COPERNICUS MARINE ENVIRONMENT MONITORING SERVICE

MED MFC
CMEMS ELEMENT

PRODUCT USER MANUAL

For Mediterranean Sea Waves Hindcast Product MEDSEA_HINDCAST_WAV_006_012

Reference: CMEMS-MED-PUM-006-012

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CHANGE RECORD

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TABLE OF CONTENTS

I Introduction *5*

I.1 Summary 5

I.2 History of Changes 5

II How to download a product *6*

II.1 Download a product through the CMEMS Web Portal Subsetter Service 6

II.2 Download a product through the CMEMS Web Portal Ftp Service 6

II.3 Download a product through the CMEMS Web Portal Direct Get File Service 6

III Description of the product specification *7*

III.1 General Information 7

III.2 Production subsystem description 8

III.2.1 Brief overview 8

III.2.2 Detailed description 8

III.2.3 Processing information 9

III.3 Details of datasets 9

IV Nomenclature of files *11*

IV.1 Nomenclature of files when downloaded through the CMEMS Web Portal Subsetter Service 11

IV.2 Nomenclature of files when downloaded through the CMEMS FTP Service 11

IV.3 Nomenclature of files when downloaded through the CMEMS DGF Service 12

IV.4 Grid 14

IV.5 Domain coverage 15

IV.6 Temporal extend of hindcast stored on delivery mechanism 15

IV.7 Other information: mean centre of Products, missing value, production chain and file dimension 16

IV.7.1 Mean Centre of Products 16

IV.7.2 Missing Value 16

IV.7.3 Production Chain 16

IV.7.4 File Dimension 16

V File format *18*

V.1 Netcdf 18

V.2 Structure and semantic of NetCDF maps files 18

V.3 Reading software 24

GLOSSARY AND ABBREVIATIONS

CF	Climate Forecast (convention for NetCDF)
CMEMS	Copernicus Marine Environment Monitoring Service
ECMWF	European Centre for Medium-Range Weather Forecasts
FAQ	Frequently Asked Question
Hindcast	Hindcast refers to a numerical model integration of a historical period where no observations have been assimilated and the model is forced by atmospheric forcing analyses
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
Med/MED	Mediterranean
MFC	Monitoring and Forecasting Centre
MFS	Mediterranean Forecasting System
NetCDF	Network Common Data Form
NOAA	*National Oceanic and Atmospheric Administration*
NWP	Numerical Weather Prediction
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)
PU	Production Unit
SL	Sea Level
SLA	Sea Level Anomaly
SSH	Sea Surface Height
SST	Sea Surface Temperature
Subsetter	CMEMS service tool to download a NetCDF file of a selected geographical box using values of longitude and latitude, and time range
WAM	Third generation Wave Prediction Model

I INTRODUCTION

I.1 Summary

This document is the user manual for the CMEMS multi-year hindcast product **MEDSEA_HINDCAST_WAV_006_012**. An archive of simulation since 01/02/2006 regularly extended (see product improvements pages http://marine.copernicus.eu/services-portfolio/product-improvements/) 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:

- **sv03-med-hcmr-wav-hi-h** containing 1-hourly instantaneous values for all the variables

- **MEDSEA_HINDCAST_WAV_006_012-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 system is described in the Quality Information Document (QUID): http://cmems-resources.cls.fr/documents/QUID/CMEMS-MED-QUID-006-012.pdf .

More detailed information can be obtained from http://marine.copernicus.eu/services-portfolio/contact-us/. See also News flash .Disclaimer: The quality of the product may vary during the proposed time series depending on the possible update of the system.

I.2 History of Changes

By April 2019 (EIS Q2/2019 MYP upgraded catalogue), time series of the Mediterranean Sea Waves multi-year product will be extended by one year.

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.

Remark: downloading via subsetter generates data in netCDF3 format

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 Web Portal 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 Service.

III DESCRIPTION OF THE PRODUCT SPECIFICATION

III.1 General Information

Table 1 provides information about hindcast products.

