PRODUCT USER MANUAL

For North-West Shelf Physical Reanalysis Products NORTHWESTSHELF_REANALYSIS_PHYS_004_009 and NORTHWESTSHELF_REANALYSIS_BIO_004_011

Issue: 1.4

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CMEMS version scope : Version 3.0

Approval Date :

CHANGE RECORD

Issue	Date	§	Description of Change	Author	Validated By
1.0	December 2014	All	Creation of the document from MYO2-NWS-PUM-004-009-V1.0 including addition of BIO information and bed temperature dataset.	Ed Blockley	L. Crosnier
1.1	May 1 2015	all	Change format to fit CMEMS graphical rules		L. Crosnier
1.2	Jan 2016		Extension of the time series, new variable. substitution of MyOcean with CMEMS	Niall McConnell	M. Tonani
1.3	Jun 2016	III.2 table 7-8	Dataset refactoring	M. Tonani	M. Tonani
1.4	Jan 2017	All	Addition of Direct Get File (DGF) capability to access methods. Review of text for all sections.	Ray Mahdon	M. Tonani

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GLOSSARY AND ABBREVIATIONS

MFC	Monitoring and Forecasting Centre
NWS	North-West Shelf
NetCDF	Network Common Data Form
CF	Climate Forecast (convention for NetCDF)
SSH	Sea surface height
RMS	Root mean square
PC	Production Centre
PU	Production Unit
Meridional Velocity	West to East component of the horizontal velocity vector
Zonal Velocity	South to North component of the horizontal velocity vector
ftp	Protocol to download files
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)
Subsetter	CMEMS service tool to download a NetCDF file of a selected geographical box using values of longitude an latitude, and time range
Direct Get File - DGF	CMEMS service tool (FTP like) to download a NetCDF file

I INTRODUCTION

I.1 Summary

This guide describes the physical reanalysis product files from the Met Office Dissemination Unit of the NWS MFC (NWS-METOFFICE-EXETER-UK), what data services are available to access them, and how to use the files and services. The products NORTHWESTSHELF_REANALYSIS_PHYS_004_009 and NORTHWESTSHELF_REANALYSIS_BIO_004_011 are the physical and biogeochemical components of reanalysis produced at the Met Office, UK.

NORTHWESTSHELF_REANALYSIS_PHYS_004_009 includes:

- 3D daily mean fields of temperature, salinity, zonal velocity and meridional velocity
- 3D monthly mean fields of temperature, salinity, zonal velocity and meridional velocity
- Daily mean sea bottom temperature fields
- Monthly mean sea bottom temperature fields

NORTHWESTSHELF_REANALYSIS_BIO_004_011 includes:

- 3D daily mean fields of light attenuation, chlorophyll-a, dissolved oxygen, dissolved organic phosphate, dissolved organic nitrate, total phytoplankton biomass, and net primary productivity
- 3D monthly mean fields of light attenuation, chlorophyll-a, dissolved oxygen, dissolved organic phosphate, dissolved organic nitrate, total phytoplankton biomass, and net primary productivity.

I.2 History of changes

I.2.1 *NORTHWESTSHELF_REANALYSIS_PHYS_004_009*

- On April 8 2015, Monthly mean sea bed temperature fields are added.

I.2.2 *NORTHWESTSHELF_REANALYSIS_BIO_004_011*

- On April 8 2015, this product appears in catalogue.

I.2.3 *NORTHWESTSHELF_REANALYSIS_PHYS_004_009*

- On April 13 2016, Mixed layer depth added and the reanalysis is extended to July 2014

I.2.4 *NORTHWESTSHELF_REANALYSIS_BIO_004_011*

- On April 13 2016, The reanalysis is extended to July 2014

I.2.5 *NORTHWESTSHELF_REANALYSIS_PHYS_004_009*

- On July 5 2016, refactoring of the reanalysis datasets.

I.2.6 *NORTHWESTSHELF_REANALYSIS_BIO_004_011*

- On July 5 2016, refactoring of the reanalysis datasets.

