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Deliverable Lead authors	Rita Lecci (CMCC)
Deliverable Contributors	Gianandrea Mannarini (CMCC), Sergio Cretì (CMCC)
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1. Executive Summary

This report includes useful information for establishing an operational chain of forecast fields to feed the tool for eco-routes of the GUTTA project. It is based on the data feed available at the data center of CMCC and focuses on meteo-oceanographic variables relevant to ferry boat navigation.

2. Introduction

According to the ISO 15016:2015 standard (s. Bibliography), the environmental fields that have a major impact on speed and engine power use of vessels are: wind, sea state (i.e., surface gravity waves), water temperature and density (for their effect on viscosity), and sea currents.
The availability of real-time model outputs relative to these fields is then a crucial input for an automated vessel voyage planner, such as the GUTTA's one. In the following (Sect.3), a catalogue of these fields is provided, from the viewpoint of the operational data centre of CMCC.
The Appendix includes a few useful commands for directly operating on environmental field files stored in netcdf format.

3. Catalogue of fields

The environmental fields of interest described in the following subsections (among brackets) are:
(3.1): Wind
(3.2): Waves
(3.3): Sea currents
(3.4): Temperature and density

Apart from water Temperature and density (cf. Sect.3.4), they immediately correspond to forecast model outputs.

3.1 Wind

In the following subsections, information about the wind forecast model and its outputs are provided.

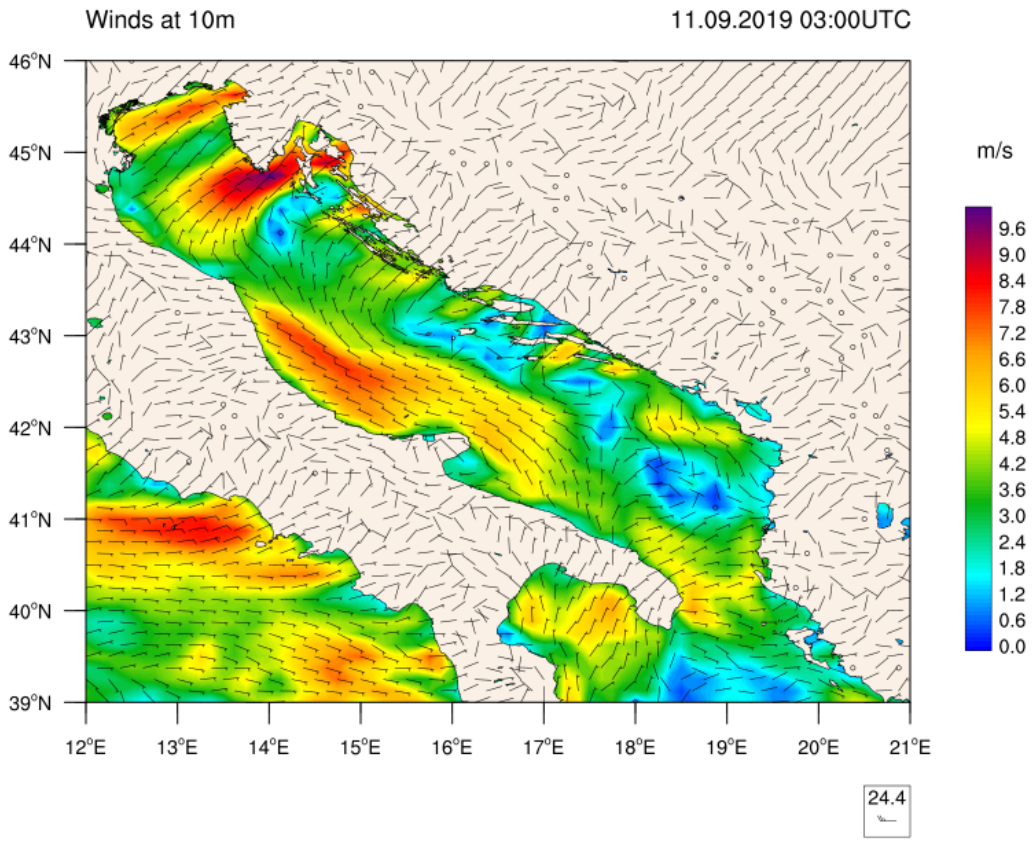

Figura 1 Example of 10m-wind magnitude and direction field from ECMWF 1/8 degree forecast model.