Table 1 MEDSEA_HINDCAST_WAV_006_012 Product Specification

Product Specification	**MEDSEA_HINDCAST_WAV_006_012**
Geographical coverage	18.125°W → 36.2917°E; 30.1875°S → 45.9792°N
Variables	Spectral Significant Wave Height (Hm0) Wave Period at Spectral Peak / Peak Period (Tp) Spectral Moments (-1,0) Wave Period (Tm-10) Spectral Moments (0,2) Wave Period (Tm02) Mean Wave Direction from (Mdir) Spectral Significant Wind Wave Height Spectral Moments (0,1) Wind Wave Period Mean Wind Wave Direction from Spectral Significant Primary Swell Wave Height Spectral Significant Secondary Swell Wave Height Spectral Moments (0,1) Primary Swell Wave Period Spectral Moments (0,1) Secondary Swell Wave Period Mean Primary Swell Wave Direction from Mean Secondary Swell Wave Direction from Wave Principal Direction at Spectral Peak Stokes Drift U Stokes Drift V
Hindcast	Yes
Forecast	No
Available time series	Since 2006 regularly extended (see product improvements pages http://marine.copernicus.eu/services-portfolio/product-improvements/))
Temporal resolution	1hr instantaneous field
Target delivery time	Once
Delivery mechanism	CMEMS Information System (Subsetter, CMEMS FTP, DGF)
Horizontal resolution	1/24°

Format	Netcdf CF1.0, NETCDF-4

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

MEDSEA_HINDCAST_WAV_006_012 is the hindcast product of the Mediterranean Sea Waves forecasting system (WAM 4.5.4) starting in Feb 2006, yearly updated, composed by hourly wave parameters at 1/24° horizontal resolution covering the Mediterranean Sea and extending up to 18.125W into the Atlantic Ocean.

III.2.2 Detailed description

The Mediterranean waves forecast system (Med-Waves) is based on the state-of-the-art third-generation wave model WAM Cycle 4.5.4 (Günther and Behrens, 2012), which is a modernized and improved version of the well-known and extensively used WAM Cycle 4 wave model (WAMDI Group, 1988; Komen et al., 1994). Cycle 4.5.4 has been released during MyWave (“A pan - European concerted and integrated approach to operational wave modelling and forecasting – a complement to GMES MyOcean services”) EU FP7 Research Project and is freely available to the entire research and forecasting community.

WAM solves the wave transport equation explicitly without any presumption on the shape of the wave spectrum. Its source terms include the wind input, whitecapping dissipation, nonlinear transfer and bottom friction. The wind input term is adopted from Snyder et al. (1981). The whitecapping dissipation term is based on Hasselmann et al. (1974) whitecapping theory. The wind input and whitecapping dissipation source terms of the present cycle of the wave model are a further development based on Janssen´s quasi-linear theory of wind-wave generation (Janssen, 1989, 1991). The nonlinear transfer term is a parameterization of the exact nonlinear interactions as proposed by Hasselmann et al. (1985a, 1985b). Finally, the bottom friction term is based on the empirical JONSWAP model of Hasselmann et al. (1973).

The Med-Waves set up includes a coarse grid domain with a resolution of 1/6° covering the North Atlantic Ocean from 75° W to 10° E and from 70° N to 10° S and a nested fine grid domain with a resolution of 1/24° covering the Mediterranean Sea from 18.125° W to 36.2917° E and from 30.1875° S to 45.9792° N.

The Mediterranean Sea model receives from the North Atlantic model full wave spectrum at 3-hourly intervals at its Atlantic Ocean open boundary. The latter model is considered to have all of its four boundaries closed with no wave energy propagation from the adjacent seas. This assumption in combination with the wide geographical coverage of the North Atlantic model does not affect the swell propagation towards the open boundary of the Mediterranean model, which is the main interest of this nesting approach.

The wave spectrum is discretized using 32 frequencies, which covers a logarithmically scaled frequency band from 0.04177 Hz to 0.8018 Hz at intervals of df/f=0.1 and 24 equally spaced directions (15 degrees bin).

The Mediterranean model runs in shallow water mode considering wave refraction due to depth and currents in addition to depth induced wave breaking. The North Atlantic model runs in deep water mode with wave refraction due to currents only. The North Atlantic model additionally considers wave energy damping due to the presence of sea ice. A model grid point is considered to be a sea ice point if the ice fraction at that point exceeds 60%. At all sea ice points, the wave energy is set to zero.

