Baltic Sea Physical Reanalysis Product

BALTICSEA_REANALYSIS_PHYS_003_008

Issue: 1.5

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CMEMS version scope : Version 3.0

Approval Date :

CHANGE RECORD

Issue	Date	§	Description of Change	Author	Validated By
1.0	2014-12-15	All	Creation of the document	L. Axell	L. Crosnier
1.1	May 1 2015	all	Change format to fit CMEMS graphical rules		L. Crosnier
1.2	January 2016	All	Update for CMEMS V2	V.Huess L. Axell	
1.3	March 2016	All	Includes comments from Mercator Ocean	V.Huess	
1.4	January 2017	All	Update for CMEMS V3	L. Axell	
1.5	March 2017	All	Design Update for the CMEMS V3.0 upgrade	C. Derval, MO V. Huess	

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GLOSSARY AND ABBREVIATIONS

MFC	Monitoring and Forecasting Centre
BAL	Baltic
NetCDF	Network Common Data Form
ftp	Protocol to download files
Subsetter	CMEMS service tool to download a NetCDF file of a selected geographical box using values of longitude, latitude, and time range

I INTRODUCTION

I.1 Summary

This guide describes the Baltic Sea physical reanalysis product BALTICSEA_REANALYSIS_PHYS_003_008 produced by the Copernicus Marine Environment Monitoring Service's (CMEMS) Baltic Monitoring and Forecasting Centre (BAL MFC), the data services that are available to access them and how to use the files and services.

BALTICSEA_REANALYSIS_PHYS_003_008 is the physical reanalysis for the Baltic Sea using the ice-ocean model HIROMB (High-Resolution Operational Model for the Baltic) together with 3D Ensemble Variational data assimilation. The surface variables are available every hour and include sea surface height, ice concentration, total ice thickness, sea surface temperature, sea surface salinity, and horizontal sea surface current components (eastward and northward). The deep variables are available every six hours and include salinity, temperature, and horizontal current components.

The observation types used in the data assimilation are sea surface temperature, sea ice concentration, level ice thickness, and profiles of salinity and temperature. The reanalysis has been produced using six-hour cycling, which implies that every six hours (at 00, 06, 12, 18 UTC), all available observations are assimilated into the model before a six-hour forecast is made. In the present setup, the sea ice and SST observations were available once a day and assumed valid at 00 UTC, whereas the salinity and temperature profiles were assumed to be valid at 12 UTC and 18 UTC, respectively. Hence, no observations are available at 06 UTC.

I.2 History of changes

- **<u>On January 17 2017</u>**

  The product was upgraded to include a complete rerun of the period 1989-2014 as well as the additional year 2015. The reason for rerunning the whole reanalysis from 1989 was that improvements had been made in the data assimilation regarding

  - Sea ice:
    - spurious ice is no longer generated, as in the two previous versions
    - ice thickness is now assimilated throughout the period
  - temperature:

- the warm bias in bottom temperatures in the south-western Baltic Sea has been reduced
- the cold bias in the Kattegat-Skagerrak region has been reduced

- **<u>On April 13 2016</u>**

  The product was upgraded to:

  include year 2014.

  include Bottom Temperature.

  include daily mean values of all variables.

- **<u>on April 8 2015</u>**

  This product was introduced into the MyOcean/CMEMS catalogue. The product covered the time period: 1989 – 2013.

II DESCRIPTION OF THE PRODUCT SPECIFICATION

II.1 General Information

Product Specification	BALTIC_REANALYSIS_PHYS_003_008
Geographical coverage	9°E→ 31°E ; 53°N → 66°N
Variables	Sea surface variations Ice concentration and thickness Temperature Salinity Horizontal velocities (eastward and northward) Bottom temperature
Analysis	Yes
Forecast	Yes
Available time series	From January 1989 to December 2015.
Temporal resolution	Hourly instantaneous values for surface variables, six-hourly instantaneous values for deep variables. Daily mean values.
Target delivery time	n.a.
Delivery mechanism	CMEMS Information System (Subsetter and FTP)
Horizontal resolution	App. 3 nautical miles: Delta Longitude: 5’ or 0.08333 degrees Delta Latitude: 3’ or 0.0500 degrees
Number of vertical levels	Surface layer plus up to 50 vertical levels.
Format	Netcdf CF1.0

