeochemistry: NEMO-BAMHBI model outputs (previous version)
Bathymetry	GEBCO 30sec interpolated on the model grid
River run-off	Danube: data from the Romanian Hydrological institute. Other rivers: SESAME / PERSEUS deliverable

The biogeochemical hindcasts and forecasts for the Black Sea are produced by the MAST / ULg Production Unit by means of the NEMO 4.2 3D circulation model online coupled with the BAMHBI biogeochemical model. The workflow runs at the Cenaero (Belgium) Tier-1 supercomputing centre called Lucia. Analysis is produced once a week; forecasts are produced daily.

II.3.1.1 [Production Cycle](#)

BLKSEA_ANALYSISFORECAST_BGC_007_010 analysis and forecast products are updated daily before 17 UTC. The production is composed by: 1 day of hindcast (also referred to as simulation, S) and 10 days of forecast (F). An example of aggregated product is shown in the Figure below.

		days w.r.t. Tuesday of A&F cycle = 1																													
		A&F cycle	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15			
Tuesday	1		A	A	A	A	A	A	A	A	A	H	F	F	F	F	F	F	F	F	F	F							A	PHYS analysis (Sat & Insitu assimil)	
Wednesday	1				A	A	A	A	A	A	A	H	F	F	F	F	F	F	F	F	F	F							H	PHYS hindacast	
Thursday	1											H	F	F	F	F	F	F	F	F	F	F	F						F	PHYS forecast	
Friday	1											H	F	F	F	F	F	F	F	F	F	F	F	F					A	BIO analysis (Sat & Insitu assimil)	
Saturday	1											H	F	F	F	F	F	F	F	F	F	F	F	F					A	BIO analysis (Insitu assimil)	
Sunday	1											H	F	F	F	F	F	F	F	F	F	F	F	F	F				H	BIO hindacast	
Monday	1											H	F	F	F	F	F	F	F	F	F	F	F	F	F				F	BIO forecast	
Tuesday	2				A	A	A	A	A	A	A	A	A	A	A	A	A	H	F	F	F	F	F	F	F	F	F	F	F		
Wednesday	2											A	A	A	A	A	A	A	H	F	F	F	F	F	F	F	F	F	F		

II.3.1.2 [Observational Data](#)

Observational data are assimilated into the system in the weekly analysis. The following data are assimilated: sea surface chlorophyll-a (CHL) observations from the multi-satellite product.

Product: OCEANCOLOUR_BS_CHL_L3_NRT_OBSERVATIONS_009_044

Dataset: dataset-oc-bs-chl-multi-l3-chl_1km_daily-rt-v02

II.4 Grid

The product is delivered on the native NEMO-BAMHBI grid with a horizontal resolution of approx. 2.5 km, and 59 unevenly-spaced z-levels.

II.5 Vertical Levels

The vertical layers are unevenly spaced; the mid-cell depth is given in section II.3



II.6 Processing information

II.6.1 Update Time

Daily datasets are updated daily at 17:00 UTC.

The monthly dataset is updated monthly on the 15th (addition of the monthly mean of the previous month) at 17:00 UTC

II.6.2 Temporal extent of analysis and forecast stored on delivery mechanism

An archive of analysis over the last two years up to real-time is available.

II.6.3 Time averaging

For the monthly dataset, the fields are monthly means over the calendar month (first to last day of the month). For the daily dataset, the fields are daily means over a day (midnight to midnight, centered at noon). For the hourly dataset, the fields are hourly means (60 minutes).

III DOWNLOAD A PRODUCT

After registration, you will be able to download our data. To assist you, our HelpCenter is available, and more specifically its [section about download](#).

Information on operational issues on products and services can be found on our [User Notification Service](#). If you have any questions, please [contact us](#).

IV FILES NOMENCLATURE

IV.1 Nomenclature of files when downloaded through the CMS Web Portal Subsetter Service

BLKSEA_ANALYSISFORECAST_BGC_007_010 files nomenclature when downloaded through the Copernicus Marine Web Portal Subsetter is based on product dataset name and a numerical reference related to the request date on the portal.

The scheme is: **datasetname_nnnnnnnnnnnnn.nc**

where:

- ✓ **datasetname**: as described previously
- ✓ **nnnnnnnnnnnnnn**: 13-digit integer corresponding to the current time (download time) in milliseconds since January 1, 1970 midnight UTC.
- ✓ **.nc**: standard NetCDF filename extension.