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#1

Once registered, the CMEMS FAQ http://marine.copernicus.eu/web/34-products-and-services-faq.php#3 will guide you on How to download a product through the CMEMS Web Portal Subsetter Service.

II.2 Download a product through the CMEMS FTP Service

You first need to register. Please find below the registration steps:
http://marine.copernicus.eu/web/34-products-and-services-faq.php#1

The ftp site is accessed using your CMEMS user name and password and the files are located in directories named NORTHWESTSHELF_REANALYSIS_PHYS_004_009 and NORTHWESTSHELF_REANALYSIS_BIO_004_011.

II.3 Download a product through the CMEMS DGF (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#1

Once registered, the CMEMS FAQ http://marine.copernicus.eu/web/34-products-and-services-faq.php#3 will guide you on How to download a product through the CMEMS Web Portal DGF Service.

III DESCRIPTION OF THE PRODUCT SPECIFICATION

III.1 General Information

Table 1: NORTHWESTSHELF_REANALYSIS_PHYS_004_009 Product Specification of 3D daily mean fields

Product Lines	NORTHWESTSHELF_REANALYSIS_PHYS_004_009
Geographical coverage	20°W → 13°E ; 40°N → 65°N
Variables	Temperature Salinity Horizontal velocity (meridional and zonal component) Mixed Layer Depth
Available time series	01/01/1985 – 01/07/2014
Temporal resolution	25hr average, normally referred to as daily mean
Delivery mechanism	Subsetter, FTP, DGF
Horizontal resolution	~7km (1/9^{o} lon x 1/15^{o} lat)
Number of vertical levels	24
Format	Netcdf CF1.0

Table 2: NORTHWESTSHELF_REANALYSIS_PHYS_004_009 Product Specification of 3D monthly mean fields

Product Lines	NORTHWESTSHELF_REANALYSIS_PHYS_004_009
Geographical coverage	20°W → 13°E ; 40°N → 65°N
Variables	Temperature Salinity Horizontal velocity (meridional and zonal component) Mixed Layer Depth
Available time series	January 1985 – June 2014
Temporal resolution	Monthly average

Delivery mechanism	Subsetter, MFTP
Horizontal resolution	~7km (1/9° lon x 1/15° lat)
Number of vertical levels	24
Format	Netcdf CF1.0

Table 3: NORTHWESTSHELF_REANALYSIS_PHYS_004_009 Product Specification of daily mean sea bed fields

Product Lines	NORTHWESTSHELF_REANALYSIS_PHYS_004_009
Geographical coverage	20°W → 13°E ; 40°N → 65°N
Variables	Temperature
Available time series	01/01/1985 – 01/07/2014
Temporal resolution	25hr average, normally referred to as daily mean
Delivery mechanism	Subsetter, FTP, DGF
Horizontal resolution	~7km (1/9° lon x 1/15° lat)
Number of vertical levels	1
Format	Netcdf CF1.0

Table 4: NORTHWESTSHELF_REANALYSIS_PHYS_004_009 Product Specification of monthly mean sea bed fields

Product Lines	NORTHWESTSHELF_REANALYSIS_PHYS_004_009
Geographical coverage	20°W → 13°E ; 40°N → 65°N
Variables	Temperature
Available time series	01/01/1985 – 01/07/2014
Temporal resolution	monthly mean
Delivery mechanism	Subsetter, FTP, DGF
Horizontal resolution	~7km (1/9° lon x 1/15° lat)
Number of vertical levels	1

Format	Netcdf CF1.0

Table 5: NORTHWESTSHELF_REANALYSIS_BIO_004_011 Product Specification of 3D daily mean fields

Product Lines	NORTHWESTSHELF_REANALYSIS_BIO_004_011
Geographical coverage	20°W → 13°E ; 40°N → 65°N
Variables	light attenuation chlorophyll-a dissolved oxygen dissolved organic phosphate dissolved organic nitrate total phytoplankton biomass net primary productivity
Available time series	01/01/1985 – 01/07/2014
Temporal resolution	25hr average, normally referred to as daily mean
Delivery mechanism	Subsetter, FTP, DGF
Horizontal resolution	~7km (1/9^{o} lon x 1/15^{o} lat)
Number of vertical levels	24
Format	Netcdf CF1.0