Table 1: BALTICSEA_REANALYSIS_PHYS_003_008 Product Specification

II.2 Details of datasets

BALTIC_REANALYSIS_PHYS_003_008	
Datasets	**Variables name** in the NetCDF file and Unit Long_name Standard_name
dataset-reanalysis-hiromb-surface (every hour, only surface data)	**elev** (m) Deviation of sea level from mean sea_surface_height_above_sea_level
	ice_thk (m) Total ice thickness sea_ice_thickness
	ice_cov (0, 1) Ice cover sea_ice_area_fraction
	vvel (m / s) y-component of current northward_sea_water_velocity
	uvel (m / s) x-component of current eastward_sea_water_velocity
	salt (1e-3) Salinity sea_water_salinity
	temp (C) Temperature sea_water_temperature
dataset-reanalysis-hiromb-3D (every six hours, all depths)	**elev** (m) Deviation of sea level from mean sea_surface_height_above_sea_level
	ice_thk (m) Total ice thickness sea_ice_thickness
dataset-reanalysis-hiromb-monthlymeans (monthly means, all depths)	**ice_cov** (0, 1) Ice cover sea_ice_area_fraction
	vvel (m / s) y-component of current northward_sea_water_velocity
dataset-reanalysis-hiromb-dailymeans (daily means, all depths)	**uvel** (m / s) x-component of current eastward_sea_water_velocity
	salt (1e-3) Salinity

	sea_water_salinity
	temp (C) Temperature sea_water_temperature
	bottom_temp (C) Temperature sea_bottom_temperature

Table 2 list of the datasets (column 1) and variable names and unit (column2) for the BALTICSEA_REANALYSIS_PHYS_003_008

II.3 Production System Description

II.3.1 Description

The circulation model used is HIROMB (High-Resolution Operational Model for the Baltic). It has been the operational ocean and sea ice forecasting model used at SMHI (the Swedish Meteorological and Hydrological Institute) since the mid 1990s, and has delivered forecasting data to the countries surrounding the Baltic Sea for almost 20 years. Version 2.0 of HIROMB ("hiromb-2.0") was described by Wilhelmsson (2002) and Funkquist and Kleine (2007), and the changes in the ice model and turbulence scheme leading to hiromb-3.0 are described in Axell (2013). Later changes include improved air-ice and air-sea interaction, thermodynamics and a rotated grid. In the operational setup (as well as in the present work), the domain covers the North Sea as well as the Baltic Sea; see Figure 1.

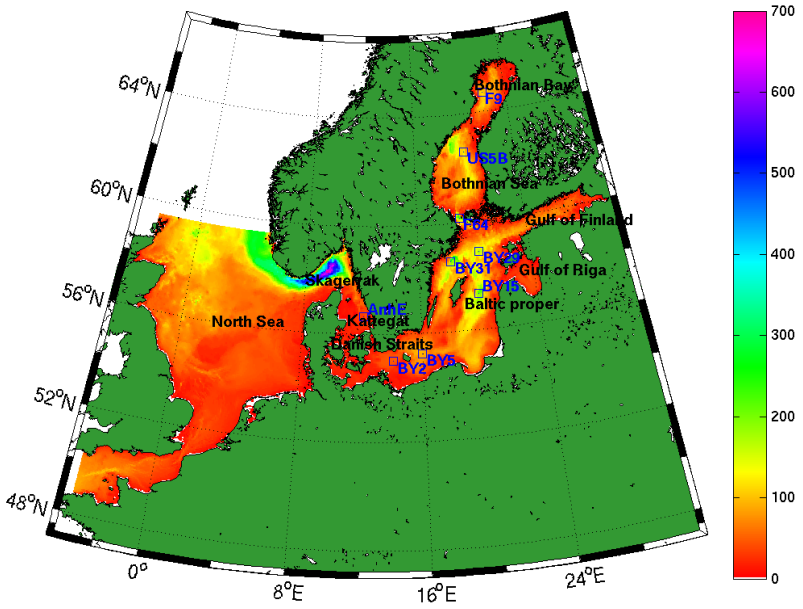


Figure 1. Map of the North-Sea Baltic Sea area showing the model domain.