Following ECMWF (ECMWF, 2015), the tunable whitecapping dissipation coefficients C_{ds} and δ have been altered from their default values. Specifically, the values of $C_{ds} = 1.33$ ($C_{ds} = 2.1$ default) and $\delta = 0.5$ (δ = 0.6 default) have been adopted for the Mediterranean model and the values of $C_{ds} = 1.8$ and $\delta = 0.5$ for the North Atlantic model. The aim of this tuning is to produce results which are in good agreement with data on fetch-limited growth and with data on the dependence of the surface stress on wave age.

The system is forced by 10m-above-sea-surface 6-hourly analysis wind fields obtained from the ECMWF Integrated Forecasting System at 1/8° resolution The wind is bi-linearly interpolated onto the model grids. Sea ice coverage fields are also obtained from ECMWF at the same horizontal resolution (1/8°) and are updated at daily frequency. With respect to currents forcing, the Mediterranean Sea model is forced by daily averaged surface currents obtained from CMEMS Med MFC Reanalysis at 1/16° resolution and the North Atlantic model is forced by daily averaged surface currents obtained from the CMEMS Global Reanalysis at 1/4° resolution (for the years 2006-2015) and CMEMS Global analysis at 1/12° resolution from 2016.

III.2.3 Processing information

The model has been initialized at mid-January 2006. Several days of wave spectrum spin-up are considered, thus the available data starts at 1st February 2006.

III.3 Details of datasets

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

MEDSEA_HINDCAST_WAV_006_012		
DATASETS	VARIABLES AND UNITS	NAME OF VARIABLES IN THE NETCDF FILE
MEDSEA_HINDCAST_WAV_006_012-statics	Cell dimension along X axis [m] Cell dimension along Y axis [m] Land-sea mask: 1 = sea ; 0 = land [1] Bathymetry [m]	e1t e2t mask deptho
sv03-med-hcmr-wav-hi-h	Spectral significant wave height [m]	VHM0
	Wave period at spectral peak / peak period [s]	VTPK
	Spectral moments (-1,0) wave period [s]	VTM10
	Spectral moments (0,2) wave period [s]	VTM02

	Mean wave direction from [degree]	VMDR
	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 significant secondary swell wave height [m]	VHM0_SW2
	Spectral moments (0,1) primary swell wave period [s]	VTM01_SW1
	Spectral moments (0,1) secondary swell wave period [s]	VTM01_SW2
	Mean primary swell wave direction from [degree]	VMDR_SW1
	Mean secondary swell wave direction from [degree]	VMDR_SW2
	Wave principal direction at spectral peak [degree]	VPED
	Stokes drift U [m/s]	VSDX
	Stokes drift V [m/s]	VSDY

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

MEDSEA_HINDCAST_WAV_006_012 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_nnnnnnnnnnnnn.nc**

where :

.datasetname is the following character string:

- sv03-med-hcmr-wav-hi-h

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

.nc: standard NetCDF filename extension.

Example for a file:

```
sv03-med-hcmr-wav-hi-h_1303461772348.nc
```

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

MEDSEA_HINDCAST_WAV_006_012 files nomenclature when downloaded through CMEMS FTP is based as follows:

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

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)
- **producer** is a short version of the CMEMS production unit
- **parameter** is a four letter code for the parameter or parameter set from Standard BODC
- **config** identifies the producing system and configuration
- **region** is a six letter code for the region
- **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, sm for hindcast.
- **file version** is xx.yy where xx is the CMEMS version and yy is an incremental version number

Table 3 shows the nomenclature for the MEDSEA_HINDCAST_WAV_006_012 product.

