PRODUCT USER MANUAL

for the Black Sea Waves Analysis and Forecast Product

BLKSEA_ANALYSIS_FORECAST_WAV_007_003

Issue: 1.0

Contributors: Arno Behrens, Joanna Staneva, Stefania Ciliberti, Rita Lecci

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CHANGE RECORD

Issue	Date	§	Description of Change	Author	Validated By
1.0	20.11.16	all	First version of PUM doc for Waves prod.	S. Ciliberti	1.0
	13.01.17	all	Revision n.1 of PUM doc for Waves prod	S. Ciliberti	
	16.01.17	all	Revision n.2 of PUM doc for Waves prod	J. Staneva	
	18.01.17	all	Final version	S. Ciliberti, A. Behrens, J. Staneva	
1.1	21.01.19	all	General revision in the framework of Q2/2019 and addition of static files description	R. Lecci, A. Behrens, J. Staneva	C. Derval

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GLOSSARY AND ABBREVIATIONS

BS	Black Sea
CF	Climate Forecast (convention for NetCDF)
CLS	Collecte Localisation Satellites
CMAP	CPC Merged Analysis of *Precipitation*
CMEMS	Copernicus Marine Environment Monitoring Service
CTD	Conductivity Temperature Depth
DAC	Dynamic Atmospheric Correction
DGF	DirectGetFile
DirectGetFile	CMEMS service tool (FTP like) to download a NetCDF file
ECMWF	European Centre for Medium-Range Weather Forecasts
EOF	Empirical Orthogonal Function
FAQ	Frequently Asked Question
FTP	File Transfer Protocol
HZG	Helmholtz-Zentrum Geesthacht
Meridional Velocity	South to North component of the horizontal velocity vector
MFC	Monitoring and Forecasting Centre
NEMO	Nucleous for European Modelling of the Ocean
NetCDF	Network Common Data Form
NOAA	*National Oceanic and Atmospheric Administration*
OA	Objective Analyses
OCEANVAR	Oceanographic variational data assimilation scheme developed at INGV/CMCC.
OGCM	Ocean General Circulation Model
OpenDAP	Open-Source Project for a Network Data Access Protocol. Protocol to download subset of data from a n-dimensional gridded dataset (ie: 4 dimensions: lon-lat,depth,time)

OSI	Ocean and Sea Ice
PU	Production Unit
Subsetter	CMEMS service tool to download a NetCDF file of a selected geographical box using values of longitude and latitude, and time range
TAC	Thematic Assembly Centre
WW3	WaveWatch-III
Zonal Velocity	West to East component of the horizontal velocity vector

I INTRODUCTION

I.1 Summary

This document is the user manual for the CMEMS analysis and forecast product **BLKSEA_ANALYSIS_FORECAST_WAV_007_003**. It provides aggregated simulations updated daily with 10-day forecast. An archive of simulations since 01/01/2016 up to real-time is available on the CMEMS server.

The wave products are the integrated parameters computed from the total wave spectrum (significant wave height, period, direction, Stokes drift,...etc), as well as the following partitions: the wind wave, the primary swell wave and the secondary swell wave.

The product is organised in 2 datasets:

- **bs-hzg-wav-an-fc-h** containing hourly instantaneous values for all the variables;
- **BLKSEA_ANALYSIS_FORECAST_WAV_007_003-statics** containing the coordinates, mask and bathymetry

The product is published on the CMEMS dissemination server after automatic and human quality controls. Product is available on-line and disseminated through the CMEMS Information System. Files downloaded are in NetCDF format.

The simulation and forecasting system is described in the Quality Information Document (QUID): http://cmems-resources.cls.fr/documents/QUID/CMEMS-BS-QUID-007-003.pdf.
More detailed information can be obtained from http://marine.copernicus.eu/services-portfolio/contact-us/. See also News flash.

I.2 History of changes

- V1.0 for the EIS in Apr 2017
  - In Jan 2019, adding the description of static files

II HOW TO DOWNLOAD A PRODUCT

II.1 Download a product through the CMEMS Web Portal Subsetter Service

You first need to register. Please find below the registration steps:

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

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 Service.

II.2 Download a product through the CMEMS Web Portal Ftp Service

You first need to register. Please find below the registration steps:

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

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 FTP Service.

II.3 Download a product through the CMEMS Web Portal Direct Get File Service

You first need to register. Please find below the registration steps:

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

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 Direct Get File (DGF) Service.

III DESCRIPTION OF THE PRODUCT SPECIFICATION

III.1 General Information

Table 1 provides information about forecast/analysis products.