3.1.1 Model information

Specification	Value
Production Unit	ECMWF (UK)
Model name and version	Integrated Forecasting System (IFS)
Model short description	The IFS consists of several components coupled together: an atmospheric model, an ocean wave model (ECWAM), an ocean model (NEMO) including a sea ice model, a land surface model (HTESSEL) including a lake model (FLake), a data analysis system (4D-VAR), and perturbation techniques for generation of the ensembles. The IFS models the dynamics of the atmosphere and the physical processes that occur, and other processes that influence the weather such as atmospheric composition, surface energy fluxes, the marine environment and processes at the atmosphere/surface interface. The IFS is documented in detail at: https://www.ecmwf.int/en/publications/ifs-documentation
Type of fields	- Analyses - Forecasts
Available analysis fields	- Everyday at 00 UTC - Everyday at 12 UTC

3.1.2 Output variables

Variable	Units	Nc variable name
Mean sea-level pressure	hPa	MSL
2 metre dewpoint temperature	K	T2M
2 metre temperature	K	D2M
Land-Sea mask, 1 all land, 0 all sea	1	LSM

10 metre U wind component	m/s	U10M
10 metre V wind component	m/s	V10M

3.1.3 Spatial Grid

feature	Value	
Geographical coverage	Longitude	19 °W → 42° E
	Latitude	30 °N → 48 °N
Grid size	Longitude	489
	Latitude	145
Resolution	0.125°	
Vertical levels	surface	10m height

3.1.4 Temporal Grid

feature	value	
Time steps		52
Resolution	0-72h	3 h
	72h-240h	6 h

Target delivery time

KK (UTC)		Target (UTC)
/	an	08:00
00	an00	08:00
00	fc00	08:00
12	an12	20:00
12	fc12	20:00

3.2 Waves

In the following subsections, information about the wave forecast model and its outputs are provided.

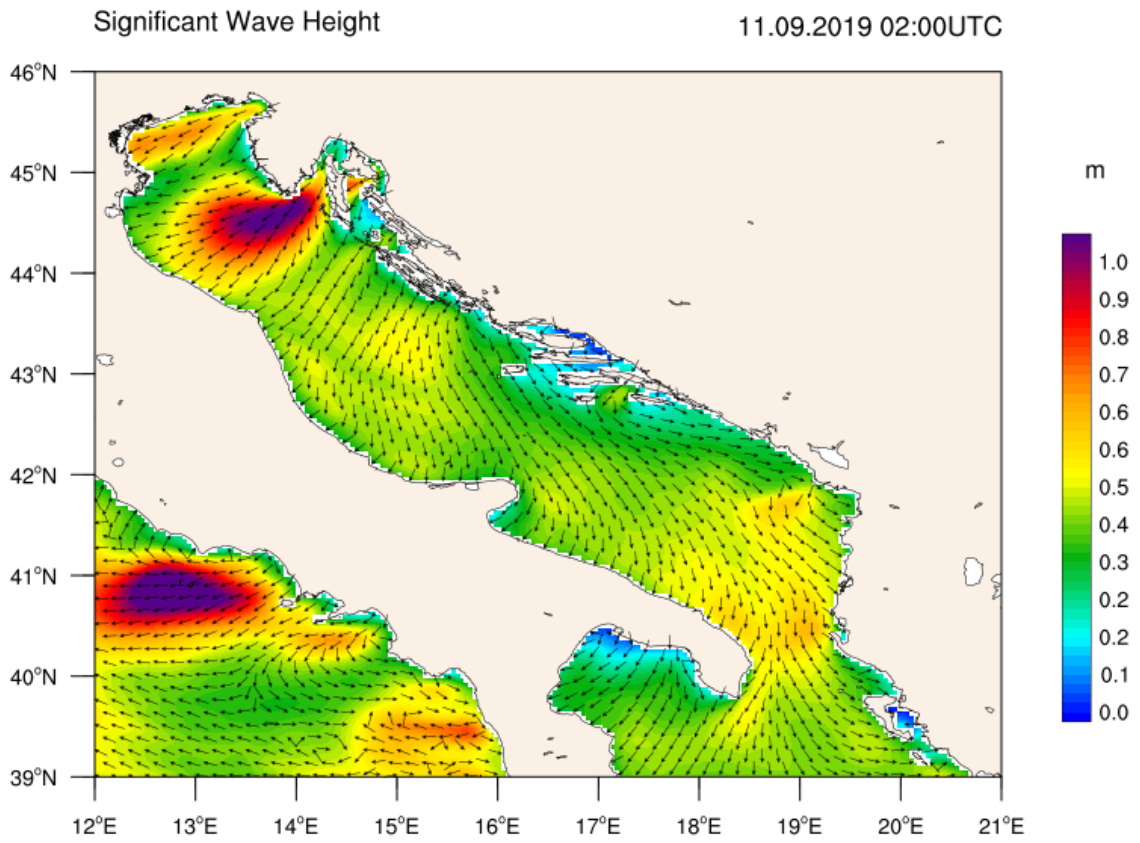

Figure 2 Example of significant wave height and direction field from WAM 1/24 degree forecast model.