Table 3 Description of the nomenclature for MEDSEA_HINDCAST_WAV_006_012

valid date	YYYYMMDD
freq flag	h (hourly)
producer	HCMR
config	MEDWAMHI
region	MEDATL
parameter	WAVE
bul date	bYYYYMMDD
product type	sm (hindcast)
file version	03.00

Example for a hindcast file:

`20141212_h-HCMR--WAVE-MEDWAMHI-MEDATL-b20170401_sm-sv03.00.nc`

This file contains the hourly instantaneous fields of the wave parameters listed analytically in Table 2, from noon (12:00 UTC) of the 11th of December 2014 to noon (11:00 UTC) of the 12th of December 2014.

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

MEDSEA_HINDCAST_WAV_006_012 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:

http---purl.org-myocean-ontology-product-database-**datasetname_nnnnnnnnnnnnn.zip**

where :

.datasetname is the following character string:

- sv03-med-hcmr-wav-hi-h

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

Example for a file:

`http---purl.org-myocean-ontology-product-database-sv03-med-hcmr-wav-hi-h_1303461772348.zip`

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}-sv{file version}.nc.gz

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)
- **producer** is a short version of the CMEMS production unit
- **parameter** is a four letter code for the parameter or parameter set from Standard BODC
- **config** identifies the producing system and configuration
- **region** is a six letter code for the region
- **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, sm for hindcast.
- **file version** is xx.yy where xx is the CMEMS version and yy is an incremental version number

Table 4 shows the nomenclature for the MEDSEA_HINDCAST_WAV_006_012 product.

Table 4 Description of the nomenclature for MEDSEA_HINDCAST_WAV_006_012

valid date	YYYYMMDD
freq flag	h (hourly)
producer	HCMR
config	MEDWAMHI
region	MEDATL
parameter	WAVE
bul date	bYYYYMMDD
product type	sm (hindcast)
file version	03.00

Example for a hindcast file:

`20141212_h-HCMR--WAVE-MEDWAMHI-MEDATL-b20170401_sm-sv03.00.nc`

This file contains the hourly instantaneous fields of the wave parameters listed analytically in Table 2, from noon (12:00 UTC) of the 11th of December 2014 to noon (11:00 UTC) of the 12th of December 2014.

IV.4 Grid

The horizontal grid step is regular in latitude and longitude with a resolution of 1/24° x 1/24° of degree (~4.6km). In Table 5 there is the description of the grid and the spatial coverage for each variable for the MEDSEA_HINDCAST_WAV_006_012 product.

Table 5 Description of grid and spatial coverage

MEDSEA_HINDCAST_WAV_006_012						
VARIABLE	LON MIN	LON MAX	LAT MIN	LAT MAX	XPOINT	YPOINT
Spectral significant wave height	18.125°W	36.2917°E	30.1875°N	45.97917°N	1307	380
Spectral moments (-1,0) wave period	18.125°W	36.2917°E	30.1875°N	45.97917°N	1307	380
Spectral moments (0,2) wave period	18.125°W	36.2917°E	30.1875°N	45.97917°N	1307	380
Wave period at spectral peak	18.125°W	36.2917°E	30.1875°N	45.97917°N	1307	380
Mean wave direction from	18.125°W	36.2917°E	30.1875°N	45.97917°N	1307	380
Wave direction at spectral peak (principal direction)	18.125°W	36.2917°E	30.1875°N	45.97917°N	1307	380
U-component wave stokes drift	18.125°W	36.2917°E	30.1875°N	45.97917°N	1307	380
V-component wave stokes drift	18.125°W	36.2917°E	30.1875°N	45.97917°N	1307	380
Spectral significant wind-wave height	18.125°W	36.2917°E	30.1875°N	45.97917°N	1307	380
Spectral moments (0,1) wind wave period	18.125°W	36.2917°E	30.1875°N	45.97917°N	1307	380
Mean wind wave direction from	18.125°W	36.2917°E	30.1875°N	45.97917°N	1307	380
Spectral significant primary swell wave height	18.125°W	36.2917°E	30.1875°N	45.97917°N	1307	380
Spectral moments (0,1) primary swell wave period	18.125°W	36.2917°E	30.1875°N	45.97917°N	1307	380
Spectral significant secondary swell wave height	18.125°W	36.2917°E	30.1875°N	45.97917°N	1307	380
Mean primary swell wave direction from	18.125°W	36.2917°E	30.1875°N	45.97917°N	1307	380
Spectral moments (0,1) secondary swell wave period	18.125°W	36.2917°E	30.1875°N	45.97917°N	1307	380
Mean secondary swell wave direction from	18.125°W	36.2917°E	30.1875°N	45.97917°N	1307	380

IV.5 Domain coverage

The blue area in Fig.2 represents the spatial coverage of the MEDSEA_HINDCAST_WAV_006_012 product.

