CMCC WEBINAR

April 05, 2019 - h. 3.00 pm CEST

IMMERSE User Remote Workshop on Interfaces

Stefania Ciliberti , Laura Stefanizzi - Presenters
Euro-Mediterranean Centre on Climate Change Foundation (CMCC)

Yann Drillet - Presenter
Mercator Ocean International

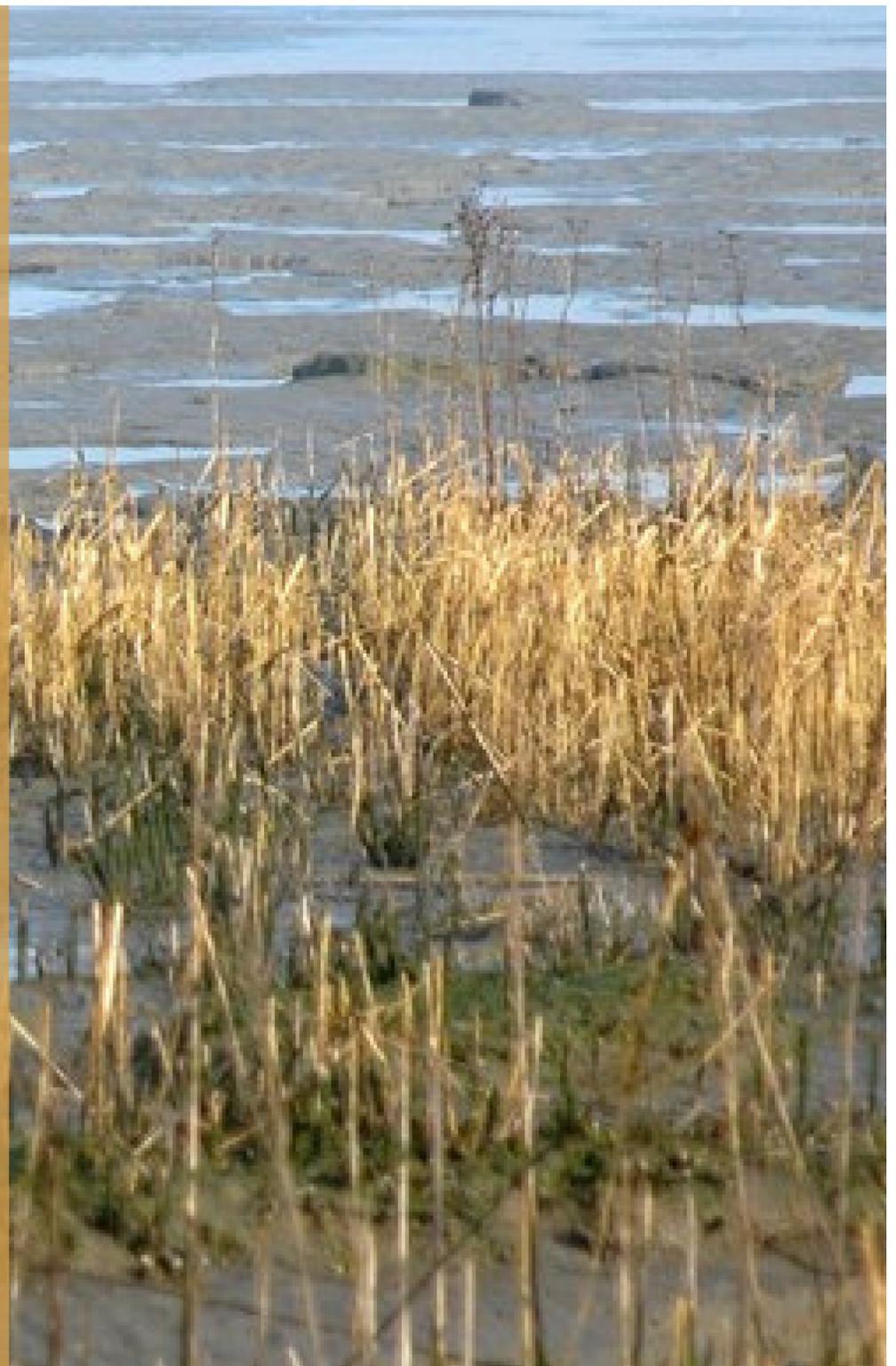**Michela De Dominicis, James Harle, Jeff Polton - Presenters**
National Oceanography Center (UK)

Dorotea Iovino - Presenter & Moderator
Euro-Mediterranean Centre on Climate Change Foundation (CMCC)

cmcc immerse
IMPROVING OCEAN MODELS
FOR THE COPERNICUS PROGRAMME

www.cmcc.it

To investigate and model our **climate system** and its interaction with **society**

- to provide reliable, rigorous and timely **scientific results**, which will in turn stimulate sustainable growth
- to protect the **environment**
- to develop science-driven **adaptation** and **mitigation policies** in a changing climate

MISSION

TOPICS

RESEARCH DIVISIONS

Advanced Scientific Computing (ASC)

Climate Simulation and Prediction (CSP)

Economic analysis of Climate Impacts and Policy (ECIP)

Impacts on Agriculture, Forests and Ecosystem Services (IAFES)

Ocean modeling and Data Assimilation (ODA)

Ocean Predictions and Applications (OPA)

Risk Assessment and Adaptation Strategies (RAAS)

REgional Models and geo-Hydrological Impacts (REMHI)

Sustainable Earth Modelling Economics (SEME)

IMMERSE project overview

- IMMERSE project selected in response to H2020 call **LC-SPACE-03-EO-2018**

- IMMERSE gathers **a consortium of 14 institutions** across Europe:

- IMMERSE project **started in Dec 2018 for 48 months (until Dec 2022)**

Overall concept of IMMERSE project

- **Concept** : developing new capabilities for CMEMS by improving NEMO ocean model, used in the majority of CMEMS Monitoring and Forecasting Centers

- **Activities**: IMMERSE will accelerate the development of NEMO ocean model and prepare a seamless transition from research to operation in CMEMS, CMEMS MFCs and downstream systems.

