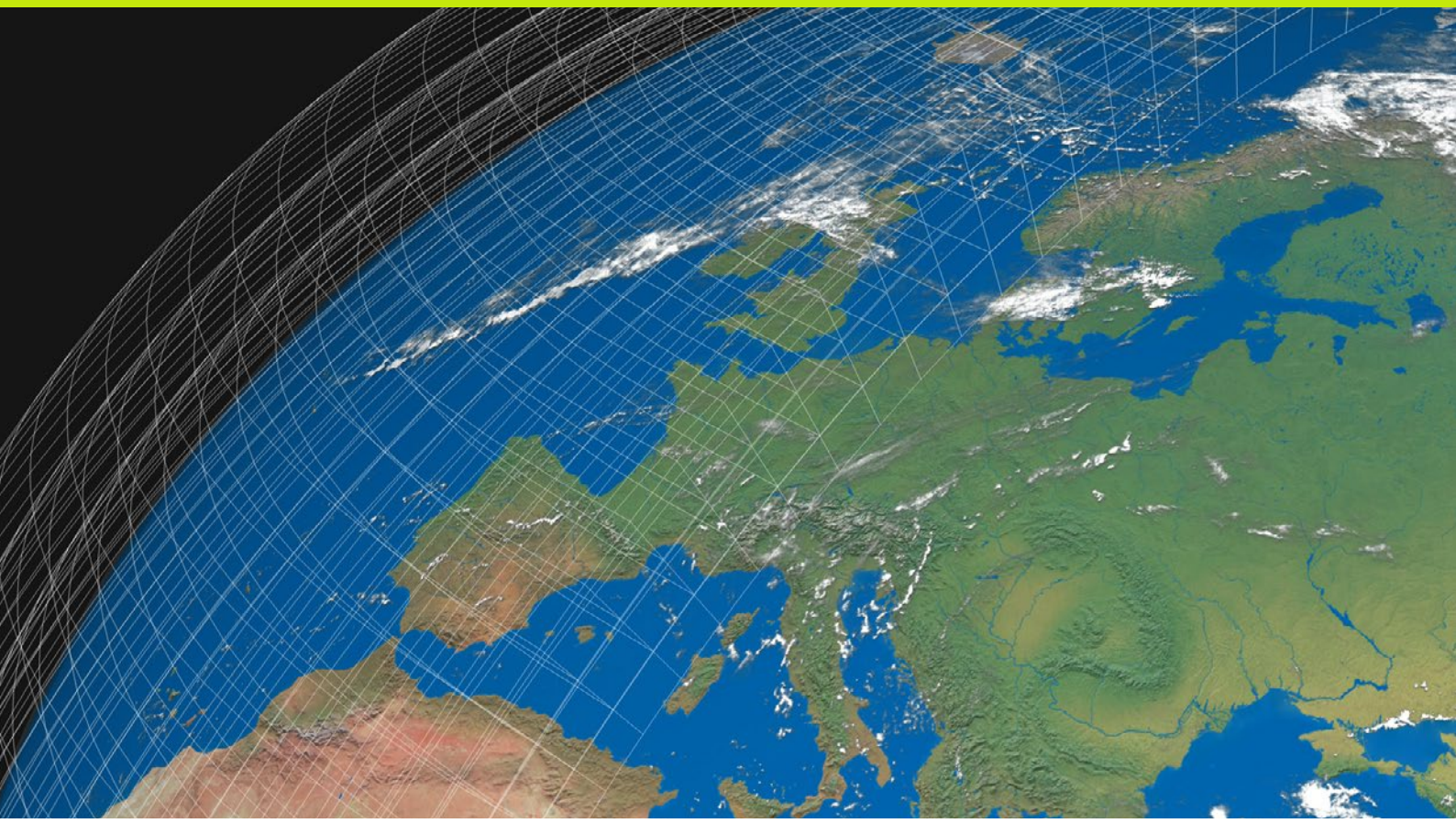
Met Office

Product user manual



For Global Ocean level-1 data products from the Met Office Global Coupled Atmosphere-Land-Ocean-Ice system