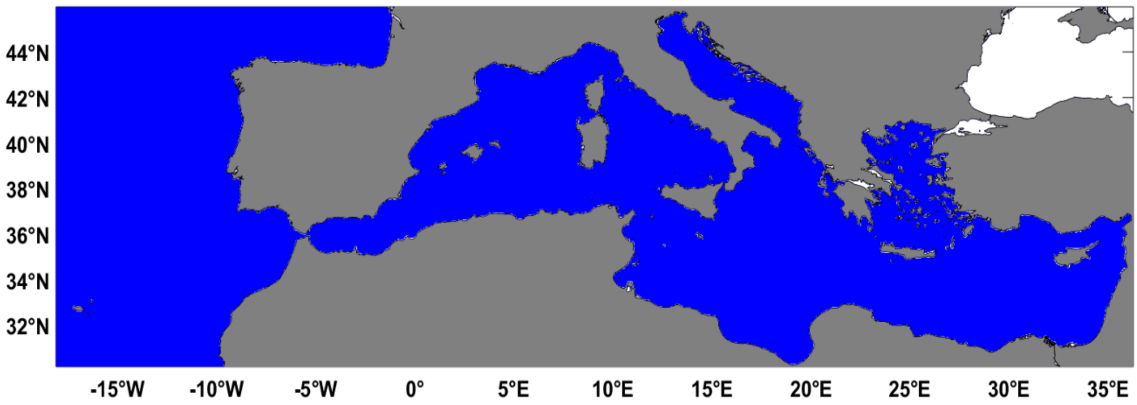

Figure 1 Spatial coverage of the MEDSEA_HINDCAST_WAV_006_012 product (blue zone).

Grid type is the following standard projection:

Regular projection: longitude and latitude step is constant	

IV.6 Temporal extend of hindcast stored on delivery mechanism

MEDSEA_HINDCAST_WAV_006_012 temporal coverage from February 2006 is regularly updated

and it will be yearly updated. The hindcast has been produced using the Med-Waves model system (MEDWAMHI).

IV.7 Other information: mean centre of Products, missing value, production chain and file dimension

IV.7.1 Mean Centre of Products

MEDSEA_HINDCAST_WAV_006_012 product hindcast is available as hourly instantaneous fields.

IV.7.2 Missing Value

The **missing value** for the MEDSEA_HINDCAST_WAV_006_012 product is 1e+20.

IV.7.3 Production Chain

MEDSEA_HINDCAST_WAV_006_012 production chain:

MEDSEA_HINDCAST_WAV_006_012 has been generated by the HCMR Production Unit using the Med-Waves model system (MEDWAMHI), based on WAM Cycle 4.5.4. The system is forced by 10m-above-sea-surface 6-hourly analysis wind fields obtained from the ECMWF Integrated Forecasting System at $1/8^{o}$ resolution for the hindcast period.Sea ice coverage fields are also obtained from ECMWF at the same horizontal resolution ($1/8^{o}$) and are updated at daily frequency. The Mediterranean Sea model is forced by daily averaged surface currents obtained from CMEMS Med MFC at $1/16^{o}$ resolution and the North Atlantic model is forced by daily averaged surface currents obtained from the CMEMS Global Reanalysis system at $1/4^{o}$ resolution for the period 2006-2015 and from the CMEMS Global analysis system at 1/12° resolution since 2016. The system is updated every year.

IV.7.4 File Dimension

Table 6 describes the dimensions of the files for hindcast for one day.

Table 6 Names and dimensions of the files

DATASET NAME	NAME OF FILE	DIMENSION [MB]*
sv03-med-hcmr-wav-hi-h	{date1}_h-HCMR--WAVE-MEDWAMHI-MEDATL-b{date2}_sm-sv03.00.nc	~326*
MEDSEA_HINDCAST_WAV_006_012-statics	MED-MFC_006_012_${field}.nc	0.938

* Netcdf4 files are internally compressed.