- **In practice**, the project combines activities aiming at :
  - developing NEMO ocean model (in coordination with NEMO consortium);
  - preparing the evolution of CMEMS MFCs and downstream systems.

To our knowledge, IMMERSE is the only H2020 project targeting explicitly the *development* of a geo-scientific model.

IMMERSE project overview

Specific project objectives

1. Develop a new, efficient, stable and scalable NEMO reference code with improved performances adapted to <u>exploit future HPC technologies</u> in the context of CMEMS systems

2. Develop NEMO for the challenges of delivering ocean state estimates and forecasts describing ocean dynamics and biogeochemistry <u>at kilometric scale</u> with improved accuracy

3. Prepare the exploitation of the next generation of <u>high resolution observing networks</u> within CMEMS systems and in detailed, downstream modelling systems.

4. Develop a flexible and generic software tools series for interfacing CMEMS observation and model-based products and detailed, <u>downstream modelling systems</u>

5. Provide proven model code and <u>software tools with assessments</u> suitable for rapid deployment in CMEMS

Next generation numerical kernel for NEMO
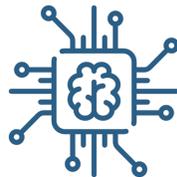
Preparing CMEMS to future HPC infrastructures

Modeling key processes at kilometric scales

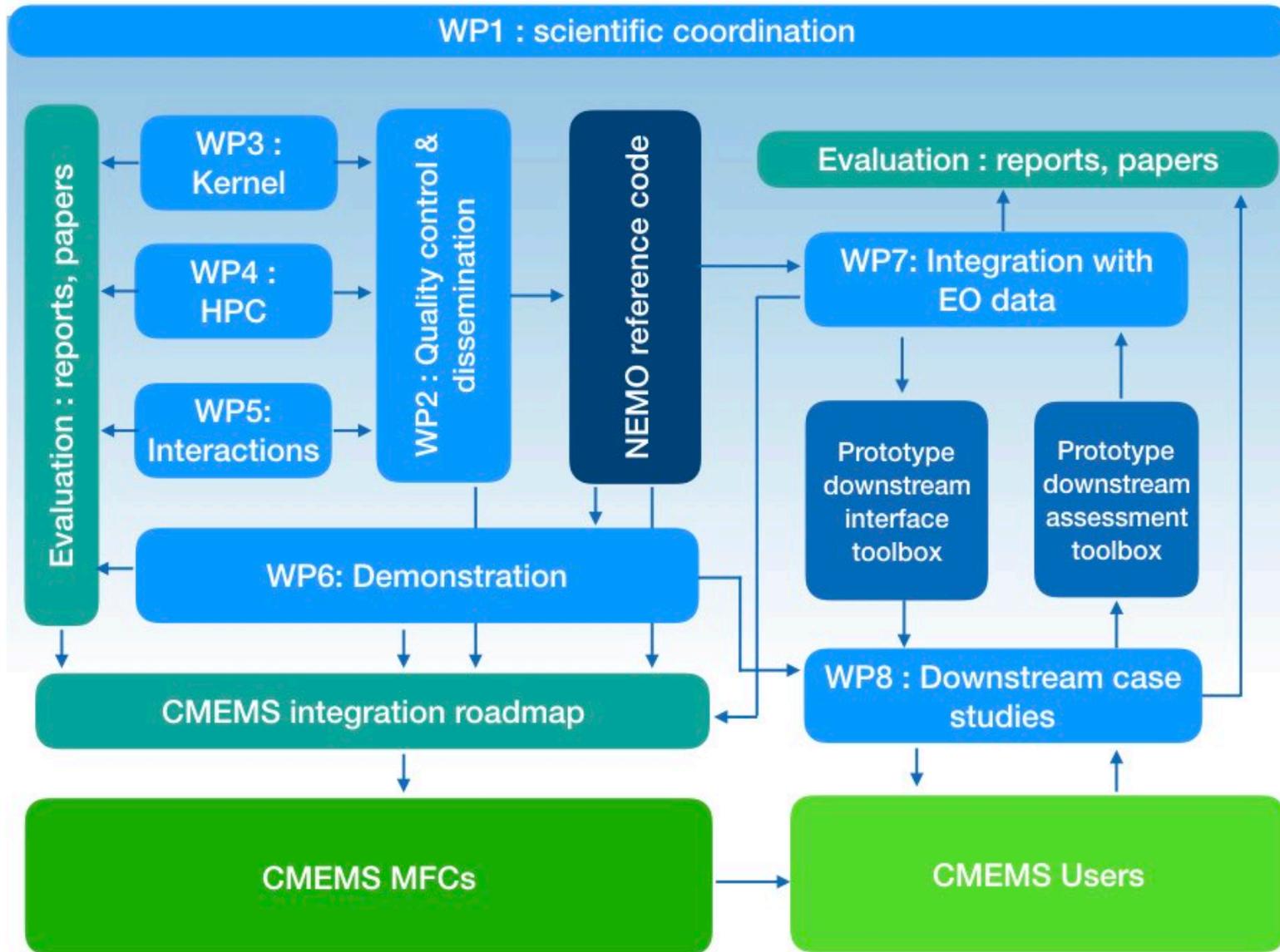Integrating model-based products and observations