Table 6: **NORTHWESTSHELF_REANALYSIS_BIO_004_011 Product Specification of 3D monthly mean fields**

Product Lines	NORTHWESTSHELF_REANALYSIS_BIO_004_011
Geographical coverage	20°W → 13°E ; 40°N → 65°N
Variables	light attenuation chlorophyll-a dissolved oxygen dissolved organic phosphate dissolved organic nitrate total phytoplankton biomass

	net primary productivity
Available time series	January 1985 – June 2014
Temporal resolution	Monthly average
Delivery mechanism	Subsetter, FTP, DGF
Horizontal resolution	~7km (1/9^{o} lon x 1/15^{o} lat)
Number of vertical levels	24
Format	Netcdf CF1.0

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

III.2 Details of datasets

Table 7: List of the datasets (column 1), of the variable for each dataset (column 2) and their names in the NetCDF files (column 3) for the NORTHWESTSHELF_REANALYSIS_PHYS_004_009

DATASETS	**VARIABLES AND UNIT**	**NAME OF VARIABLES IN THE NETCDF FILE**
MetO-NWS-REAN-PHYS-daily-CUR	Northward Current Velocity in the Water Column [ms^{-1}]	vomecrty
	Eastward Current Velocity in the Water Column [ms^{-1}]	vozocrtx
MetO-NWS-REAN-PHYS-daily-TEM	Sea Water Potential Temperature [K]	votemper
MetO-NWS-REAN-PHYS-daily-SAL	Sea Water Salinity [1e^{-3}]	vosaline
MetO-NWS-REAN-PHYS-daily-MLD	Mixed Layer Depth [m]	karamld
MetO-NWS-REAN-PHYS-monthly-CUR	Northward Current Velocity in the Water Column [ms^{-1}]	vomecrty
	Eastward Current Velocity in the Water Column [ms^{-1}]	vozocrtx
MetO-NWS-REAN-PHYS-monthly-TEM	Sea Water Potential Temperature [K]	votemper

MetO-NWS-REAN-PHYS-monthly-SAL	Sea Water Salinity [1e-3]	vosaline
MetO-NWS-REAN-PHYS-monthly-MLD	Mixed Layer Depth [m]	karamld
MetO-NWS-REAN-PHYS-bed-daily	Sea Water Potential Temperature at Sea Bed [K]	votemper
MetO-NWS-REAN-PHYS-bed-monthly	Sea Water Potential Temperature at Sea Bed [K]	votemper

Table 8: List of the datasets (column 1), of the variable for each dataset (column 2) and their names in the NetCDF files (column 3) for the NORTHWESTSHELF_REANALYSIS_BIO_004_011

NORTHWESTSHELF_REANALYSIS_BIO_004_011		
DATASETS	**VARIABLES AND UNIT**	**NAME OF VARIABLES IN THE NETCDF FILE**
MetO-NWS-REAN-BIO-daily-ATTN	Volume Beam Attenuation Coefficient of Radiative Flux in Sea Water [m^{-1}]	attn
MetO-NWS-REAN-BIO-daily-CPWC	Concentration of Chlorophyll in Sea Water [mgC m^{-3}]	CHL
MetO-NWS-REAN-BIO-daily-DOXY	Mole Concentration of Dissolved Oxygen in Sea Water [mmol m^{-3}]	O2o
MetO-NWS-REAN-BIO-daily-NITR	Mole Concentration of Nitrate in Sea Water [mmol m^{-3}]	N3n
MetO-NWS-REAN-BIO-daily-PHOS	Mole Concentration of Phosphate in Sea Water [mmol m^{-3}]	N1p
MetO-NWS-REAN-BIO-daily-PHYT	Mass Concentration of Total Phytoplankton in Sea Water Expressed as Carbon [mgC m^{-3}]	PhytoC
MetO-NWS-REAN-BIO-daily-PPRD	Net Primary Productivity of Carbon [mgC $m^{-3}day^{-1}$]	netPP
MetO-NWS-REAN-BIO-monthly-ATTN	Volume Beam Attenuation Coefficient of Radiative Flux in Sea Water [m^{-1}]	attn