Table 7 describes the dimensions of the entire time series for the dataset.

Table 7 Names and dimensions of the entire dataset

DATASET NAME	DIMENSION [MB]*
sv03-med-hcmr-wav-hi-h	~1300000*
MEDSEA_HINDCAST_WAV_006_012-statics	0.938

* Netcdf4 files are internally compressed.

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 MEDSEA_HINDCAST_WAV_006_012

DIMENSIONS	VARIABLES		
	NAME	**DIMENSIONS**	**TYPE**
lon=1307 lat=380 time=24	lon	lon	float
	lat	lat	float
	time	time	int
	VHM0	time,lat,lon	float
	VTPK	time,lat,lon	float
	VTM10	time,lat,lon	float
	VTM02	time,lat,lon	float

	VMDR	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
	VHM0_SW2	time,lat,lon	float
	VTM01_SW1	time,lat,lon	float
	VTM01_SW2	time,lat,lon	float
	VMDR_SW1	time,lat,lon	float
	VMDR_SW2	time,lat,lon	float
	VPED	time,lat,lon	float
	VSDX	time,lat,lon	float
	VSDY	time,lat,lon	float

For 20141212_h-HCMR--WAVE-MEDWAMHI-MEDATL-b20170401_sm-sv03.00.nc:

```
netcdf \20141212_h-HCMR--WAVE-MEDWAMHI-MEDATL-b20170401_sm-sv03.00 {
dimensions:
        time = UNLIMITED ; // (24 currently)
        lat = 380 ;
        lon = 1307 ;
variables:
        float lat(lat) ;
                lat:standard_name = "latitude" ;
                lat:units = "degrees_north" ;
                lat:long_name = "latitude" ;
                lat:axis = "Y" ;
                lat:valid_max = 45.97917f ;
                lat:valid_min = 30.1875f ;
        float lon(lon) ;
                lon:standard_name = "longitude" ;
                lon:units = "degrees_east" ;
```

```
            lon:long_name = "longitude" ;
            lon:axis = "X" ;
            lon:valid_max = 36.29167f ;
            lon:valid_min = -18.125f ;
        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:_FillValue = 1.e+20f ;
            VHM0:missing_value = 1.e+20f ;
            VHM0:long_name = "Spectral significant wave height (Hm0)" ;
            VHM0:standard_name = "sea_surface_wave_significant_height" ;
            VHM0:coordinates = "time lat lon" ;
            VHM0:units = "m" ;
            VHM0:valid_min = 0.f ;
            VHM0:valid_max = 20.f ;
        float VTPK(time, lat, lon) ;
            VTPK:_FillValue = 1.e+20f ;
            VTPK:missing_value = 1.e+20f ;
            VTPK:long_name = "Wave period at spectral peak / peak period (Tp)" ;
            VTPK:standard_name =
    "sea_surface_wave_peak_period_at_variance_spectral_density_maximum" ;
            VTPK:coordinates = "time lat lon" ;
            VTPK:units = "s" ;
            VTPK:valid_min = 0.f ;
            VTPK:valid_max = 40.f ;
        float VTM10(time, lat, lon) ;
            VTM10:_FillValue = 1.e+20f ;
            VTM10:missing_value = 1.e+20f ;
            VTM10:long_name = "Spectral moments (-1,0) wave period (Tm-10)" ;
            VTM10:standard_name =
    "sea_surface_wave_mean_period_from_variance_spectral_density_inverse_frequency_moment" ;
            VTM10:coordinates = "time lat lon" ;
            VTM10:units = "s" ;
            VTM10:valid_min = 0.f ;
            VTM10:valid_max = 40.f ;
        float VTM02(time, lat, lon) ;
```

```
        VTM02:_FillValue = 1.e+20f ;
        VTM02:missing_value = 1.e+20f ;
        VTM02:long_name = "Spectral moments (0,2) wave period (Tm02)" ;