At the lateral boundary in the western English Channel and along the Scotland-Norway boundary, the sea levels are prescribed using a coarse (24 nautical miles resolution) storm-surge model called NOAMOD (North Atlantic Model). Climatological monthly mean values of salinity and temperature are used at the boundary, and it is assumed there is no sea ice.

The turbulence model is a state-of-the-art buoyancy-extended k-omega model, with parameterizations for internal wave energy and Langmuir circulation (see Axell, 2002, Umlauf et al., 2003). The ice model has a Hibler-type of ice rheology and has parameterizations for ice ridges included, based on the work by Lensu (2003); see also the ice model descriptions in Wilhelmsson (2002) and Axell (2013).

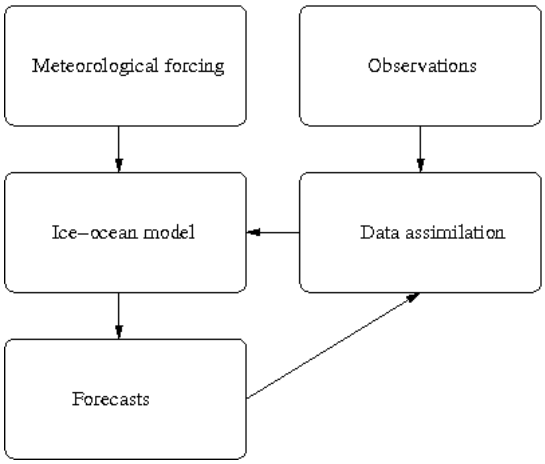
The river runoff is specified as daily means from the output of the hydrological model E-HYPE, run operationally at SMHI. The number of rivers is of the order of 500 along the coastline.

The meteorological forcing is from the HIRLAM (High-Resolution Limited Area Model) model with 22 km resolution, from the recently finished project Euro4M (Dahlgren et al., 2014) and covers the most of the reanalysis period, 1989-2013. From 2014 onwards, the meteorological forcing is from the SMHI version of the operational HIRLAM forecasts, 11 km resolution.

The data assimilation method chosen for this project is 3D Ensemble Variational (3D EnVar), which is a variational technique using an ensemble of model states; see Liu et al. (2008, 2009) and Axell and Liu (2016). It is a multivariate method, which means many variables are affected by each observation. The model uncertainty is specified using an ensemble of model states, which implies that the Background Error Covariances are inhomogeneous and non-isotropic.

The variables assimilated are charts of SST, SIC (Sea Ice Concentration) and SIT (Sea Ice Thickness) from the Swedish Ice Service at SMHI as well as in-situ meassurements of T/S (Temperature and Salinity) profiles from the ICES data base (http://www.ices.dk). Independent T/S profiles are obtained from the Swedish data base SHARK (Svenskt Havsarkiv) at SMHI.

The forecasting system is run with six-hour cycling, which implies a new forecast of six hours is made every six hours (at 00Z, 06Z, 12Z and 18Z), using the best weather forcing. The 2-D fields of observations (SST, SIC and SIT) are assimilated at 00Z whereas the salinity profiles are assimilated at 12Z and the temperature profiles at 18Z.



III

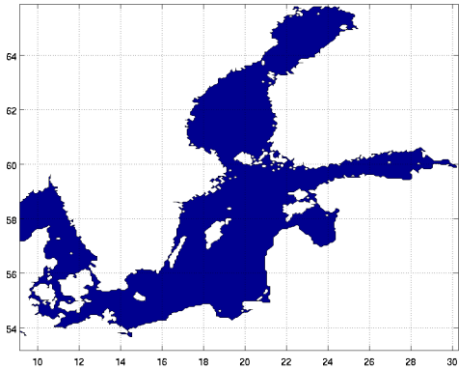
Figure 2. Schematic showing the forecasting cycle.

Domain

Resolution and grid

Geographic coverage

North Sea – Baltic Sea **:** 53°N - 66°N, 9°E - 30°E
The Grid type is on a regular projection. The native grid has larger domain, covering the whole North Sea and the English Channel.