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CHANGE RECORD

Issue	Date	§	Description of Change	Author	Approver
0.1	20/12/18	All	Document adapted from Copernicus Marine product user manual.	M. Price	
0.2	8/1/19	III.1, III.7	Minor edit from review comments.	M Price	
1.0	19/12/24	All	Section II rewritten for Global Coupled system, minor updates other sections.	J Roberts Jones M Price	Andy Saulter

TABLE OF CONTENTS

I INTRODUCTION

This guide describes the level-1 data products from the Global Ocean component of the Met Office Global Coupled Atmosphere-Land-Ocean-Ice system which has been running in operations since May 2022. The system provides a global physical analysis and coupled forecast products providing:

- 3D daily mean fields of temperature and salinity, zonal and meridional velocities,
- 2D daily mean fields of sea surface height, bottom temperature, mixed layer depth, sea ice fraction, sea ice thickness and sea ice zonal and meridional velocities,
- Instantaneous hourly fields for sea surface height, sea surface temperature and surface currents.

Section II is a brief system description, sections III and IV provide technical details of the data products. References are given in section V.

II PRODUCTION SYSTEM DESCRIPTION

II.1 INTRODUCTION

The coupled modelling system being used to provide the analysis and forecast products is the Met Office Global Coupled Atmosphere-Land-Ocean-Ice system which has been running in operations since May 2022.

The model components of the global coupled system are from the Global Coupled model version 4 (GC4) of the MetUM system (Xavier et al, 2024). The atmosphere-land surface component and the ocean-ice components are coupled every hour using the OASIS3-MCT coupler. The coupled forecast is initialised by weakly coupled data assimilation (DA). In this approach the coupled model is used to provide background information for separate ocean and sea ice and atmosphere and land analyses. The increments generated from these separate analyses are added back into the coupled model. The technical development of the coupled system is described in Lea et al., (2015).

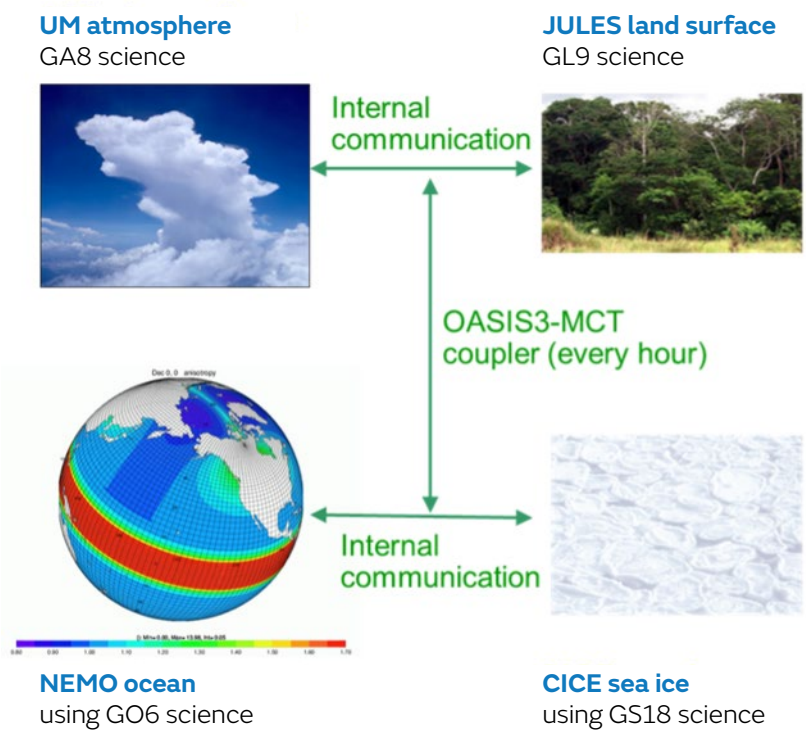


Figure 1. Schematic of the Global Coupled Atmosphere-Land-Ocean-Ice system.