Example: cmems_mod_blk_bgc-co2_anfc_3km_PT1H-m_1303461772348.nc

IV.2 Nomenclature of files when downloaded through the CMS Web Portal DirectGetFile or CMS FTP Service

BLKSEA_ANALYSISFORECAST_BGC_007_010 files nomenclature when downloaded through the Copernicus Marine FTP service is based as follows:

{valid date}_{freq flag}-{producer}-{parameter}-{config}-{region}-{bul date}_{product type}-sv{file version}.nc

where

- **valid date** YYYYMMDD is the validity day of the data in the file
- **freq flag** is the frequency of data values in the file (d = daily, m=monthly)
- **producer** is a short version of the Copernicus Marine production unit
- **config** identifies the producing system and configuration
- **region** is a maximum six letter code for the region
- **parameter** is a four-letter code for the parameter or parameter set from Standard BODC.
- **bul date** bYYYYMMDD is the bulletin date the product was produced
- **product type** is a two-letter code for the product type, for example fc for forecast, an for analysis and sm for hindcast.
- **file version** is xx.yy where xx is the Copernicus Marine version and yy is an incremental version number

Table 1 shows the nomenclature for the BLKSEA_ANALYSISFORECAST_BGC_007_010 products.

Table 1 Description of the nomenclature for BLKSEA_ANALYSISFORECAST_BGC_007_010

valid date	YYYYMMDD
freq flag	m (monthly) d (daily)
producer	ULg
config	nemo_bamhbi
region	BLK
parameter	NUTR PFTC BIOL CARB CO2F OPTI
bul date	bYYYYMMDD
product type	fc (forecast) an (analysis) sm (hindcast)
file version	12.00

Example for a forecast file:

20210410_d-ULg--NUTR-nemo_bamhbi-BLK-b20220601_an-sv12.00.nc

This is the mean field of biogeochemistry centered at 12:00 UTC of the 10th April 2021, and the time coverage is from midnight (00:00 UTC) of the 10th April 2021 to midnight (00:00 UTC) of the 11th April 2017 (see section IV.8).

IV.3 Other information: mean centre of Products, land mask value, missing value

The missing value for this product is: 1.e+20

Land mask is equal to “_FillValue” (see variable attribute on NetCDF file).

The BGC forecasts are using the NetCDF4 format without offset nor scale factors.

In the Copernicus Marine online system data from the latest 2 years (running window) are available via these download interfaces: Subsetter and FTP download

IV.4 File size

DATASET NAME	FILE NAME	DIMENSION [MB]
cmems_mod_blk_bgc-co2_anfc_3km_PT1H-m	{date1}_h-ULg--CO2F-nemo_bamhbi-BLK-b{date2}_fc-sv12.00.nc {date1}_h-ULg--CO2F-nemo_bamhbi-BLK-b{date2}_sm-sv12.00.nc {date1}_h-ULg--CO2F-nemo_bamhbi-BLK-b{date2}_an-sv12.00.nc	7.2-36.0
cmems_mod_blk_bgc-nut_anfc_3km_P1D-m	{date1}_d-ULg--NUTR-nemo_bamhbi-BLK-b{date2}_fc-sv12.00.nc {date1}_d-ULg--NUTR-nemo_bamhbi-BLK-b{date2}_sm-sv12.00.nc {date1}_d-ULg--NUTR-nemo_bamhbi-BLK-b{date2}_an-sv12.00.nc	7.5 – 10.0
cmems_mod_blk_bgc-pft_anfc_3km_P1D-m	{date1}_d-ULg--PFTC-nemo_bamhbi-BLK-b{date2}_fc-sv12.00.nc {date1}_d-ULg-- PFTC-nemo_bamhbi-BLK-b{date2}_sm-sv12.00.nc {date1}_d-ULg--PFTC-nemo_bamhbi-BLK-b{date2}_an-sv12.00.nc	7.5 – 10.0
cmems_mod_blk_bgc-bio_anfc_3km_P1D-m	{date1}_d-ULg--BIOL-nemo_bamhbi-BLK-b{date2}_fc-sv12.00.nc {date1}_d-ULg--BIOL-nemo_bamhbi-BLK-b{date2}_sm-sv12.00.nc {date1}_d-ULg--BIOL-nemo_bamhbi-BLK-b{date2}_an-sv12.00.nc	8.2 – 11.5
cmems_mod_blk_bgc-car_anfc_3km_P1D-m	{date1}_d-ULg--CARB-nemo_bamhbi-BLK-b{date2}_fc-sv12.00.nc {date1}_d-ULg--CARB-nemo_bamhbi-BLK-b{date2}_sm-sv12.00.nc {date1}_d-ULg--CARB-nemo_bamhbi-BLK-b{date2}_an-sv12.00.nc	9.0 – 12.0