Demonstrating impact on CMEMS systems

Assessing impact on downstream systems

Q&A session

To participate in the Q&A Session, please use the "Questions" menu provided by the Go-to-Webinar system

A **list of questions** is available in order to collect your specific feedbacks

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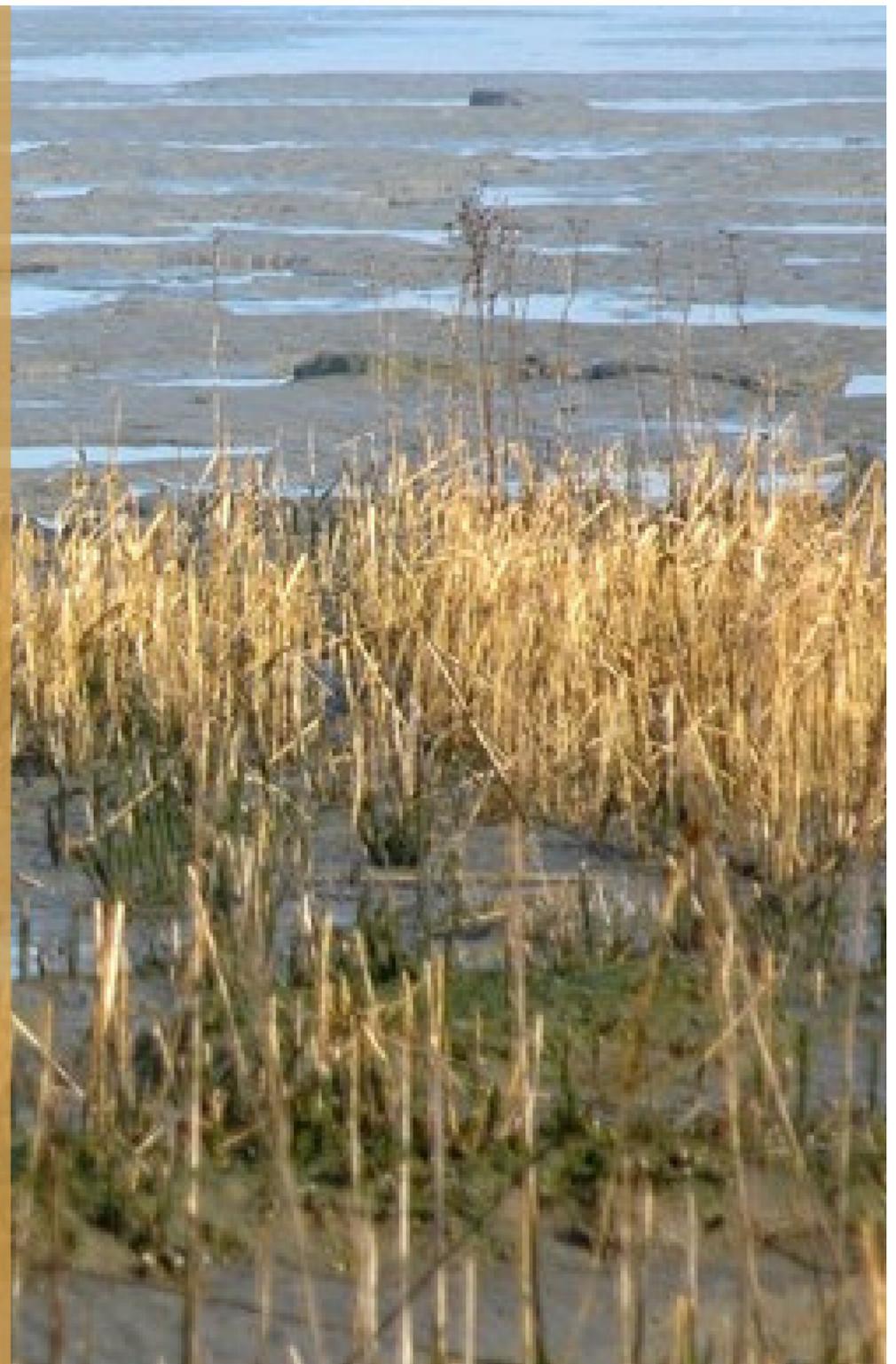**Michela De Dominicis, James Harle, Jeff Polton - Presenters**

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If you have any further question about the webinar, please email: webinar@cmcc.it

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Centro Euro-Mediterraneo
sui Cambiamenti Climatici

Forthcoming CMCC Webinar

RFF-CMCC – EIEE Webinar on "Asset Prices and Climate Policy"

April 11, 2019 – h. 12:00 pm CEST

Presenter: Armon Rezai, Institute for Ecological Economics, Vienna University of Economics and Business