Table 1 BLKSEA_ANALYSIS_FORECAST_WAV_007_003 Product Specification

Product Specification	**BLKSEA_ANALYSIS_FORECAST_WAV_007_003**
Geographical coverage	27.37°E → 41.96°E ; 40.86°N → 46.80°N
Variables	Spectral significant wave height Spectral moments (-1,0) wave period Spectral moments (0,2) wave period Wave period at spectral peak / peak period Mean wave direction from Wave principal direction at spectral peak Stokes drift U Stokes drift V Spectral significant wind wave height Spectral moments (0,1) wind wave period Mean wind wave direction from Spectral significant primary swell wave height Spectral moments (0,1) primary swell wave period Mean primary swell wave direction from Spectral significant secondary swell wave height Spectral moments (0,1) secondary swell wave period Mean secondary swell wave direction from
Analysis	No
Hindcast	Yes
Forecast	Yes
Available time series	01/01/2016-ongoing
Temporal resolution	1hr instantaneous field

Target delivery time	Forecast : daily, 00:00 UTC of the day+1 from the nominal start of the forecast Simulation: daily, 00:00 UTC of the day+1 from the nominal start of the forecast
Delivery mechanism	CMEMS Information System (Subsetter, CMEMS FTP, DGF)
Horizontal resolution	About 3 km (1/36° zonal resolution, 1/27° meridional resolution)
Number of vertical levels	surface only
Format	Netcdf 3.0 CF1.0

Detailed information on the systems and products are on CMEMS web site: http://marine.copernicus.eu

III.2 Production subsystem description

III.2.1 Brief overview

The third generation spectral wave model WAM Cycle 4.6 has been adapted to the Black Sea area und runs successfully on the Sun-Cluster at HZG. The shallow water version is implemented on a spherical grid with a spatial resolution of about 3 km (133 * 100 sec) with 24 directional and 30 frequency bins. The number of active wave model grid points is 44699. The model takes into account depth refraction and wave breaking and provides currently a three days forecast with one-hourly output once a day. The atmospheric forcing is taken from tessa.cmcc.it in NetCDF and locally (on ocean.hzg.de) transformed into WAM format forcing, following the PQWG metrics definitions. Detailed description.

III.2.2 Detailed description

The wave model used is the well-established advanced third generation spectral wave model WAM that runs successfully at many institutions worldwide. It is based on the spectral description of the wave conditions in frequency and directional space at each of the active model sea grid points of a certain model area. The energy balance equation, complemented with a suitable description of the relevant physical processes is used to follow the evolution of each wave spectral component. WAM computes the two dimensional wave variance spectrum through integration of the transport equation (1) in spherical coordinates:

$$\frac{\partial F}{\partial t}+(\cos\phi)^{-1}\frac{\partial}{\partial\phi}\left(\dot{\phi}\cos\phi F\right)+\frac{\partial}{\partial\lambda}\left(\dot{\lambda}F\right)+\sigma\frac{\partial}{\partial\sigma}\left(\dot{\sigma}\frac{F}{\sigma}\right)+\frac{\partial}{\partial\theta}\left(\dot{\theta}F\right)=S \qquad (1)$$

with:

$F(\lambda,\phi,\sigma,\theta,t)$ wave energy density spectrum

$$\dot{\phi}=\left(c_g\cos\theta+u_{North}\right)/R$$

$$\dot{\lambda}=\left(c_g\sin\theta+u_{\quad}\right)/(R\cos\phi)$$

(λ, ϕ) longitude, latitude

(σ, θ) intrinsic frequency, wave direction

The first term of (1) describes the local rate of change of energy density in time, the second and third ones the propagation in geographical space, the fourth one the shifting of the relative frequency due to variations in depths and currents and the last one on the left side of the equation the contribution of the depth- and current-induced refraction. The source functions on the right of the transport equation comprise the contributions of wind input (Sin), nonlinear interaction (Snl), dissipation (Sdis), bottom friction (Sbf) and wave breaking (Sbr) :

S = Sin + Snl + Sds + Sbf + Sbr

A detailed description is given by the WAMDI group (1988), Komen et al. (1994), Günther et al. (1992) and Janssen (2008). The WAM Cycle 4.5.4 that is used for the Black Sea wave hindcast is an update of the former WAM Cycle 4. The basic physics and numerics are kept in that new release. The source function integration scheme made by Hersbach and Janssen (1999), and the model updates by Bidlot et al. (2007) are incorporated.

The regional wave model for the semi-enclosed Black Sea runs in shallow water mode on a model grid situated between 40°51'36" N to 046°48'16" N and 27°22'12" E to 41°57'45" E, with a spatial resolution of about 3 km, also 100 seconds in latitude, respectively 133 seconds in longitude. The required bathymetry for the model grid bases upon the General Bathymetric Chart of the Oceans (GEBCO, http://www.gebco.net). The model area and the corresponding depth distribution are shown in Figure 1.