MetO-NWS-REAN-BIO-monthly-CPWC	Concentration of Chlorophyll in Sea Water [mgC m^{-3}]	CHL
MetO-NWS-REAN-BIO-monthly-DOXY	Mole Concentration of Dissolved Oxygen in Sea Water [mmol m^{-3}]	O2o
MetO-NWS-REAN-BIO-monthly-NITR	Mole Concentration of Nitrate in Sea Water [mmol m^{-3}]	N3n
MetO-NWS-REAN-BIO-monthly-PHOS	Mole Concentration of Phosphate in Sea Water [mmol m^{-3}]	N1p
MetO-NWS-REAN-BIO-monthly-PHYT	Mass Concentration of Total Phytoplankton in Sea Water Expressed as Carbon [mgC m^{-3}]	PhytoC
MetO-NWS-REAN-BIO-monthly-PPRD	Net Primary Productivity of Carbon [mgC $m^{-3}day^{-1}$]	netPP

III.3 Production Subsystem Description

III.3.1 *NORTHWESTSHELF_REANALYSIS_PHYS_004_009*

The North West shelf reanalysis was produced using version 3.4 of the Nucleus for European Modelling of the Ocean (NEMO) ocean model code (Madec, 2008) coupled to the European Regional Seas Ecosystem Model (ERSEM; Blackford et al. 2004). Tidal forcing is included both on the open boundary conditions via a Flather radiation boundary condition (Flather, 1976) and through the inclusion of the equilibrium tide. The external elevation and depth mean velocity was determined from 15 tidal constituents taken from a tidal model of the north-east Atlantic (Flather, 1981). With the exception of the Baltic Sea, the model was forced at its open boundaries by temperature, salinity, sea surface height and depth integrated currents taken from global ocean analyses. For the early part of the reanalysis (January 1984 – March 1989) horizontal fluxes were taken from the National Oceanography Centre's ORCA025 hindcast (Megann et al., 2014), before switching to GloSea data (MacLachlan et al., 2014) thereafter. Baltic boundary conditions were taken from IOW-GETM model (see http://getm.eu/index.php?option=com_content&task=view&id=109&Itemid=42). Freshwater inflow into the model from rivers and other sources was prescribed from the E-HYPE hydrological reanalysis (Donnelly, 2013). Surface forcing of 3 hourly precipitation, wind stress, pressure and shortwave fluxes were taken from the ECMWF ERA-Interim reanalysis (Dee et al., 2011). These fluxes were then processed through the CORE bulk forcing algorithms (Large and Yeager, 2004; Large and Yeager 2009) before being applied to the model. The inverse barometer effect of atmospheric pressure gradients on the sea surface height was also included.

A non-linear free surface was implemented using a variable volume layer method. The short time scales associated with tidal propagation and the free surface require a time splitting approach, splitting modes into barotropic and baroclinic components. The bottom boundary condition includes a log layer representation and a k-epsilon turbulence scheme is implemented with a generic length

scale (Umlauf and Burchard, 2003). The model uses a non-linear free surface, and an energy and enstrophy conserving form of the momentum advection. It uses free slip boundary conditions. The tracer equations use a TVD advection scheme (Zalesak, 1979). For tracer diffusion a Laplacian diffusion scheme on geopotential surfaces is applied, whereas for momentum diffusion a mixed Laplacian/bilaplacian scheme is used, with the Laplacian operator applied on geopotential surfaces and the bilaplacian on model surfaces.