3.2.1 Model information

Specification	Value
Production Unit	HCMR (GR)
Model name and version	WAve Model (WAM)
Model short description	The wave component of the Mediterranean Forecasting System (Med-Waves) is a wave model based on WAM Cycle 4.6.2 with proper tuning and maximum spectral steepness limitation and it has been developed as a nested sequence of two computational grids (coarse and fine) to ensure that swell propagating from the North Atlantic (NA) towards the strait of Gibraltar is correctly entering the Mediterranean Sea (MED). The coarse grid covers the North Atlantic Ocean from 75°W to 10°E and from 70°N to 10°S in 1/6° resolution while the nested fine grid covers the Mediterranean Sea from 18.125°W to 36.2917°E and from 30.1875°N to 45.9792°N with a 1/24° (~4.6km) resolution. The Med-Waves modelling system resolves the prognostic part of the wave spectrum with 24 directional and 32 logarithmically distributed frequency bins and the model solutions are corrected by an optimal interpolation data assimilation scheme of along track satellite significant wave height observations. The system provides a Mediterranean wave analysis and 10 days Mediterranean wave forecasts updated daily.
Type of fields	- Analyses - Forecasts
Available analysis fields	- Everyday at 05 UTC

3.2.2 Output variables

Variable	Units	Nc variable name
sea_surface_wave_significant_height	degree	VHM0
sea_surface_wave_period_at_variance_spectral_density_maximum	s	VTPK
sea_surface_wave_mean_period_from_variance_spectral_density_inverse_frequency_moment	s	VTM10
sea_surface_wave_mean_period_from_variance_spectral_density_second_frequency_moment	s	VTM02
sea_surface_wave_from_direction	degree	VMDR

sea_surface_wind_wave_significant_height	m	VHM0_WW
sea_surface_wind_wave_mean_period	s	VTM01_WW
sea_surface_wind_wave_from_direction	degree	VMDR_WW
sea_surface_wave_from_direction_at_variance_spectral_density_maximum	degree	VPED
sea_surface_primary_swell_wave_significant_height	m	VHM0_SW1
sea_surface_primary_swell_wave_mean_period	s	VTM01_SW1
sea_surface_primary_swell_wave_from_direction	degree	VMDR_SW1
sea_surface_secondary_swell_wave_significant_height	m	VHM0_SW2
sea_surface_secondary_swell_wave_mean_period	s	VTM01_SW2
sea_surface_secondary_swell_wave_from_direction	degree	VMDR_SW2
sea_surface_wave_stokes_drift_x_velocity	m/s	VSDX
sea_surface_wave_stokes_drift_y_velocity	m/s	VSDY

3.2.3 Spatial Grid

feature	Value	
Geographical coverage	Longitude	18.125 °W → 36.2917° E
	Latitude	30.1875 °N → 45.9792 °N
Grid size	Longitude	1307
	Latitude	380
Resolution	0.0417°	
Vertical levels	surface	

3.2.4 Temporal Grid

feature	value	
Time steps		24
Resolution	0-23h	1 h

Target delivery time

	Target (UTC)
an	05:00
fc	05:00

3.3 Currents

In the following subsections, information about the sea currents forecast model and its outputs are provided.