Moderator: Johannes Emmerling, RFF-CMCC European Institute on Economics and the Environment (EIEE), Euro-Mediterranean Centre on Climate Change Foundation (CMCC)
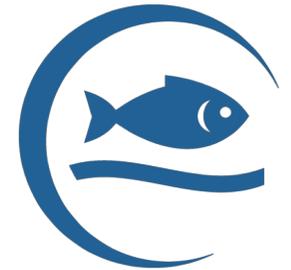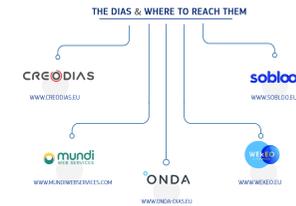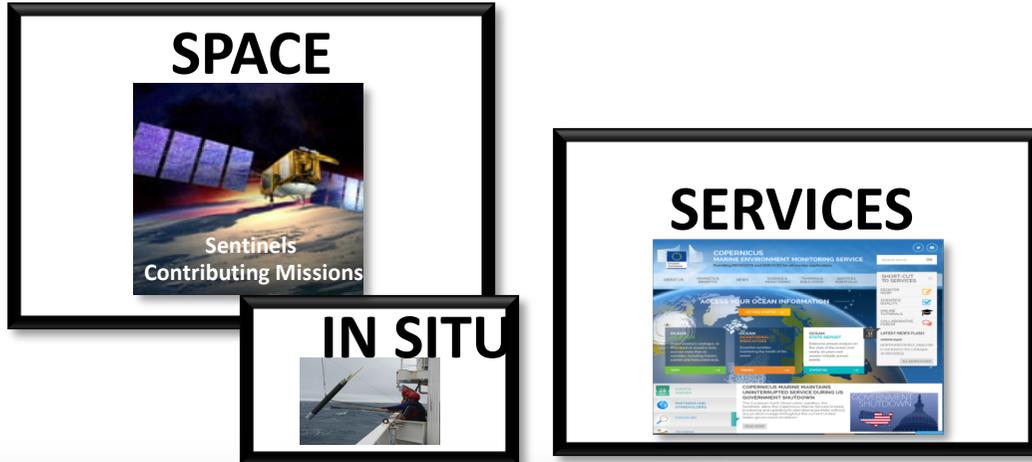
CMEMS and DIAS

Yann Drillet, Mercator Ocean International

- COPERNICUS programme
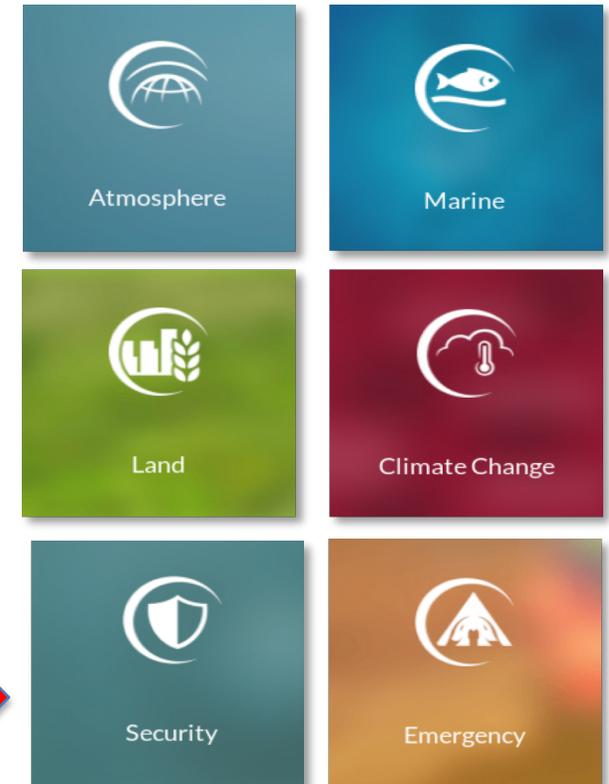
- DIAS platforms and WEkEO

- Copernicus Marine Service

COPERNICUS PROGRAMME

MERCATOR OCEAN INTERNATIONAL
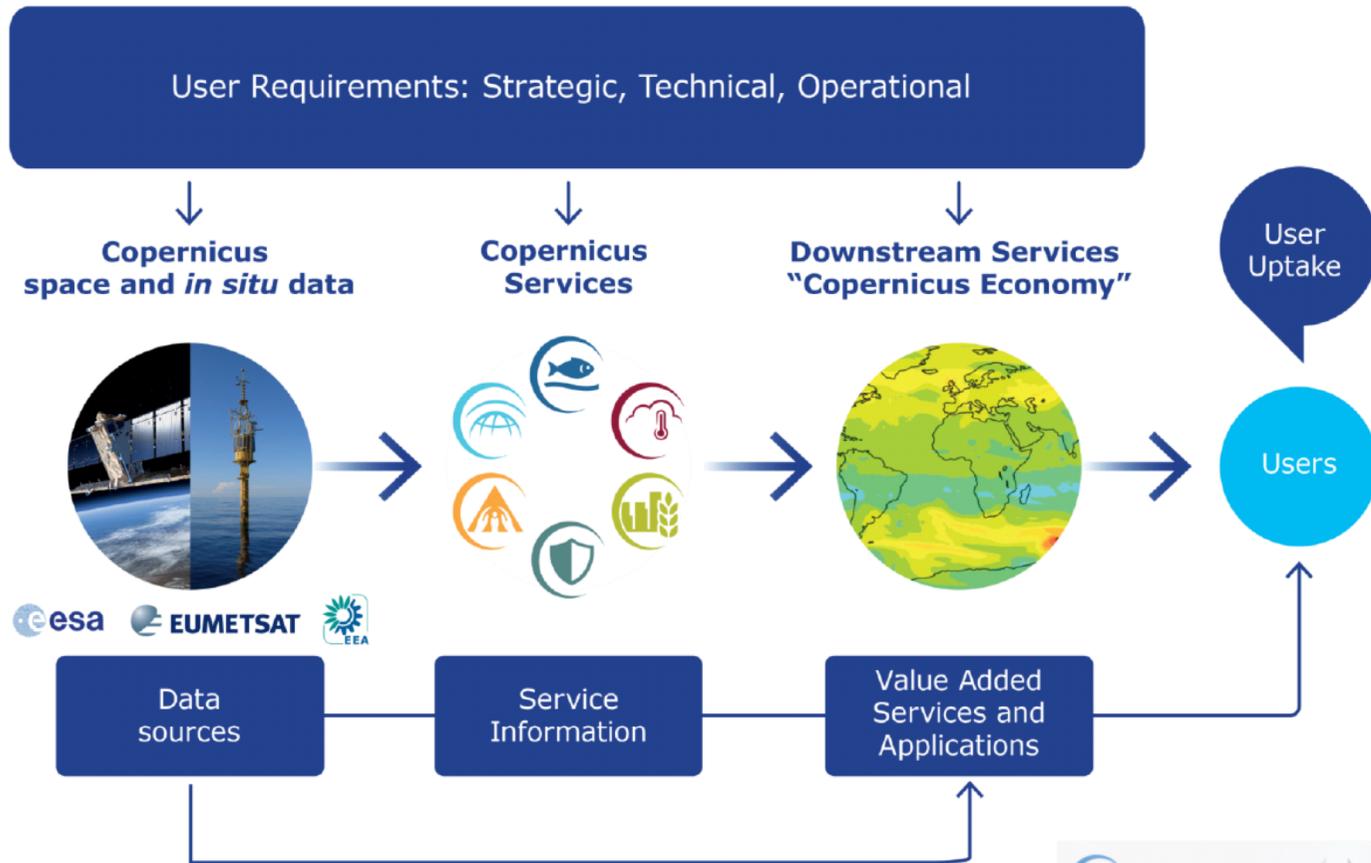
- Satellite Data distribution Hubs (Sentinels, Contributing missions)