The horizontal grid step is regular in latitude and longitude and the resolution is approximately 3 nautical miles (lat: 0.0500 degrees; lon: 0.0833 degrees). The grid is a staggered Arakawa C-grid (see figure 3). The dataset of the scalar variables (temperature, salinity, sea Level and ice) are centred in the T point of the grid; at the grid cell node. The velocity components are located half-way between adjacent grid cell nodes on the face of the grid cell in the respective direction. That is, the components of the velocity vector (u, v) have spatially staggered locations.

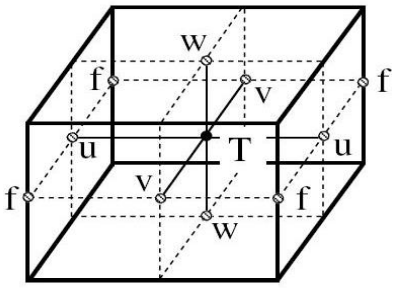


Figure 1: The staggered Arakawa C-grid used by BAL-MFC numerical models.

BALTICSEA_REANALYSIS_PHYS_003_008

VARIABLE	GRID	LON MIN	LON MAX	LAT MIN	LAT MAX	XPOINT
All scalar variables (see text)	T	9.014˚E	30.347˚E	53.842˚N	65.892˚N	257
Eastward velocity	U	As above	As above	As above	As above	As above
Northward velocity	V	As above	As above	As above	As above	As above

Table 3: Description of the staggered grid and spatial coverage for each variable

Vertical grid	BALTICSEA_REANALYSIS_PHYS_003_008 product is delivered on the surface layer plus the 50 native vertical levels [m]: 2, 6, 10, 14, 18, 22, 26, 30, 34, 38, 42, 46, 50, 54, 58, 62, 66, 70, 74, 78, 82.5, 87.5, 92.5, 97.5, 102.5, 108, 114, 120, 126.5, 133.5, 141, 149.5, 159, 169.5, 182, 197.5, 216.5, 240, 269, 303, 340.5, 380, 420, 460, 500, 540, 580, 620, 660, 700.

IV HOW TO DOWNLOAD A PRODUCT

Before download of a product you first need to register. Please register through CMEMS web page by following link 'Register now' (http://marine.copernicus.eu/services-portfolio/register-now/) or see the online tutorial at http://marine.copernicus.eu/tutorials/how-to-register-to-copernicus-marine-service-update-september-2015/

IV.1 Download a product through the CMEMS Web Portal

Once registered, the tutorial:

http://marine.copernicus.eu/web/95-online-tutorials.php?item=1949

will guide you on *How to download* a product .

V NOMENCLATURE OF FILES

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

BALTICSEA_REANALYSIS_PHYS_003_008 file nomenclature when downloaded through the CMEMS Web Portal Subsetter is based on product dataset name and a numerical reference related to the request date on the MIS.

The scheme is: **datasetname_nnnnnnnnnnnn.nc**

where :

datasetname is the character string :

"dataset-reanalysis-hiromb-surface" for surface variables (every hour)

"dataset-reanalysis-hiromb-3D" for 3-D variables (every six hours)

"dataset-reanalysis-hiromb-dailymeans" (for daily means)

"dataset-reanalysis-hiromb-monthlymeans" (for monthly means)

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

since January 1, 1970 midnight UTC.

.nc: standard NetCDF filename extension.

V.2 Nomenclature of files when downloaded through the CMEMS Web Portal FTP Service

BALTICSEA_REANALYSIS_PHYS_003_008 file nomenclature when downloaded through the CMEMS Web Portal FTP service is based on the original file names behind the products. The files are in NetCDF and are named:

CMEMS_SMHI_PHYS_reanalysis_surf_"analysistime".nc for surface variables (every hour, 24 time steps)

CMEMS_SMHI_PHYS_reanalysis_deep_“analysistime”.nc for 3-D variables (every six hours, 4 time steps)

CMEMS_SMHI_PHYS_reanalysis_dailymeans_“analysistime”.nc for 3-D variables (every 24 hours, 1 time step)

CMEMS_SMHI_PHYS_reanalysis_monthlymeans_“analysistime”.nc for 3-D variables (every month, 1 time step)

“analysistime” indicates the first timestamp in the file.

VI FILE FORMAT

VI.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.

VI.2 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…