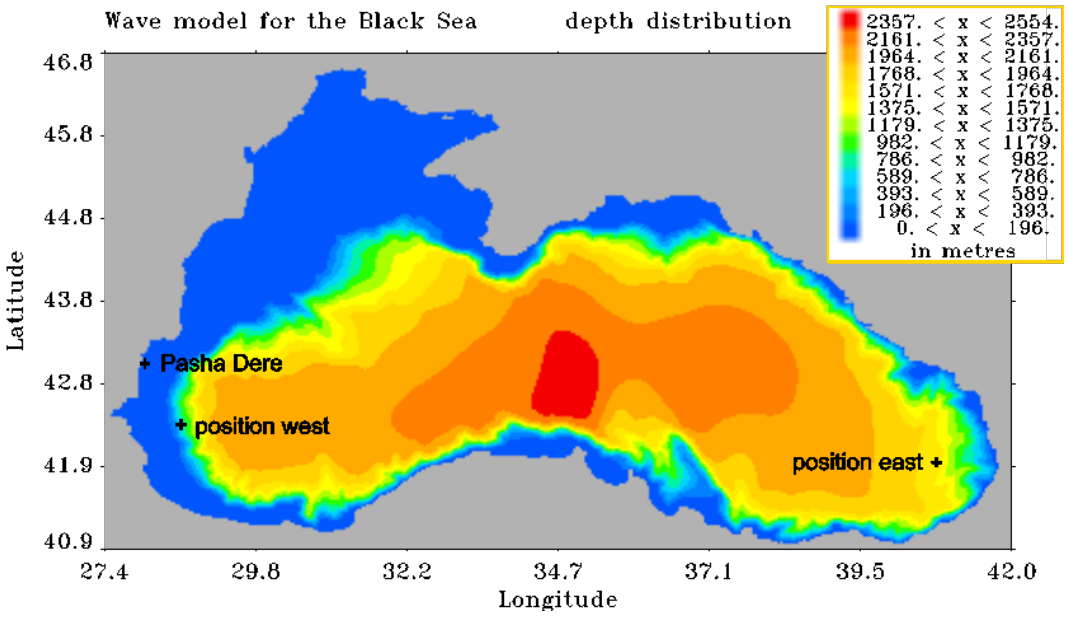

Figure 1: Black Sea depth distribution

WAM calculates the two-dimensional energy density spectrum at each of the 44699 active model grid points in the frequency and directional space. The solution of the energy balance equation is provided for 36 directional bands at 10° each, starting at 5° and measured clockwise with respect to

true north, and 30 frequencies logarithmically spaced from 0.042 Hz to 0.66 Hz at intervals of Δf/f = 0.1.

The driving force for the wave model are the six-hourly analysed U10 wind fields provided by the atmospheric model of the ECMWF (European Centre for Medium-Range Weather Forecasts) which is the hydrostatic version of the IFS (Integrated Forecasting System) that runs operational at the ECMWF on a reduced Gaussian grid with a spatial resolution of 0.25° * 0.25° for the considered time period. A detailed description of the system is given in the official IFS documentation of the ECMWF (ECMWF, 2015).

Time dependent depth and current fields are not used in this version whereas depth refraction as well as wave breaking has been taken into account.

III.2.3 Processing information

A schematic description on the characteristics of the BS-WAV operational chain is presented in Figure 2.