- Services Information portals for : Added value products, indicators, Models, Archives, Near Real Time and Forecasts products

Access to Copernicus Services Data

- Land-related data: http://land.copernicus.eu
- Atmosphere-related data: http://atmosphere.copernicus.eu
- Marine-related data: http://marine.copernicus.eu
- Emergency-related data: http://emergency.copernicus.eu
- Climate change-related data: http://climate.copernicus.eu

FULL, FREE AND OPEN

- The Big Data Challenge : Massive amount of data; full, open and free of charge (Different types of dissemination infrastructures, new technology developments,…)

Data and Information Access Services

DIAS platforms and WEkEO

DIAS services initiated by DG GROW

Copernicus Services provide 12 Terabytes per day;
To **facilitate and standardise access to the Copernicus data** the European Commission is funding the deployment of **five cloud-based platforms providing centralised access to Copernicus data and information, as well as to processing tools**. These platforms are known as **the DIAS**, or **Data and Information Access Services**

ALL-IN-ONE ACCESS

Discover, manipulate, process and download Copernicus data and information

A WEALTH OF SERVICES

Acces to Copernicus Sentinel data, as well as to the information products from Copernicus' six operational services

USER FOCUSED
FROM PRODUCTION TO ACTIONABLE INFORMATION

Each DIAS runs its own back office (storage, computing …) starting point for development of front office and third party applications.
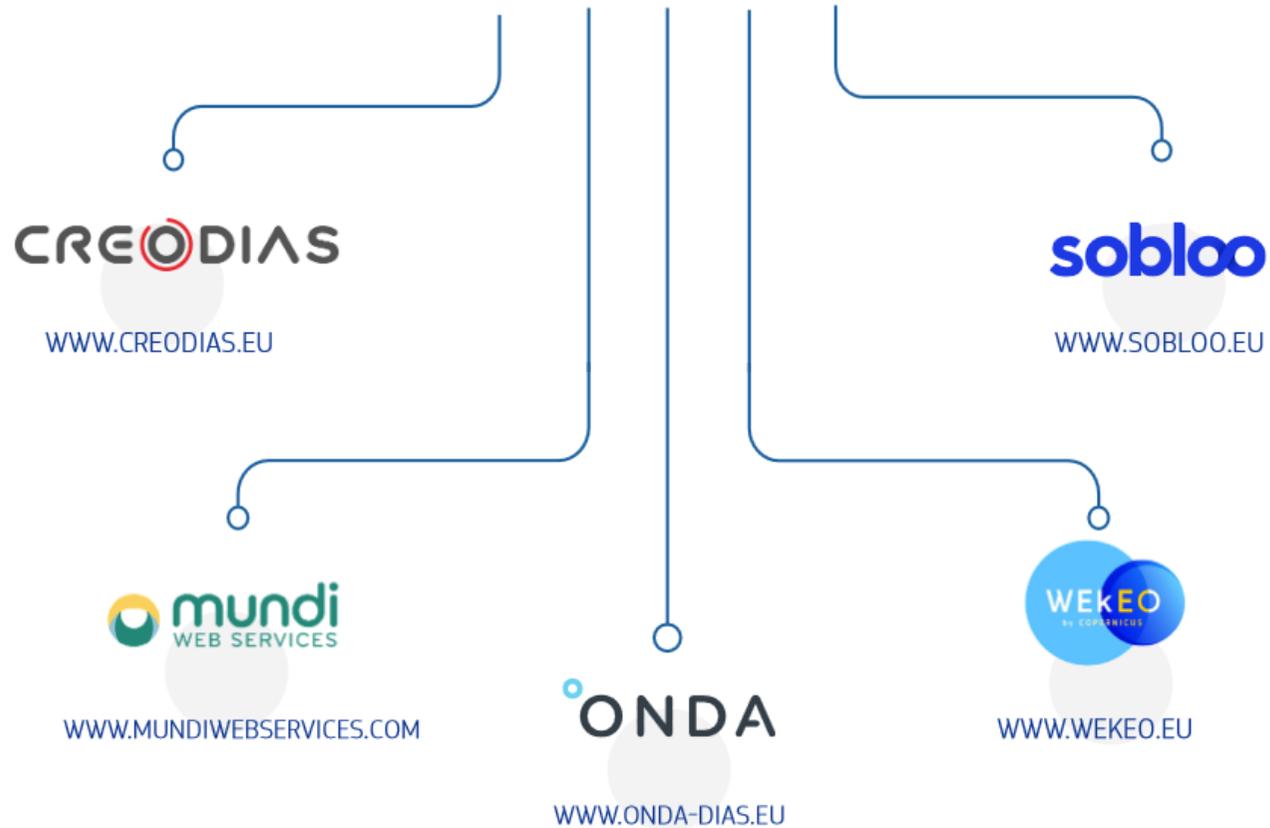
A WORLD OF OPPORTUNITIES
WAITING TO BE CAPTURED