For the reanalysis, assimilation of Sea Surface Temperature (SST) was performed using a 3DVar algorithm. Calculation of the assimilation increments was done using an adapted version of the NEMOVAR (Mogensen, 2012) system. Assimilation proceeded in three steps. Firstly a one day model forecast was performed, within which observations were compared to model output at the nearest time-step; this is a First Guess at Appropriate Time (FGAT) system. In the second stage, observation minus model differences were converted to SST increments by minimising a 3DVar cost function. In minimising this function seasonally varying estimates of the observation representativity error variance (assumed uncorrelated) and background error variance were used. The total observation error variance was obtained by adding an estimate of the measurement error variance of each observation to the representativity error variance. Information from observations was spread horizontally according to lengthscales that are inversely proportional to the potential vorticity gradient and have a maximum value of 130km. In the final stage the analysis was produced by rerunning the model for the same day with the increments added onto the SST field using the Incremental Analysis Update (IAU, Bloom et al., 1996) method. Increments were added into the model down to the base of the instantaneous mixed layer, where the mixed layer depth was determined by a 0.2°C temperature difference from the surface.

From January 1984 until October 1995 the reanalysis assimilated NOAA-AVHRR data obtained from the Pathfinder Vn5.2 dataset (Casey et al., 2010). After October 1995 the NOAA-AVHRR feed was switched to use the ESA-CCI (Merchant et al., in preparation) version of this data; this continued until February 2010 after which a GHRSST version (see http://www.ghrsst.org) of NOAA-AVHRR data, held internally at the UK Met-Office was used. ATSR data from the CCI project was assimilated from April 1991 until February 2010, with UKMO data used thereafter. Also from the CCI project, METOP-AVHRR data were assimilated from December 2006, switching to GHRSST feeds in February 2010. GHRSST data from the AMSRE and SEVIRI instruments were assimilated from August 2006, with the AMSRE instruments failing in November 2011. In-situ SST data were assimilated throughout the entire reanalysis run, using ICOADS (see http://icoads.noaa.gov/) data for the majority (January 1984 until December 2010) and data available through the Global Telecommunications System (GTS, see (http://www.wmo.int/pages/prog/www/TEM/GTS/index_en.html) thereafter. All data were quality controlled against the Ocean SST and sea Ice Analysis (OSTIA; Donlon et al., 2012) using the method of Ingleby & Huddleston (2007).

Both the reanalysis and control runs were completed in three segments, reflecting changes in forcing data. For the reanalysis the runs are divided into

Run 1: 01/01/1984 to 31/03/1989

Run 2: 01/01/1989 to 31/12/2003

Run 3: 10/10/2003 to 31/06/2012

Run 4: 30/04/2012 to 30/6/14

and for the control run

Run 1: 01/01/1981 to 31/03/1989

Run 2: 02/01/1989 to 30/03/2003

Run 3: 01/01/2003 to 30/06/2012.

Run 4: 30/04/2012 to 30/6/14

III.3.2 *NORTHWESTSHELF_REANALYSIS_BIO_004_011*

The ecosystem model used World Ocean Atlas 2009 nutrients at the boundaries and river concentration climatology for nutrients and sediment concentration. The ecosystem model is forced by the physical model via an online coupling and is run at the same time step as the physical model, (300s).

IV NOMENCLATURE OF FILES

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

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

The files nomenclature for NORTHWESTSHELF_REANALYSIS_PHYS_004_009 and NORTHWESTSHELF_REANALYSIS_BIO_004_011 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:** as described in `Table 7`
- **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:

`MetO-NWS-REAN-PHYS-daily-SAL-1303461772348.nc`

IV.2 Nomenclature of files when downloaded through the CMEMS Direct Get File services

The files nomenclature for NORTHWESTSHELF_REANALYSIS_PHYS_004_009 and NORTHWESTSHELF_REANALYSIS_BIO_004_011 when downloaded through the CMEMS Direct Get File is based on product dataset name and a numerical reference related to the request date on the CIS.