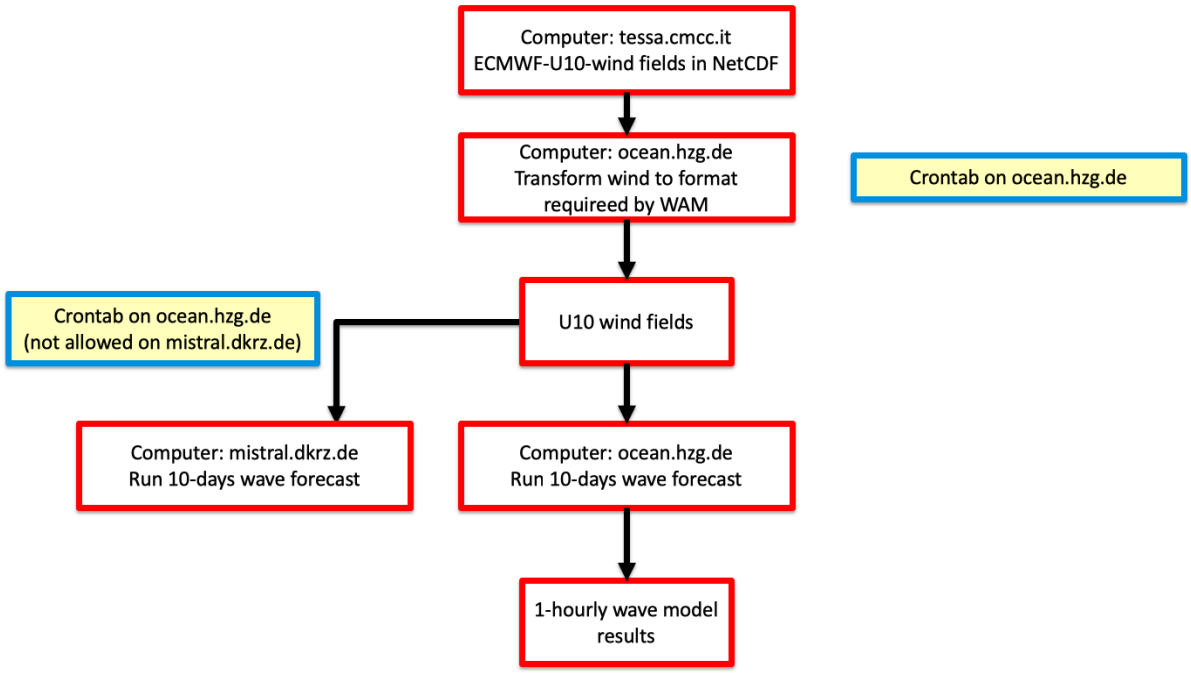

Figure 2: BS-WAV processing information

III.3 Details of datasets

Table 2 List of the variables for each dataset and their names in the NetCDF

BLKSEA_ANALYSIS_FORECAST_WAV_007_003

DATASETS	VARIABLES AND UNITS	NAME OF VARIABLES IN THE NETCDF FILE
bs-hzg-wav-an-fc-h	Spectral significant wave height [m]	VHM0
	Spectral moments (-1,0) wave period [s]	VTM10
	Spectral moments (0,2) wave period [s]	VTM02
	Wave period at spectral peak / peak period [s]	VTPK
	Mean wave direction from [degree]	VMDR
	Wave principal direction at spectral peak [degree]	VPED
	Stokes drift U [ms-1]	VSDX
	Stokes drift V [ms-1]	VSDY
	Spectral significant wind wave height [m]	VHM0_WW
	Spectral moments (0,1) wind wave period [s]	VTM01_WW
	Mean wind wave direction from [degree]	VMDR_WW
	Spectral significant primary swell wave height [m]	VHM0_SW1
	Spectral moments (0,1) primary swell wave period [s]	VTM01_SW1
	Mean primary swell wave direction from [degree]	VMDR_SW1
	Spectral significant secondary swell wave height [m]	VHM0_SW2
	Spectral moments (0,1) secondary swell wave period [s]	VTM01_SW2
	Mean secondary swell wave direction from [degree]	VMDR_SW2
BLKSEA_ANALYSIS_FORECAST_WAV_007_003-statics	Cell dimension along X axis [m]	e1t
	Cell dimension along Y axis [m]	e2t
	Land-sea mask: 1 = sea ; 0 = land [1]	mask
	Bathymetry [m]	deptho

IV NOMENCLATURE OF FILES

The nomenclature of the downloaded files differs on the basis of the chosen download mechanism **Subsetter**,**MFTP** or **DGF** service.

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

BLKSEA_ANALYSIS_FORECAST_WAV_007_003 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 CIS.

The scheme is: **datasetname_nnnnnnnnnnnn.nc**

where :

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

- bs-hzg-wav-an-fc-h

. nnnnnnnnnnnn: 13 digit integer corresponding to the current time (download time) in milliseconds since January 1, 1970 midnight UTC.

.nc: standard NetCDF filename extension.

The fields **height/period/direction/ww/sw1/sw2** are respectively for the variable of spectral significant wave height (**VHM0**), spectral moments (0,2) wave period (**VTM10**), spectral moments (-1,0) wave period (**VTM02**), wave period at spectral peak/peak period (**VTPK**), mean wave direction from (Mdir) (**VMDR**), wave principal direction at spectral peak (**VPED**), Stokes drift U (**VSDX**), Stokes drift V (**VSDY**), spectral significant wind wave height (**VHM0_WW**), spectral moments (0,1) wind wave period (**VTM01_WW**), mean wind wave direction from (**VMDR_WW**), spectral significant primary swell wave height (**VHM0_SW1**), spectral moments (0,1) primary swell wave period (**VTM01_SW1**), mean primary swell wave direction from (**VMDR_SW1**), spectral significant secondary swell wave height (**VHM0_SW2**), spectral moments (0,1) secondary swell wave period (**VTM01_SW2**), m and secondary swell wave direction from (**VMDR_SW2**).

Example for a file of wave height:

`bs-hzg-wav-an-fc-h_1303461772348.nc`

IV.2 Nomenclature of files when downloaded through the CMEMS FTP Service

BLKSEA_ANALYSIS_FORECAST_WAV_007_003 files nomenclature when downloaded through CMEMS FTP is based as follows:

{valid date}_{freq flag}-{producer}--{parameter}-{config}-{region}-{bul date}_{producttype}-fv{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 (h = hourly, d = daily)
- **producer** is a short version of the CMEMS production unit
- **config** identifies the producing system and configuration
- **region** is a two 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 CMEMS version (06, 07 or 08) and yy is an incremental version number

Table 3 shows the nomenclature for the BLKSEA_ANALYSIS_FORECAST_WAV_007_003 products.

Table 3 Description of the nomenclature for BLKSEA_ANALYSIS_FORECAST_WAV_007_003

valid date	YYYYMMDD
freq flag	h (hourly)
producer	HZG
config	BSeas3
region	BS
parameter	WAVES
bul date	bYYYYMMDD
product type	fc (forecast) sm (hindcast)
file version	07.00

Example for a forecast file of wave height:

`20161001_h-HZG--WAVES-BSeas3-BS-b20140306_fc-fv07.00.nc`

This file contains the 24 hourly instantaneous fields of wave height, each one centered at 30' of every hour from noon (12:00 UTC) of the 30th September 2016 to noon (12:00 UTC) of the 1st October 2016 (see section IV.9).

IV.3 Nomenclature of files when downloaded through the CMEMS DGF Service

BLKSEA_ANALYSIS_FORECAST_WAV_007_003 files nomenclature when downloaded through the CMEMS Web Portal DGF is based on product dataset name and a numerical reference related to the request date on the CIS.