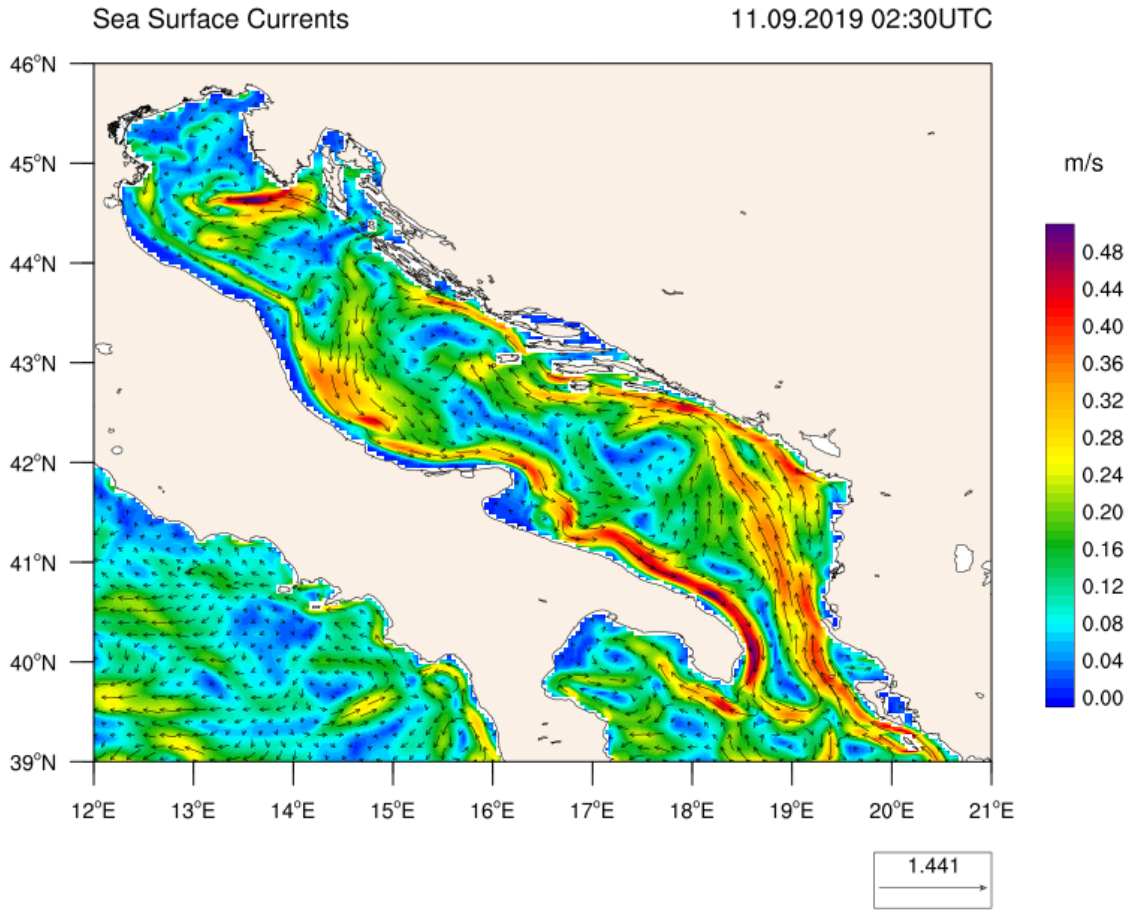

Figure 13 Example of sea surface current magnitude and direction field from MFS 1/24 degree forecast model.

3.3.1 Model information

Specification	Value
Production Unit	CMCC (IT)
Model name and version	Mediterranean Forecasting System (MFS)
Model short description	The physical component of the Mediterranean Forecasting System (Med-Currents) is a coupled hydrodynamic-wave modeling system implemented over the whole Mediterranean Basin. The model horizontal grid resolution is 1/24˚ (ca. 4 km) and has 141 unevenly spaced vertical levels. The hydrodynamics are supplied by the Nucleous for European Modelling of the Ocean (NEMO v3.6) while the wave component is provided by WaveWatch-III; the model solutions are corrected by a variational data assimilation scheme (3DVAR) of temperature and salinity vertical profiles and along track satellite Sea Level Anomaly observations. Objective Analyses-Sea Surface Temperature fields are used for the correction of surface heat fluxes with the relaxation constant of 110 W m-2 K-1 applied close to midnight.
Type of fields	- Analyses - Simulation - Forecasts
Available analysis fields	- Analyses: on Wed at 03 UTC - Simulation and Forecasts: everyday at 03 UTC

3.3.2 Output variables

Variable	Units	Nc variable name
zonal current	m/s	uo
meridional current	m/s	vo

3.3.3 Spatial Grid

feature	Value	
Geographical coverage	Longitude	17.29167°W → 36.29167° E
	Latitude	30.1875°N → 45.97917°N
Grid size	Longitude	1287
	Latitude	380

Resolution	0.0417°
Vertical levels	1.01823664, 3.1657474, 5.46496344, 7.92037725, 10.536603, 13.3183842, 16.270586, 19.3982105, 22.7063923, 26.2003994, 29.885643, 33.7676735, …, 5539.3335, 5646.19922, 5754.04395

3.3.4 Temporal Grid

feature	value	
Time steps		24
Resolution	0-23h	1 h

Conclusions

A catalogue of the most relevant environmental fields for navigation (wind, sea state and sea current) is prepared. The catalogue takes the viewpoint of the operational data centre of CMCC, where a data feed is maintained containing all these fields.
The 3D fields (currents) will be reduced to 2D fields by extracting the values at the surface layer.

References

IMO MEPC 68/INF.14 (Annex) ”ISO 15016:2015”. Technical report, International Maritime Organization, London, UK, 2015.

Gill & Donn, “Atmosphere—Ocean Dynamics 1st Edition”, Appendix 3.5 (1982)