The Met Office Global Coupled Atmosphere-Land-Ocean-Ice system is comprised of both deterministic and ensemble forecasting systems both of which are coupled to an interactive ocean. Ocean and ice analysis and forecast products are currently generated from the deterministic system once a day with forecast with lead time out to 7 days, interpolated onto a regular latitude-longitude grid products by our Global Marine Post Processing (MaPP-GL) system.

Below we describe in more detail each component of the Met Office Global Coupled Atmosphere-Land-Ocean-Ice system and its operational implementation.

II.2 OCEAN-ICE COMPONENT

The ocean-ice component of the Met Office Global Coupled Atmosphere-Land-Ocean-Ice forecasting system is the Forecast Ocean Assimilation Model (FOAM) Global Coupled (GC) system, hereafter referred to as FOAM-GC. The FOAM-GC system runs at the Met Office and produces ocean and sea ice analyses and forecasts out to 7 days.

FOAM-GC uses the Nucleus for European Modelling of the Ocean (NEMO) for the physical ocean model and the Community Ice CodE (CICE) for the sea ice model and currently uses the GO6 Global Ocean configuration (Storkey et al, 2018) and GSI8.1 Global Sea Ice configuration (Ridley et al, 2018). FOAM-GC uses the ORCA tripolar grid at ¼ degree horizontal resolution (~25 km) with 75 levels with variable vertical resolution ranging from 1 m near the surface to 200 m at depth.

FOAM assimilates observational data from a variety of sources using the NEMOVAR data assimilation (DA) scheme which is an incremental 3D-Var, first guess at appropriate time (FGAT) scheme specifically designed for use in systems using the NEMO model (Waters et al, 2015). The FOAM system and the data assimilation methodology is described in detail in Barbosa Aguiar et al (2024).

Marine observations assimilated in FOAM-GC are as follows:

- Satellite SST – sub-sampled MetOP-B AVHRR, NOAA-20 and Suomi NPP VIIRS, Sentinel-3A and 3B SLSTR infrared radiometers, GCOM-W1 AMSR2 microwave radiometer observations provided by the GHRSST project.
- In-situ SST – moored buoys, drifting buoys and ships. Drifting buoy observations are considered unbiased and are used as a reference to bias correct satellite SST observations.
- Satellite sea level anomaly – Cryosat-2, SARAL Altika, Jason-3, Sentinel-3A and 3B and Sentinel-6A altimeter observations. All from CMEMS product SEALEVEL_GLO_PHY_L3_NRT_008_044. Note these data are assimilated using the CNES CLS13 Mean Dynamic Topography (MDT).
- Sub-surface temperature and salinity profiles - from Argo profiling floats, underwater gliders, moored buoys, marine mammals, and manual profiling methods
- Satellite sea ice concentration – SSMIS data provided by the EUMETSAT OSI-SAF as a daily gridded product on 10km polar stereographic projection

II.3 ATMOSPHERIC AND LAND SURFACE COMPONENT

The atmospheric-land surface component uses the Global Atmosphere 8 and Global Land 9 configurations (GA8GL9) (Xavier et al, 2024). The deterministic system uses the N1280 grid which is ~10 km horizontal resolution (at mid-latitudes) while the ensemble system uses the N640 grid at ~20 km horizontal resolution, both systems have 70 vertical levels.

The global coupled ensemble has 44 members and is initialised using the 4D-ensemble-Var DA scheme, this ensemble provides flow-dependent background errors for the deterministic system using the Hybrid Incremental 4D-Var scheme, (Inverarity et al, 2023). The land surface model is initialised with a simplified Extended Kalman Filter.