The scheme is:

datasetname_nnnnnnnnnnnn.zip

where :

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

- bs-hzg-waves-an-fc-h

.nnnnnnnnnnnn: 13 digit integer corresponding to the current time (download time) in milliseconds since January 1, 1970 midnight UTC.

The fields **height/period/direction/ww/sw1/sw2** are respectively for the variable of spectral significant wave height (**VHM0**), spectral moments (0,2) wave period (**VTM10**), spectral moments (-1,0) wave period (**VTM02**), wave period at spectral peak/peak period (**VTPK**), mean wave direction from (Mdir) (**VMDR**), wave principal direction at spectral peak (**VPED**), Stokes drift U (**VSDX**), Stokes drift V (**VSDY**), spectral significant wind wave height (**VHM0_WW**), spectral moments (0,1) wind wave period (**VTM01_WW**), mean wind wave direction from (**VMDR_WW**), spectral significant primary swell wave height (**VHM0_SW1**), spectral moments (0,1) primary swell wave period (**VTM01_SW1**), mean primary swell wave direction from (**VMDR_SW1**), spectral significant secondary swell wave height (**VHM0_SW2**), spectral moments (0,1) secondary swell wave period (**VTM01_SW2**), m ean secondary swell wave direction from (**VMDR_SW2**).

Example:

`bs-hzg-wav-an-fc-h_1303461772348.nc`

The zip file contains one or more files, depending on the number of selected days, whose name is

{valid date}_{freq flag}-{producer}--{parameter}-{config}-{region}-{bul date}_{product type}-fv{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, h= hourly)
- **producer** is a short version of the CMEMS production unit
- **config** identifies the producing system and configuration.
- **region** is a two 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 CMEMS version (06, 07 and 08) and yy is an incremental version number

Table 4 shows the nomenclature for the BLKSEA_ANALYSIS_FORECAST_WAV_007_003 products.

Table 4 Description of the nomenclature for BLKSEA_ANALYSIS_FORECAST_WAV_007_003

valid date	YYYYMMDD

freq flag	h (hourly)
producer	HZG
config	BSeas3
region	BS
parameter	WAVES
bul date	bYYYYYMMDD
product type	fc (forecast) sm (hindcast)
file version	07.00

Example for a forecast file of wave height:

`20161001_h-HZG--WAVES-BSeas3-BS-b20140306_fc-fv07.00.nc`

This file contains the 24 hourly instantaneous fields of height, each one centered at 30' of every hour from noon (12:00 UTC) of the 30th September 2016 to noon (12:00 UTC) of the 1st October 2016 (see section IV.9).

IV.4 Grid

The horizontal grid step is regular in latitude and longitude with a resolution of 1/36° x 1/27° of degree (~3 Km).

In Table 5 there is the description of the grid and the spatial coverage for each variable for the BLKSEA_ANALYSIS_FORECAST_WAV_007_003 products.

Table 5: Description of grid and spatial coverage

BLKSEA_ANALYSIS_FORECAST_WAV_007_003							
VARIABLE	LON MIN	LON MAX	LAT MIN	LAT MAX	XPOINT	YPOINT	ZPOINT
Spectral significant wave height (Hm0)	27.37°E	41.96°E	40.86°N	46.80°N	215	395	1
Spectral moments (-1,0) wave period (Tm-10)	27.37°E	41.96°E	40.86°N	46.80°N	215	395	1
Spectral moments (0,1) wave period	27.37°E	41.96°E	40.86°N	46.80°N	215	395	1

(Tm01)							
Spectral moments (0,2) wave period (Tm02)	27.37°E	41.96°E	40.86°N	46.80°N	215	395	1
Wave period at spectral peak / peak period (Tp)	27.37°E	41.96°E	40.86°N	46.80°N	215	395	1
Mean wave direction from (Mdir)	27.37°E	41.96°E	40.86°N	46.80°N	215	395	1
Wave principal direction at spectral peak	27.37°E	41.96°E	40.86°N	46.80°N	215	395	1
Stokes drift U	27.37°E	41.96°E	40.86°N	46.80°N	215	395	1
Stokes drift V	27.37°E	41.96°E	40.86°N	46.80°N	215	395	1
Spectral significant wind wave height	27.37°E	41.96°E	40.86°N	46.80°N	215	395	1
Spectral moments (0,1) wind wave period	27.37°E	41.96°E	40.86°N	46.80°N	215	395	1
Mean wind wave direction from	27.37°E	41.96°E	40.86°N	46.80°N	215	395	1
Spectral significant primary swell wave height	27.37°E	41.96°E	40.86°N	46.80°N	215	395	1
Spectral moments (0,1) primary swell wave period	27.37°E	41.96°E	40.86°N	46.80°N	215	395	1
Mean primary swell wave direction from	27.37°E	41.96°E	40.86°N	46.80°N	215	395	1

IV.5 Domain coverage

The blue area in Figure 3 represents the spatial coverage of the BLKSEA_ANALYSIS_FORECAST_WAV_007_003 products.