Extraction of value from Copernicus data and information. Serving public authorities, industry, data users and public

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THE DIAS & WHERE TO REACH THEM

CREODIAS
WWW.CREODIAS.EU

sobloo
WWW.SOBLOO.EU

mundi WEB SERVICES
WWW.MUNDIWEBSERVICES.COM

ONDA
WWW.ONDA-DIAS.EU

WEkEO
WWW.WEKEO.EU

WEkEO is one DIAS

WHAT IS WEkEO?

1 + 2 + 3

COPERNICUS DATA + VIRTUAL ENVIRONMENT & TOOLS + USER SUPPORT
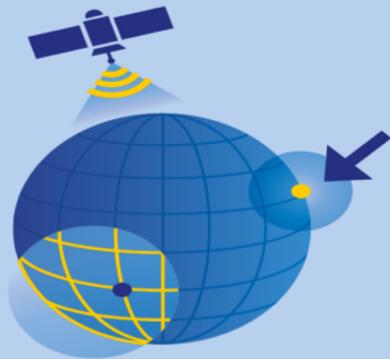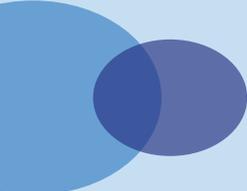
WEkEO STRENGHTS

- Experience and skills of the Consortium

- Minimisation of risk thanks to re-use of existing infrastructure in a cost efficient approach

- Capitalizing on user feedback thanks to the Copernicus service approach

- Strong industry involvement through procurements (~80% of allocated budget)

WEkEO will be fully operational by October 2019

WEkEO is starting phase 2, with 200 pilots users

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INTERNATIONAL

What is Copernicus Marine Environment Monitoring Service ?

CMEMS : Marine Service
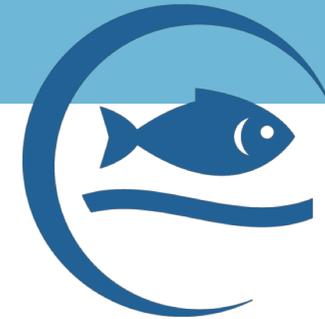
A unique European Marine capability and core-knowledge base

- **Operational** and **scientifically assessed**

- **Observations** (satellite, in-situ) and **models** (analyses/forecasts)

- **Physics** (e.g. sea level, currents, temperature, sea ice, waves) and **Biogeochemistry** (e.g. oxygen, primary production, nutrients)

- A **network** of European producer

- A **unique catalogue**: **Worldwide** and **European-wide** coverage

- A **central information system** to search, view, download products and monitor the system

- A **service desk** to support users who relies on a network of technical & marine experts

Serving many areas of benefits

MARITIME SAFETY

MARINE RESOURCES

COASTAL AND MARINE ENVIRONMENT

WEATHER, SEASONAL FORECASTING AND CLIMATE

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CROSS-CUTTING COORDINATION
CENTRAL USER SERVICE

System	Service	Outreach	Science

**CMEMS OPERATIONS
PRODUCTION AND SERVICE**

Service operations:
1. Thematic Assembly Centres (Observations)
2. Monitoring and Forecasting Centres (Models)
3. Central Information System

CMEMS EVOLUTIONS

Additional activities complementing CMEMS operations

ICE TAC	WIND TAC	SL TAC	INS TAC	OC TAC

GLO MFC	ARC MFC	BAL MFC	NWS MFC	IBI MFC

Service Evolution	User Uptake

SST TAC	WAVE TAC	MULTI OBS TAC

MED MFC	BS MFC

1. Global
2. Arctic
3. Baltic
4. NWS
5. IBI
6. Med Sea
7. Black Sea

CMEMS : R&D roadmap / organisation

CMEMS : R&D roadmap / organisation

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GLOBAL ①

NEMO 1/12°, 50 zL, TKE, real time and reanalysis (Mercator Ocean)
¼° Ocean Atmosphere Coupled system (metoffice)
¼° , 75 z L, reanalysis (CMCC, ECMWF, Mercator Ocean, MetOffice)

ARCTIC ②

HYCOM 12.5km resolution in real time and reanalysis (NERSC)

Baltic ③

HBM at 2km resolution in real time (DMI)
NEMO at 4km in reanalysis, k_ϵ , tides (SMHI)

NWS ④

NEMO 1/60° , 33 $_\sigma$ L, tides, real time and reanalysis 1/16°, 24 $_\sigma$ L, tides (metoffice)

MED ⑥

NEMO real time (1/24°, 141 zL) and reanalysis (1/16°, 72 zL) (CMCC)

IBI ⑤

NEMO 1/36° , 50 zL, tides, GLS, real time forecast and 1/12° reanalysis (Mercator Ocean, Puertos del Estado)