The scheme is: **datasetname-nnnnnnnnnnnnn.zip**

where :

- **datasetname:** as described in `Table 7`
- **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:

`MetO-NWS-REAN-PHYS-daily-SAL1303461772348.zip`

IV.3 Nomenclature of files when downloaded through the CMEMS FTP

The below describes the reanalysis products:

- NORTHWESTSHELF_REANALYSIS_PHYS_004_009
- NORTHWESTSHELF_REANALYSIS_BIO_004_011

The files are delivered containing data for:

* the full spatial coverage of the model domain
* one variable or variable group
* a single day data

The filenames contain fields that identify the model, domain, variable and time of the contents:

metoffice_foam1_amm7_NWS_XXXX_dmYYYYMMDD.nc

* metoffice: production centre that produced the file
* foam1: model system and version
* amm7: model configuration
* NWS: region
* XXXX: variable or variable group, see Table 9 below
* dmYYYYMMDD: daily mean for validity date YYYYMMDD (or mmYYYYMM for monthly mean)

Table 9: Variable naming convention for the filenames

TEMP	Potential temperature (including SST)
PSAL	Salinity
RFVL	Water velocities
MLDD	Mixed layer depth
TBED	Sea bed potential temperature
ATTN	Attenuation coefficient
CPWC	Chlorophyll
DOXY	Dissolved Oxygen
NITR	Nitrate
PHOS	Phosphate
PHYT	Total phytoplanton biomass

PPRD	Primary productivity

IV.4 Horizontal Grid

The products are released on a grid based upon the numerical model grid.

The horizontal grid step is 1/9° longitude x 1/15° latitude (referred to as regular lat-lon), which gives an approximately square grid; at 53 °N (near the mid-latitude of the domain) the grid is 7.3 x 7.3 km. The NEMO model used to make these products uses a staggered Arakawa-C, which places tracers and velocity fields at different points as shown in Figure 1.

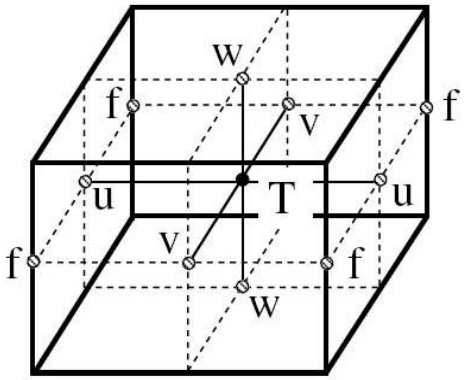

Figure 1: *The Arakawa-C grid showing the relative positions of the tracer (T) and velocity (u, v) fields.*

All products are delivered on the tracer grid. This means velocity fields have been interpolated from their original grid positions.

The reference position of the data point is at the centre of the grid box for which the data is representative, and the data is valid for ±0.5 times the grid resolution in that dimension, i.e. ±1/18° in the longitude and ±1/30° in the latitude. So for a data point with a position given as, for example, 19.888°W, 40.066°N (the furthest south-west grid point in the domain) the data point is valid for a square 19.944°W -19.833 °W, 40.033 °N- 40.099°N.

Table 10: Grid definitions

NORTHWESTSHELF_REANALYSIS_PHYS_004_009 / NORTHWESTSHELF_REANALYSIS_BIO_004_011								
VARIABLE	LON MIN	LON MAX	LAT MIN	LAT MAX	LON SIZE	LAT SIZE	XPOINT	YPOINT
All	19.888°W	13.000°E	40.066°N	65.000°N	0.111°	0.066°	297	375

IV.5 Domain coverage

The domain is pictured below in Figure 2 which shows the model bathymetry separately for (left) on-shelf areas where the depth is less than 200m and off-shelf areas where the depth is greater than 200m (right). The NWS region is a broad shelf, and the models used here in the NWS production have been designed to give optimal results on the shelf (Figure 2, right). The cross-shelf exchange is critical to achieving good results on-shelf, and therefore the models (and products) also include an off-shelf region.