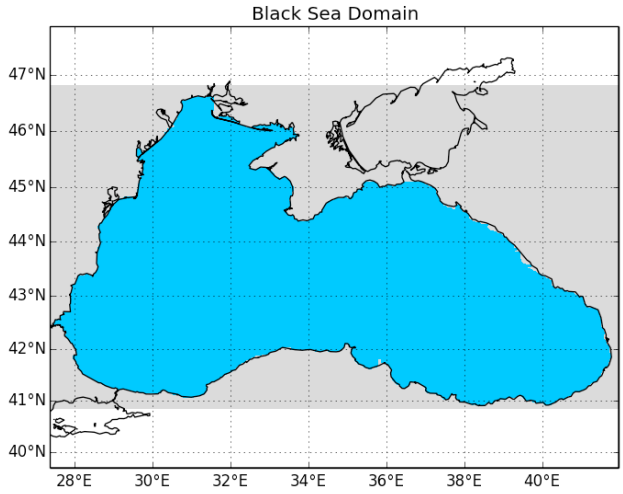

Figure 3: Spatial coverage of the BLKSEA_ANALYSIS_FORECAST_WAV_007_003 products (blue zone)

Grid type is the following standard projection:

Regular projection: longitude and latitude step is constant	

IV.6 Vertical Levels

IV.7 Update Time

BLKSEA_ANALYSIS_FORECAST_WAV_007_003 products: the forecast fields and the simulation fields are updated daily at 00:00 UTC.

IV.8 Temporal extend of analysis and forecast stored on delivery mechanism

BLKSEA_ANALYSIS_FORECAST_WAV_007_003 products temporal coverage: for the hourly instantaneous fields, every day J is available a time series starting from 01/01/2016 to the day J+10. Every day, the time series is updated 1-day of simulation and 10-days of forecast.

For the hourly instantaneous fields, every day J is available a time series starting from D-30, implemented as a rolling archive.

IV.9 Other information: mean centre of products, missing value, production chain and file dimension

IV.9.1 Mean Centre of Products

BLKSEA_ANALYSIS_FORECAST_WAV_007_003 hourly hindcast/forecast products as instantaneous fields are centered at midnight (00:00 UTC) of J. The time series starts from 01/01/2016-ongoing.

IV.9.2 Missing Value

The **missing value** for the BLKSEA_ANALYSIS_FORECAST_WAV_007_003 products is 1e+20.

IV.9.3 Production Chain

BLKSEA_ANALYSIS_FORECAST_WAV_007_003 production chain is represented in **Figure 4**.

Figure 4: BS-WAV Production Chain

IV.9.4 File Dimension

Table 6 describes the dimensions of the files for simulation and forecast for one day.

Table 6: Names and dimensions of the files

DATASET NAME	NAME OF FILE	DIMENSION [MB]
bs-hzg-wav-an-fc-h	{date1}_h-HZG--WAVES-BSeas3-BS-b{date2}_fc-fv07.00.nc {date1}_h-HZG-- WAVES -BSeas3-BS-b{date2}_sm-fv07.00.nc	264
BLKSEA_ANALYSIS_FORECAST_WAV_007_003-statics	BS-MFC_007_003_${field}.nc	1

Table 7 describes the dimensions of the entire time series 2016-2018 for the given dataset.

Table 7: Names and dimensions of the entire datasets (2016/01/01-2018/12/31)

DATASET NAME	DIMENSION [MB]
bs-hzg-wav-an-fc-h	144672.0
BLKSEA_ANALYSIS_FORECAST_WAV_007_003-statics	1

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 UnidataNetCDF 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.2 Structure and semantic of NetCDF maps files

Table 8: Dimensions and variables included in the files NetCDF of BLKSEA_ANALYSIS_FORECAST_WAV_007_003

DIMENSIONS	VARIABLES		
lon=395 lat=215 time=1	**NAME**	**DIMENSIONS**	**TYPE**
	Lon	lon	float
	Lat	lat	float
	Time	time	int

	VHM0	time,lat,lon	float
	VTM10	time,lat,lon	float
	VTM02	time,lat,lon	float
	VTPK	time,lat,lon	float
	VMDR	time,lat,lon	float
	VPED	time,lat,lon	float
	VSDX	time,lat,lon	float
	VSDY	time,lat,lon	float
	VHM0_WW	time,lat,lon	float
	VTM01_WW	time,lat,lon	float
	VMDR_WW	time,lat,lon	float
	VHM0_SW1	time,lat,lon	float
	VTM01_SW1	time,lat,lon	float
	VMDR_SW1	time,lat,lon	float
	VHM0_SW2	time,lat,lon	float
	VTM01_SW2	time,lat,lon	float
	VMDR_SW2	time,lat,lon	float

For 20160401_h-HZG--WAVES-BSeas3-BS-b20160402_fc-fv07.00.nc

netcdf \20160401_h-HZG--WAVES-BSeas3-BS-b20160402_fc-fv07.00.{

dimensions:

lat = 215 ;

lon = 395 ;

time = UNLIMITED ; // (24 currently)

variables:

float lat(lat) ;

lat:units = "degrees_north" ;

lat:long_name = "latitude" ;

lat:standard_name = "latitude" ;

lat:axis = "Y" ;

lat:valid_max = 46.80458f;

lat:valid_min = 40.86015f;

float lon(lon) ;

lon:units = "degrees_east" ;

lon:long_name = "longitude" ;

lon:standard_name = "longitude" ;

lon:axis = "X" ;

lon:valid_max = 41.96229f;

lon:valid_min = 27.37007f;

int time(time) ;

time:units = "seconds since 1970-01-01 00:00:00" ;

time:calendar = "standard" ;

time:long_name = "time" ;

time:standard_name = "time" ;

time:axis = "T" ;

float VHM0(time, lat, lon) ;