① Global
② Arctic
③ Baltic
④ NWS
⑤ IBI
⑥ Med Sea
⑦ Black Sea

Black Sea ⑦

NEMO 1/36°, 31 zL**,** real time and reanalysis (CMCC)

CMEMS Production Center systems : evolution

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GLOBAL ①

NEMO version, bulk, coupling with waves
IMMERSE DEMO in WP6
Global high resolution (1/36°)
Global reanalysis configuration (1/12°)

ARCTIC ②

Increase resolution → 6km
Test with NEMO, config under development

Baltic ③

Move to NEMO, real time system under development
Increase resolution (500m)

NWS ④

Wetting and drying, coupling with waves

MED ⑥

Tides, vertical mixing, river input, coupling with waves, link with BS

IBI ⑤

NEMO version, bulk, coupling with waves
IMMERSE DEMO in WP6
AGRIF ZOOM

Black Sea ⑦

Tides, vertical mixing, river input coupling with waves, link with MED

① Global
② Arctic
③ Baltic
④ NWS
⑤ IBI
⑥ Med Sea
⑦ Black Sea

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Catalogue & Production

➢ **164 Ocean Products**
(152 in 2017, 148 in 2016, 134 in 2015)

➢ **8 Ocean Monitoring Indicators**
(New!)

➢ **99% availability of Central System**
(99% in 2017, in 2016, in 2015)

➢ **98% availability of products**
(99% in 2017, 97% in 2016, 97% in 2015)

➢ **98% timeliness of products**
(98% in 2017, 97% in 2016, 97% in 2015)

MERCATOR OCEAN INTERNATIONAL

Users behaviour

➤ **3933 new subscribers** (+23% compared to 2017)

➤ **5 062 downloaders** (+34% compared to 2017)

➤ **1 135 regular users** (+24% compared to 2017)

➤ **594 518 downloads** (+41% compared to 2017)

25% users (regular) downloaded 87% of the data

➤ *1 364 Tb downloaded* *(+126% compared to 2017)*

15 863

10 457

IMMERSE will contribute to CMEMS :

- **NEMO** developement and maintain. Model is extensively used in CMEMS

- **DEMO** integrating new development and capabilities in prototypes (for global, regional high resolution and reanalysis)

- **DOWNSTREAM** applications (coastal processes, sediment transport, search and rescue, oil spill, marine plastic litter, water quality, Pollution transport)

IMMERSE Interfaces and Questionnaire for Users

S. Ciliberti (CMCC), D. Iovino (CMCC), L. Stefanizzi (CMCC),
M. De Dominicis (NOC), J. Harle (NOC), J. Polton (NOC)

1. The IMMERSE interfaces: strategy for T7.3

2. Questionnaire for Intermediate Users

WP7 – Integrating model based products with high resolution EO datasets for downstream applications

- To prepare the articulation of future **high resolution CMEMS models** using **EO datasets** for the benefit of **downstream applications**
- To describe the **predictability and accuracy** of high resolution forecasting systems
- To design and implement a **seamless interface for CMEMS users** to access and use model & observations products (prototype toolbox to demonstrate in WP8)

> **T7.1 [M1-M24]: Ensemble quantification of short term predictability of ocean fine scale dynamics**