II.4 OPERATIONAL IMPLEMENTATION

The global coupled system inherited the cycling strategy of the atmospheric system. The operational deterministic global coupled system which generates marine products runs a 6-hour assimilation window valid from T-3 to T+3 four times a day at 00Z, 06Z, 12Z and 18Z. In the 00Z and 12Z cycles a forecast out to 7-days is run, shorter 2-day forecast are produced in the 06Z and 18Z cycles. Note that ocean analysis and forecast products are only generated once daily from the 00Z 7-day forecast. Within each cycle a set of forecast/analysis models are run. The main analysis and forecast model (GLM) is run at T+2:40 so observations need to be available within 2 hours 40 minutes (assuming an observation with validity time in the middle of the assimilation window) to be assimilated in this main model and directly initialise the forecast. This is unrealistic for the majority of marine observation types assimilated by FOAM-GC. A set of analysis-only update models (named GLU, GLV and GLW) are run at increased latency as shown by table 1, the timing of these update models was designed with the observational availability in mind. For observational data (valid in the middle of the assimilation window) to be picked up by the latest running GLW analysis it needs to be available for assimilation within 15 hours 15 minutes. Any observations not timely enough to be used by the GLW analysis will not by assimilated by the FOAM-GC system. The analysis-only update models provide the initial state for subsequent cycles models as illustrated by figure 2, thus the information from these analyses is able to indirectly constrain the coupled forecasts. Note the GLV model is only run in 00Z and 12Z cycles.

Model	Latency (HH:MM)	Analysis/Forecast
GLM	02:40	Analysis & Forecast
GLU	06:15	Analysis
GLV*	10:45	Analysis
GLW	15:15	Analysis

Tabel 1. Latency of the main forecast model (GLM) and update analysis-only models (GLU, GLV, GLW) in the operational global coupled forecasting system. * GLV model is only run in the 00Z and 12Z cycles.

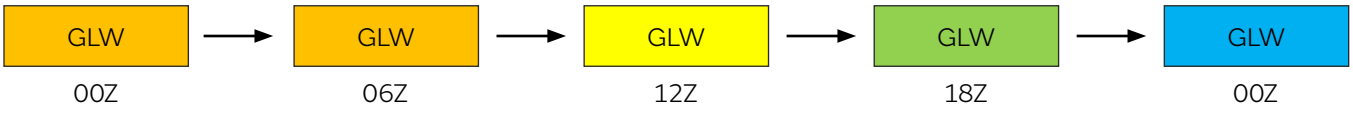


Figure 2. Inter-cycle model dependencies for the 00Z main forecast model (GLM).

III PRODUCT DETAILS

III.1 OVERVIEW

Product Specification	Global Ocean level-1 products from the Met Office Global Coupled Atmosphere-Land-Ocean-Ice system
Geographical coverage	Global
Variables [temporal resolution in brackets]	Temperature [3d daily mean + 2D surface hourly instantaneous] Bottom temperature [2D bottom daily mean] Salinity [3D daily mean] Sea surface height [2D daily mean + 2D hourly instantaneous] Horizontal velocity (meridional and zonal component) [3D daily mean + 2D surface hourly instantaneous] Mixed layer depth [2D daily mean] Sea ice fraction [2D daily mean] Sea ice velocity (meridional and zonal component) [2D daily mean] Sea ice thickness [2D daily mean]
Analysis	2 days: best estimate (day-minus-2) and analysis (day-minus-1)
Forecast	7 days
Target delivery time	12:00 UTC
Horizontal resolution	¼ degree (regular latitude-longitude grid)
Number of vertical levels	43 (0 to 5500m)
Format	Netcdf-4
Metadata conventions	CF-1.7, ACDD-1.3

III.2 LIST OF VARIABLES

VARIABLE AND UNITS	NAME OF VARIABLE IN THE NETCDF FILE
Zonal Velocity [m/s]	
Meridional Velocity [m/s]	uo
vo	
Sea Surface Height [m]	zos
Temperature [degrees C]	thetao
Bottom temperature [degrees C]	bottomT
Salinity [PSU]	so
Mixed Layer Depth [m]	mlotst
Sea Ice Thickness [m]	
Sea Ice Fraction	
Sea Ice Zonal Velocity [m/s]	
Sea Ice Meridional Velocity [m/s]	sithick
siconc	
usi	
vsi	