VHM0:standard_name = "sea_surface_wave_significant_height" ;

VHM0:long_name = "Spectral significant wave height (Hm0)" ;

VHM0:units = "m" ;

VHM0:_FillValue = 1.e+20f ;

VHM0:valid_min = 0.f ;

VHM0:valid_max = 20.f ;

VHM0:missing_value = 1.e+20f ;

VHM0:Coordinates = "time lat lon" ;

float VTPK(time, lat, lon) ;

VTPK:standard_name = "sea_surface_wave_period_at_variance_spectral_density_maximum" ;

VTPK:long_name = "Wave period at spectral peak / peak period (Tp)" ;

VTPK:units = "s" ;

VTPK:_FillValue = 1.e+20f ;

VTPK:valid_min = 1.f ;

VTPK:valid_max = 30.f ;

VTPK:missing_value = 1.e+20f ;

VTPK:Coordinates = "time lat lon" ;

float VTM10(time, lat, lon) ;

VTM10:standard_name = "sea_surface_wave_mean_period_from_variance_spectral_density_inverse_frequency_moment" ;

VTM10:long_name = "Spectral moments (-1,0) wave period (Tm-10)" ;

VTM10:units = "s" ;

VTM10:_FillValue = 1.e+20f ;

VTM10:valid_min = 1.f ;

VTM10:valid_max = 20.f ;

VTM10:missing_value = 1.e+20f ;

VTM10:Coordinates = "time lat lon" ;

float VTM02(time, lat, lon) ;

VTM02:standard_name = "sea_surface_wave_mean_period_from_variance_spectral_density_second_frequency_moment" ;

VTM02:long_name = "Spectral moments (0,2) wave period (Tm02)" ;

VTM02:units = "s" ;

VTM02:_FillValue = 1.e+20f ;

VTM02:valid_min = 1.f ;

VTM02:valid_max = 20.f ;

VTM02:missing_value = 1.e+20f ;

VTM02:Coordinates = "time lat lon" ;

float VMDR(time, lat, lon) ;

VMDR:standard_name = "sea_surface_wave_from_direction" ;

VMDR:long_name = "Mean wave direction from (Mdir)" ;

VMDR:units = "degree" ;

VMDR:_FillValue = 1.e+20f ;

VMDR:valid_min = 0.f ;

VMDR:valid_max = 360.f ;

VMDR:missing_value = 1.e+20f ;

VMDR:Coordinates = "time lat lon" ;

float VHM0_WW(time, lat, lon) ;

VHM0_WW:standard_name = "sea_surface_wind_wave_significant_height" ;

VHM0_WW:long_name = "Spectral significant wind wave height" ;

VHM0_WW:units = "m" ;

VHM0_WW:_FillValue = 1.e+20f ;

VHM0_WW:valid_min = 0.f ;

VHM0_WW:valid_max = 20.f ;

VHM0_WW:missing_value = 1.e+20f ;

VHM0_WW:Coordinates = "time lat lon" ;

float VHM01_WW(time, lat, lon) ;

VHM01_WW:standard_name = "sea_surface_wind_wave_mean_period" ;

VHM01_WW:long_name = "Spectral moments (0,1) wind wave period" ;

VHM01_WW:units = "s" ;

VHM01_WW:_FillValue = 1.e+20f ;

VHM01_WW:valid_min = 1.f ;

VHM01_WW:valid_max = 20.f ;

VHM01_WW:missing_value = 1.e+20f ;

VHM01_WW:Coordinates = "time lat lon" ;

float VMDR_WW(time, lat, lon) ;

VMDR_WW:standard_name = "sea_surface_wind_wave_from_direction" ;

VMDR_WW:long_name = "Mean wind wave direction from" ;

VMDR_WW:units = "degree" ;

VMDR_WW:_FillValue = 1.e+20f ;

VMDR_WW:valid_min = 0.f ;

VMDR_WW:valid_max = 360.f ;

VMDR_WW:missing_value = 1.e+20f ;

VMDR_WW:Coordinates = "time lat lon" ;

float VHM0_SW1(time, lat, lon) ;

VHM0_SW1:standard_name = "sea_surface_primary_swell_wave_significant_height"
;

VHM0_SW1:long_name = "Spectral significant primary swell wave height" ;

VHM0_SW1:units = "m" ;

VHM0_SW1:_FillValue = 1.e+20f ;

VHM0_SW1:valid_min = 0.f ;

VHM0_SW1:valid_max = 20.f ;

VHM0_SW1:missing_value = 1.e+20f ;

VHM0_SW1:Coordinates = "time lat lon" ;

float VTM01_SW1(time, lat, lon) ;

VTM01_SW1:standard_name = "sea_surface_primary_swell_wave_mean_period" ;

VTM01_SW1:long_name = "Spectral moments (0,1) primary swell wave period" ;