cmems_mod_blk_bgc-co2_anfc_3km_P1D-m	{date1}_d-ULg--CO2F-nemo_bamhbi-BLK-b{date2}_fc-sv12.00.nc {date1}_d-ULg--CO2F-nemo_bamhbi-BLK-b{date2}_sm-sv12.00.nc {date1}_d-ULg--CO2F-nemo_bamhbi-BLK-b{date2}_an-sv12.00.nc	0.3 – 1.5
cmems_mod_blk_bgc-opt_anfc_3km_P1D-m	{date1}_d-ULg--OPTI-nemo_bamhbi-BLK-b{date2}_fc-sv12.00.nc {date1}_d-ULg--OPTI-nemo_bamhbi-BLK-b{date2}_sm-sv12.00.nc {date1}_d-ULg--OPTI-nemo_bamhbi-BLK-b{date2}_an-sv12.00.nc	9.0-12.0
cmems_mod_blk_bgc-nut_anfc_3km_P1M-m	{date1}_m-ULg--NUTR-nemo_bamhbi-BLK-b{date2}_an-sv12.00.nc	7.5 – 10.0
cmems_mod_blk_bgc-pft_anfc_3km_P1M-m	{date1}_m-ULg--PFTC-nemo_bamhbi-BLK-b{date2}_an-sv12.00.nc	7.5 – 10.0
cmems_mod_blk_bgc-bio_anfc_3km_P1M-m	{date1}_m-ULg--BIOL-nemo_bamhbi-BLK-b{date2}_an-sv12.00.nc	8.2-11.5
cmems_mod_blk_bgc-car_anfc_3km_P1M-m	{date1}_m-ULg--CARB-nemo_bamhbi-BLK-b{date2}_an-sv12.00.nc	9.0 – 12.0
cmems_mod_blk_bgc-car_anfc_3km_P1M-m	{date1}_m-ULg--CO2F-nemo_bamhbi-BLK-b{date2}_an-sv12.00.nc	0.3 – 1.5
cmems_mod_blk_bgc-opt_anfc_3km_P1M-m	{date1}_m-ULg--OPTI-nemo_bamhbi-BLK-b{date2}_an-sv12.00.nc	9.0-12.0
cmems_mod_blk_bgc_anf_c_3km_static	BLK-MFC_007_010_\${field}.nc	18

V FILE FORMAT

V.1 NetCDF

The products are stored using the NetCDF format.

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 (<http://www.unidata.ucar.edu/software/netcdf/>) for more information, and to retrieve netCDF software package.

NetCDF data format 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.

The products are compliant with the NetCDF Climate and Forecast Convention CF-1.4 (see <http://cf-pcmdi.llnl.gov/>).

The BLKSEA_ANALYSISFORECAST_BGC_007_010 product is distributed in netCDF4 format.

V.2 Reader Software

NetCDF data can be browsed and used through a number of software packages, including:

- ✓ ncBrowse: <http://www.epic.noaa.gov/java/ncBrowse/>,
- ✓ NetCDF Operator (NCO): <http://nco.sourceforge.net/>
- ✓ IDL, Matlab, Panoply, GMT...

V.3 Structure and semantic of netCDF maps files

The model output files contain some additional fields in addition to the variables mentioned earlier. An example output NetCDF file header for `cmems_mod_blk_bgc-pft_anfc_3km_P1D-m` is inserted below, with the additional fields in italic fonts.

```
netcdf \20210101_d-ULg--PFTC-nemo_bamhbi-BLK-b20220601_sm-sv12.00 {
```

dimensions:

longitude = 591 ;

latitude = 261 ;

depth = 59 ;

time = UNLIMITED ; // (1 currently) ;

variables:

VI REFERENCES

Quality Information Document (QUID) :
https://catalogue.marine.copernicus.eu/documents/QUID/CMEMS-BLK-QUID-007_010.pdf

Grégoire, M., & Vandenbulcke, L. (2023). Black Sea Biogeochemical Analysis and Forecast (Copernicus Marine Service BLK-Biogeochemistry) (Version 2) [Data set]. Copernicus Marine Service. https://doi.org/10.25423/CMCC/BLKSEA_ANALYSISFORECAST_BGC_007_010