        VTM02:standard_name = "sea_surface_wave_mean_period_from_variance_spectral_density_second_frequency_moment" ;
        VTM02:coordinates = "time lat lon" ;
        VTM02:units = "s" ;
        VTM02:valid_min = 0.f ;
        VTM02:valid_max = 40.f ;
    float VMDR(time, lat, lon) ;
        VMDR:_FillValue = 1.e+20f ;
        VMDR:missing_value = 1.e+20f ;
        VMDR:long_name = "Mean wave direction from (Mdir)" ;
        VMDR:standard_name = "sea_surface_wave_from_direction" ;
        VMDR:coordinates = "time lat lon" ;
        VMDR:units = "degree" ;
        VMDR:valid_min = 0.f ;
        VMDR:valid_max = 360.f ;
    float VHM0_WW(time, lat, lon) ;
        VHM0_WW:_FillValue = 1.e+20f ;
        VHM0_WW:missing_value = 1.e+20f ;
        VHM0_WW:long_name = "Spectral significant wind wave height" ;
        VHM0_WW:standard_name = "sea_surface_wind_wave_significant_height" ;
        VHM0_WW:coordinates = "time lat lon" ;
        VHM0_WW:units = "m" ;
        VHM0_WW:valid_min = 0.f ;
        VHM0_WW:valid_max = 20.f ;
    float VTM01_WW(time, lat, lon) ;
        VTM01_WW:_FillValue = 1.e+20f ;
        VTM01_WW:missing_value = 1.e+20f ;
        VTM01_WW:long_name = "Spectral moments (0,1) wind wave period" ;
        VTM01_WW:standard_name = "sea_surface_wind_wave_mean_period" ;
        VTM01_WW:coordinates = "time lat lon" ;
        VTM01_WW:units = "s" ;
        VTM01_WW:valid_min = 0.f ;
        VTM01_WW:valid_max = 40.f ;
    float VMDR_WW(time, lat, lon) ;
        VMDR_WW:_FillValue = 1.e+20f ;
        VMDR_WW:missing_value = 1.e+20f ;
```

```
        VMDR_WW:long_name = "Mean wind wave direction from" ;
        VMDR_WW:standard_name = "sea_surface_wind_wave_from_direction" ;
        VMDR_WW:coordinates = "time lat lon" ;
        VMDR_WW:units = "degree" ;
        VMDR_WW:valid_min = 0.f ;
        VMDR_WW:valid_max = 360.f ;
    float VHM0_SW1(time, lat, lon) ;
        VHM0_SW1:_FillValue = 1.e+20f ;
        VHM0_SW1:missing_value = 1.e+20f ;
        VHM0_SW1:long_name = "Spectral significant primary swell wave height" ;
        VHM0_SW1:standard_name = "sea_surface_primary_swell_wave_significant_height";
        VHM0_SW1:coordinates = "time lat lon" ;
        VHM0_SW1:units = "m" ;
        VHM0_SW1:valid_min = 0.f ;
        VHM0_SW1:valid_max = 20.f ;
    float VHM0_SW2(time, lat, lon) ;
        VHM0_SW2:_FillValue = 1.e+20f ;
        VHM0_SW2:missing_value = 1.e+20f ;
        VHM0_SW2:long_name = "Spectral significant secondary swell wave height" ;
        VHM0_SW2:standard_name =
"sea_surface_secondary_swell_wave_significant_height" ;
        VHM0_SW2:coordinates = "time lat lon" ;
        VHM0_SW2:units = "m" ;
        VHM0_SW2:valid_min = 0.f ;
        VHM0_SW2:valid_max = 20.f ;
    float VTM01_SW1(time, lat, lon) ;
        VTM01_SW1:_FillValue = 1.e+20f ;
        VTM01_SW1:missing_value = 1.e+20f ;
        VTM01_SW1:long_name = "Spectral moments (0,1) primary swell wave period" ;
        VTM01_SW1:standard_name = "sea_surface_primary_swell_wave_mean_period" ;
        VTM01_SW1:coordinates = "time lat lon" ;
        VTM01_SW1:units = "s" ;
        VTM01_SW1:valid_min = 0.f ;
        VTM01_SW1:valid_max = 40.f ;
    float VTM01_SW2(time, lat, lon) ;
        VTM01_SW2:_FillValue = 1.e+20f ;
        VTM01_SW2:missing_value = 1.e+20f ;