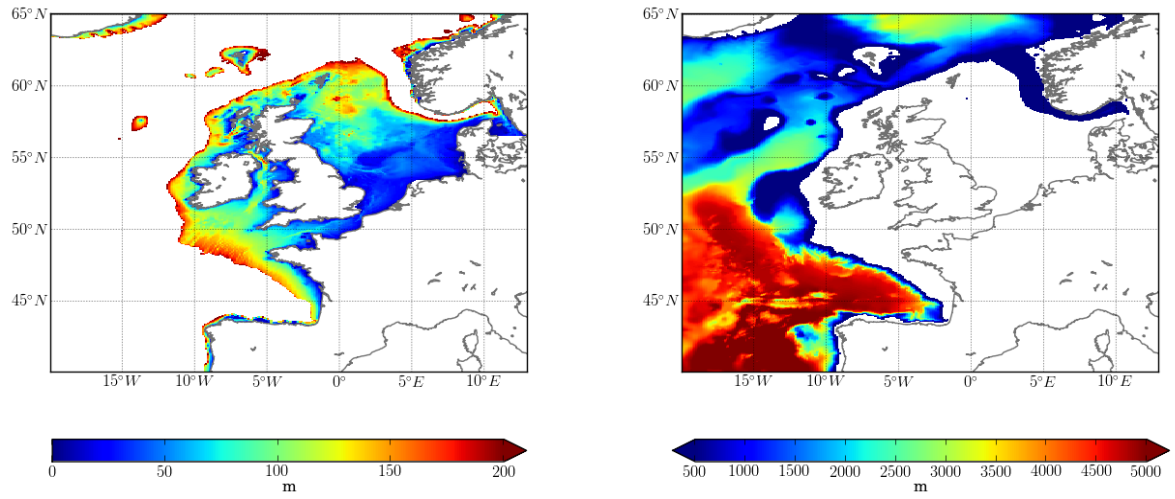

Figure 2: *NWS reanalysis bathymetry (m) showing (left) the domain on the European NorthWest Shelf (defined here as total depth less than 200m) and (right) the domain off the shelf where depth is greater than 200m.*

IV.6 Vertical Levels

The NWS models use terrain-following vertical coordinates. These are stretched in deeper waters to give increased resolution near the surface and sea bed. This is normally referred to as hybrid S-σ coordinates. Some coordinate intersection through the sea bed is also used (for improved numerics), so the model can be considered hybrid S-σ-z-coordinates. These grids, although the best solution for the modelling, are difficult to visualise and to manipulate and so the NWS MFC products are interpolated from the terrain-following coordinate system onto standard depths where appropriate.

All daily and monthly mean parameters are interpolated in the vertical to a standard set of depths based upon ICES standard depths:

0, 3, 10, 15, 20, 30, 50, 75, 100, 125, 150, 200, 250,300, 400, 500, 600, 750, 1000, 1500, 2000, 3000, 4000, 5000.

The sea bed products (both daily mean and monthly mean) are not interpolated.

IV.7 Time averaging

For the reanalysis products daily mean and monthly mean values are available.

Daily mean values are calculated as means of 25 hourly instantaneous values, starting at midnight (UTC) and finishing on the following midnight to remove both diurnal and tidal cycles.

Monthly mean fields are calculated as the average of 24-hour mean fields for each day in the month. NB. This will be different than taking the average of all the daily mean products which, as detailed above, are derived using a 25 hour period.

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 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

All variables are packed, and the netcdf metadata fully describes the scale factors and offsets required to interpret the packing. Most visualization and data handling software will automatically interpret the packing metadata to convert to real-world values.