III.3 FILE NAMES

Filenames are generally not visible to users or our data services, but are described here for reference. The filenames are constructed as follows:

{prod-type}_{config}_{model}_{region}_{parameter}_{bul date}_{freq flag}{average flag}{valid date}.nc

where

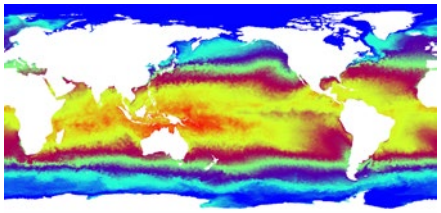
- **prod-type** is the type of data product i.e. 'level1'
- **config** identifies the producing system i.e. 'coupled'
- **model** identifies the model configuration i.e. 'orca025'
- **region** is a three letter code for the region i.e. 'GL4'
- **parameter** is a three letter code for the parameter or parameter (see Table 4).
- **bul date** bYYYYMMDD is the bulletin date the product was produced
- **freq flag** is the frequency of data values in the file (d = daily, h = hourly)
- **average flag** is i=instantaneous, m=mean
- **valid date** YYYYMMDD is the validity day of the data in the file

TEM	Potential temperature
BED	Bottom temperature
SAL	Salinity
CUR	Water velocities
SSH	Sea surface height
ICE	Sea Ice Variables
MLD	Mixed Layer Depth

For example file **level1_coupled_orca025_GL4_SSH_b20241207_dm20241205.nc** contains the (T-48h to T-24h] daily-mean Sea Surface Height analysis produced on the 7th December 2024 and valid for the 5th December 2024.

III.4 DOMAIN COVERAGE

The NEMO model for these products uses the tripolar ORCA025 grid, while the level-1 products are interpolated from the native model grid to a regular latitude-longitude grid with horizontal grid size of 1/4°. All variables are released on the same points of the grid.

Dataset	Domain	Boundaries	Projection	Resolution Grid size	Image
Met Office Global Coupled Atmosphere-Land-Ocean-Ice system	Global	0-360°E 83°S-89.75°N	Regular	1/4° 1440 x 692	

Regular projection: longitude and latitude step is constant	

III.5 VERTICAL LEVELS

The level-1 products are provided on 43 vertical levels:

depth = 0, 5, 10, 15, 20, 25, 30, 40, 50, 60, 75, 100, 125, 150, 175, 200, 225, 250, 300, 400, 500, 600, 700, 800, 900, 1000, 1100, 1200, 1300, 1400, 1500, 1750, 2000, 2250, 2500, 2750, 3000, 3250, 3500, 4000, 4500, 5000, 5500

III.6 HORIZONTAL COORDINATES

longitude = 0 to 359.75 (0.25 degree steps)

latitude = -83 to 89.75 (0.25 degree steps)

III.7 TIME COORDINATE

time = time in seconds since T+00h (midnight prior to bulletin day).

For daily mean products time is in the centre of the validity period.

III.8 UPDATE TIME

The products are updated daily by 12:00 UTC (usually by 10:30 UTC).

III.9 DAILY TEMPORAL COVERAGE

T+00h is the midnight prior to production, the following are produced:

- T-48h to T-24h best estimate
- T-24h to T+00h analyses
- 7 day forecast (from T+00h)

IV FILE FORMAT

The products are stored in NetCDF-4 format, see:

- https://www.unidata.ucar.edu/software/netcdf/

NetCDF-4 lossless compression is applied, which is transparent to the user (assuming NetCDF libraries which support it are used).

The CF-1.7 metadata conventions are followed see:

- http://cfconventions.org/

Some elements of the ACDD1.3 are also used, see:

- http://wiki.esipfed.org/index.php/Attribute_Convention_for_Data_Discovery

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