        VTM01_SW2:long_name = "Spectral moments (0,1) secondary swell wave period" ;
        VTM01_SW2:standard_name = "sea_surface_secondary_swell_wave_mean_period"
;
```

```
        VTM01_SW2:coordinates = "time lat lon" ;
        VTM01_SW2:units = "s" ;
        VTM01_SW2:valid_min = 0.f ;
        VTM01_SW2:valid_max = 40.f ;
    float VMDR_SW1(time, lat, lon) ;
        VMDR_SW1:_FillValue = 1.e+20f ;
        VMDR_SW1:missing_value = 1.e+20f ;
        VMDR_SW1:long_name = "Mean primary swell wave direction from" ;
        VMDR_SW1:standard_name = "sea_surface_primary_swell_wave_from_direction" ;
        VMDR_SW1:coordinates = "time lat lon" ;
        VMDR_SW1:units = "degree" ;
        VMDR_SW1:valid_min = 0.f ;
        VMDR_SW1:valid_max = 360.f ;
    float VMDR_SW2(time, lat, lon) ;
        VMDR_SW2:_FillValue = 1.e+20f ;
        VMDR_SW2:missing_value = 1.e+20f ;
        VMDR_SW2:long_name = "Mean secondary swell wave direction from" ;
        VMDR_SW2:standard_name =
"sea_surface_secondary_swell_wave_from_direction";
        VMDR_SW2:coordinates = "time lat lon" ;
        VMDR_SW2:units = "degree" ;
        VMDR_SW2:valid_min = 0.f ;
        VMDR_SW2:valid_max = 360.f ;
    float VPED(time, lat, lon) ;
        VPED:_FillValue = 1.e+20f ;
        VPED:missing_value = 1.e+20f ;
        VPED:long_name = "Wave principal direction at spectral peak" ;
        VPED:standard_name = "sea_surface_wave_from_direction_at_spectral_peak" ;
        VPED:coordinates = "time lat lon" ;
        VPED:units = "degree" ;
        VPED:valid_min = 0.f ;
        VPED:valid_max = 360.f ;
    float VSDX(time, lat, lon) ;
        VSDX:_FillValue = 1.e+20f ;
        VSDX:missing_value = 1.e+20f ;
        VSDX:long_name = "Stokes drift U" ;
        VSDX:standard_name = "sea_surface_wave_stokes_drift_x_velocity" ;
        VSDX:coordinates = "time lat lon" ;
        VSDX:units = "m/s" ;
```

```
                VSDX:valid_min = -1.f ;
                VSDX:valid_max = 1.f ;
        float VSDY(time, lat, lon) ;
                VSDY:_FillValue = 1.e+20f ;
                VSDY:missing_value = 1.e+20f ;
                VSDY:long_name = "Stokes drift V" ;
                VSDY:standard_name = "sea_surface_wave_stokes_drift_y_velocity" ;
                VSDY:coordinates = "time lat lon" ;
                VSDY:units = "m/s" ;
                VSDY:valid_min = -1.f ;
                VSDY:valid_max = 1.f ;

// global attributes:
                :bulletin_type = "simulation" ;
                :institution = "Hellenic Centre for Marine Research (HCMR)-Athens,Greece" ;
                :source = "MED WAMHI" ;
                :contact = "servicedesk.cmems@mercator-ocean.eu" ;
                :references = "Please check in CMEMS catalogue the INFO section for product MEDSEA_HINDCAST_WAVES_006_012 - http://marine.copernicus.eu" ;
                :comment = "Please check in CMEMS catalogue the INFO section for product MEDSEA_HINDCAST_WAVES_006_012 - http://marine.copernicus.eu" ;
                :Conventions = "CF-1.0" ;
                :bulletin_date = "2017-04-01" ;
                :field_type = "hourly_instantaneous_at_time_field" ;
                :title = "Wave fields (2D) - Hourly Instantaneous" ;
                :NCO = "\"4.5.5\"" ;
}
```

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…