Example of a daily mean netcdf metadata from these files is given below:

```
netcdf metoffice_foam1_amm7_NWS_TEMP_dm20110307 {
dimensions:
        time = UNLIMITED ; // (1 currently)
        depth = 24 ;
        lat = 375 ;
        lon = 297 ;
variables:
```

```
        short votemper(time, depth, lat, lon) ;
                votemper:_FillValue = -32768s ;
                votemper:missing_value = -32768s ;
                votemper:scale_factor = 0.001f ;
                votemper:add_offset = 298.15f ;
                votemper:standard_name = "sea_water_potential_temperature" ;
                votemper:long_name = "Sea Water Potential Temperature" ;
                votemper:units = "K" ;
                votemper:valid_min = -30000s ;
                votemper:valid_max = 30000s ;
        float depth(depth) ;
                depth:axis = "Z" ;
                depth:standard_name = "depth" ;
                depth:units = "m" ;
                depth:positive = "down" ;
                depth:long_name = "depth" ;
        float time(time) ;
                time:standard_name = "time" ;
                time:units = "seconds since 2011-03-06 00:00:00" ;
                time:calendar = "Gregorian" ;
                time:long_name = "Validity time" ;
                time:axis = "T" ;
        float lat(lat) ;
                lat:standard_name = "latitude" ;
                lat:units = "degrees_north" ;
                lat:long_name = "latitude" ;
                lat:nav_model = "Default grid" ;
                lat:axis = "Y" ;
        float lon(lon) ;
                lon:standard_name = "longitude" ;
                lon:units = "degrees_east" ;
                lon:long_name = "longitude" ;
                lon:nav_model = "Default grid" ;
                lon:axis = "X" ;

// global attributes:
                :Conventions = "CF-1.0" ;
                :title = "Daily-mean (full water column) fields" ;
                :references = "http://www.ncof.co.uk" ;
                :institution = "UK Met Office" ;
                :contact = "servicedesk.cmems@mercator-ocean.eu" ;
                :netcdf-version-id = "3.6.0-p1" ;
                :creation_date = "2014-01-07 08:07Z" ;
```

```
                :product_version = "1.0" ;
                :history = "See source and creation_date attributes" ;
                :source = "UK Met Office Operational Suite, Atlantic Margin Model FOAM 7 km
reanalysis" ;
                :grid_resolution = "Lat-lon 7 km" ;
                :start_date = "2011-03-07" ;
                :start_time = "00:00Z" ;
                :stop_date = "2011-03-07" ;
                :stop_time = "23:59Z" ;
                :file_quality_index = 0s ;
}
```

Example of a file with monthly mean values is given here:

```
netcdf metoffice_foam1_amm7_NWS_TEMP_mm201103 {
dimensions:
        time = UNLIMITED ; // (1 currently)
        depth = 24 ;
        lat = 375 ;
        lon = 297 ;
variables:
        short votemper(time, depth, lat, lon) ;
                votemper:_FillValue = -32768s ;
                votemper:missing_value = -32768s ;
                votemper:scale_factor = 0.001f ;
                votemper:add_offset = 298.15f ;
                votemper:standard_name = "sea_water_potential_temperature" ;
                votemper:long_name = "Sea Water Potential Temperature" ;
                votemper:units = "K" ;
                votemper:valid_min = -30000s ;
                votemper:valid_max = 30000s ;
        float depth(depth) ;
                depth:axis = "Z" ;
                depth:standard_name = "depth" ;
                depth:units = "m" ;
                depth:positive = "down" ;
                depth:long_name = "depth" ;
        float time(time) ;
                time:axis = "T" ;
                time:standard_name = "time" ;
                time:units = "seconds since 2011-03-06 00:00:00" ;
                time:calendar = "Gregorian" ;
                time:long_name = "Validity time" ;
```

```
                time:data_time = 86400. ;
        float lat(lat) ;
                lat:standard_name = "latitude" ;
                lat:units = "degrees_north" ;
                lat:long_name = "latitude" ;
                lat:nav_model = "Default grid" ;
                lat:axis = "Y" ;
        float lon(lon) ;
                lon:standard_name = "longitude" ;
                lon:units = "degrees_east" ;
                lon:long_name = "longitude" ;
                lon:nav_model = "Default grid" ;
                lon:axis = "X" ;


// global attributes:
                :Conventions = "CF-1.0" ;
                :title = "Monthly-mean (full water column) fields" ;
                :references = "http://www.ncof.co.uk" ;
                :institution = "UK Met Office" ;
                :contact = "servicedesk.cmems@mercator-ocean.eu" ;
                :netcdf-version-id = "3.6.0-p1" ;
                :creation_date = "2012-01-07 08:07Z" ;
                :product_version = "1.0" ;
                :history = "See source and creation_date attributes" ;
                :source = "UK Met Office Operational Suite, Atlantic Margin Model FOAM 7 km
reanalysis" ;
                :grid_resolution = "Lat-lon 7 km" ;
                :start_date = "2011-03-01" ;
                :start_time = "00:00Z" ;
                :stop_date = "2011-03-31" ;
                :stop_time = "23:59Z" ;
                :file_quality_index = 0s ;
}
```

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/
- IDL, Matlab, GMT…