VTM01_SW1:units = "s" ;

VTM01_SW1:_FillValue = 1.e+20f ;

VTM01_SW1:valid_min = 1.f ;

VTM01_SW1:valid_max = 25.f ;

VTM01_SW1:missing_value = 1.e+20f ;

VTM01_SW1:Coordinates = "time lat lon" ;

float VMDR_SW1(time, lat, lon) ;

VMDR_SW1:standard_name = "sea_surface_primary_swell_wave_from_direction" ;

VMDR_SW1:long_name = "Mean primary swell wave direction from" ;

VMDR_SW1:units = "degree" ;

VMDR_SW1:_FillValue = 1.e+20f ;

VMDR_SW1:valid_min = 0.f ;

VMDR_SW1:valid_max = 360.f ;

VMDR_SW1:missing_value = 1.e+20f ;

VMDR_SW1:Coordinates = "time lat lon" ;

float VHM0_SW2(time, lat, lon) ;

VHM0_SW2:standard_name = "sea_surface_secondary_swell_wave_significant_height" ;

VHM0_SW2:long_name = "Spectral significant secondary swell wave height" ;

VHM0_SW2:units = "m" ;

VHM0_SW2:_FillValue = 1.e+20f ;

VHM0_SW2:valid_min = 0.f ;

VHM0_SW2:valid_max = 20.f ;

VHM0_SW2:missing_value = 1.e+20f ;

VHM0_SW2:Coordinates = "time lat lon" ;

float VTM01_SW2(time, lat, lon) ;

VTM01_SW2:standard_name = "sea_surface_secondary_swell_wave_mean_period" ;

VTM01_SW2:long_name = "Spectral moments (0,1) secondary swell wave period" ;

VTM01_SW2:units = "s" ;

VTM01_SW2:_FillValue = 1.e+20f ;

VTM01_SW2:valid_min = 1.f ;

VTM01_SW2:valid_max = 25.f ;

VTM01_SW2:missing_value = 1.e+20f ;

VTM01_SW2:Coordinates = "time lat lon" ;

float VMDR_SW2(time, lat, lon) ;

VMDR_SW2:standard_name = "sea_surface_secondary_swell_wave_from_direction" ;

VMDR_SW2:long_name = "Mean secondary swell wave direction from" ;

VMDR_SW2:units = "degree" ;

VMDR_SW2:_FillValue = 1.e+20f ;

VMDR_SW2:valid_min = 0.f ;

VMDR_SW2:valid_max = 360.f ;

VMDR_SW2:missing_value = 1.e+20f ;

VMDR_SW2:Coordinates = "time lat lon" ;

float VPED(time, lat, lon) ;

VPED:standard_name = "sea_surface_wave_from_direction_at_spectral_peak" ;

VPED:long_name = "Wave principal direction at spectral peak" ;

VPED:units = "degree" ;

VPED:_FillValue = 1.e+20f ;

VPED:valid_min = 0.f ;

VPED:valid_max = 360.f ;

VPED:missing_value = 1.e+20f ;

VPED:Coordinates = "time lat lon" ;

float VSDX(time, lat, lon) ;

VSDX:standard_name = "sea_surface_wave_stokes_drift_x_velocity" ;

VSDX:long_name = "Stokes drift U" ;

VSDX:units = "m/s" ;

VSDX:_FillValue = 1.e+20f ;

VSDX:valid_min = -1.f ;

VSDX:valid_max = 1.f ;

VSDX:missing_value = 1.e+20f ;

VSDX:Coordinates = "time lat lon" ;

float VSDY(time, lat, lon) ;

VSDY:standard_name = "sea_surface_wave_stokes_drift_y_velocity" ;

VSDY:long_name = "Stokes drift V" ;

VSDY:units = "m/s" ;

VSDY:_FillValue = 1.e+20f ;

VSDY:valid_min = -1.f ;

VSDY:valid_max = 1.f ;

VSDY:missing_value = 1.e+20f ;

VSDY:Coordinates = "time lat lon" ;

// global attributes:

:bulletin_type = "forecast" ;

:institution = "Helmholtz Centre for Coastal Research - Geesthacht, Germany" ;

:source = "WAM Cycle 4.6" ;

:contact = "servicedesk.cmems@mercator-ocean.eu" ;

:references = "Please check in CMEMS catalogue the INFO section for product BLKSEA_ANALYSIS_FORECAST_WAV_007_003 - http://marine.copernicus.eu" ;

:comment = "Please check in CMEMS catalogue the INFO section for product BLKSEA_ANALYSIS_FORECAST_WAV_007_003 - http://marine.copernicus.eu" ;

:Conventions = "CF-1.0" ;

:bulletin_date = "20160402" ;

:field_type = "hourly_instantaneous_at_time_field" ;

:title = "Wave Products (2D) – Instantaneous Field " ;

}

V.3 Reading software

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

- ✓ ncBrowse: http://www.epic.noaa.gov/java/ncBrowse/,
- ✓ NetCDF Operator (NCO): http://nco.sourceforge.net/
- ✓ Net CDF Climata Data Operators (CDO): https://code.zmaw.de/projects/cdo
- ✓ IDL, Matlab, GMT…

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