> **T7.2 [M1-M18]: Statistical description of forecast accuracy in DA systems for downstream applications**
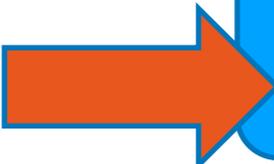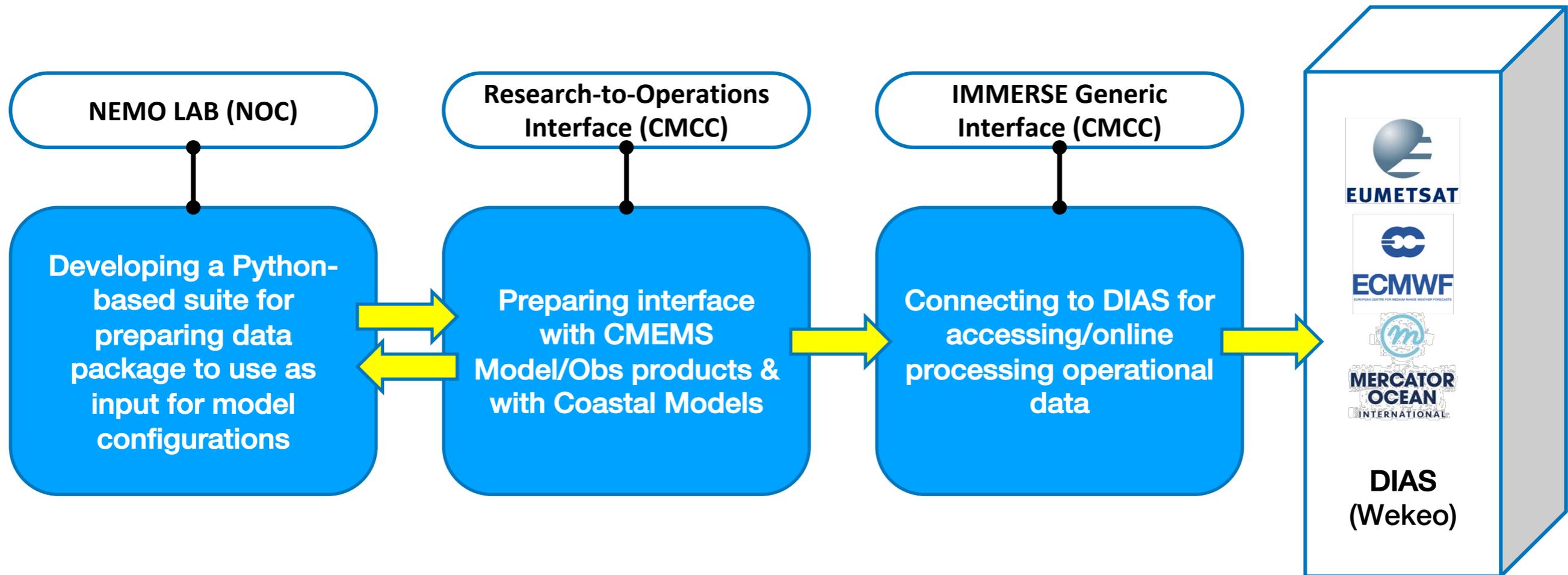
> **T7.3 [M1-M24]: Prototype toolbox for seamless uptake of CMEMS products in downstream monitoring systems**
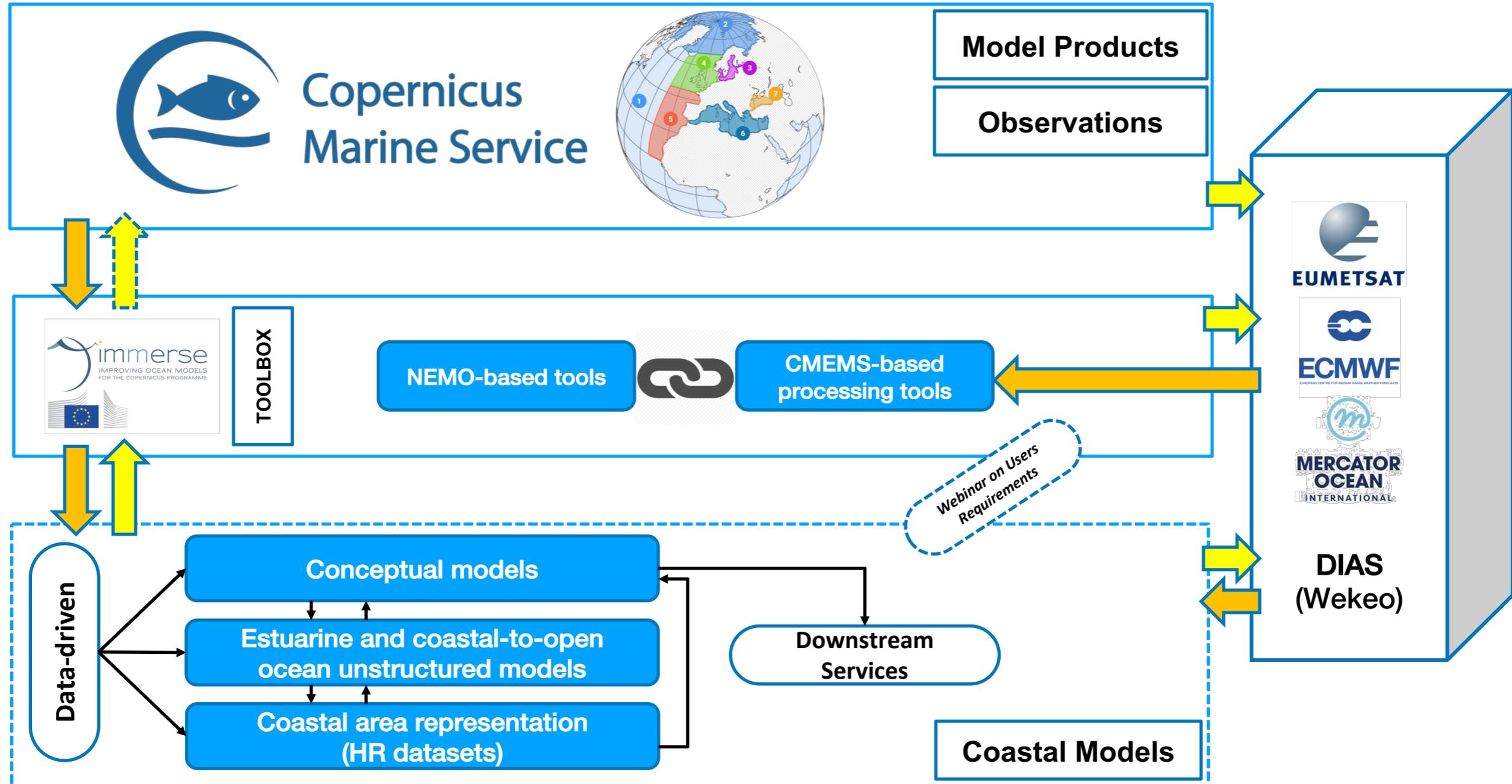
Prototype toolbox for seamless uptake of CMEMS products in downstream monitoring systems

The objective of this task is to develop a flexible tool between CMEMS and Coastal Community that will combine NEMO-based tools and custom CMEMS-oriented processing tools for interfacing coastal models with CMEMS (to be possibly used through DIAS).

T7.3 is run by CMCC (Italy) and NOC (UK).

NEMO LAB (NOC)

Developing a Python-based suite for preparing data package to use as input for model configurations

Research-to-Operations Interface (CMCC)

Preparing interface with CMEMS Model/Obs products & with Coastal Models

IMMERSE Generic Interface (CMCC)

Connecting to DIAS for accessing/online processing operational data

EUMETSAT

ECMWF
EUROPEAN CENTRE FOR MEDIUM RANGE WEATHER FORECASTS

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DIAS
(Wekeo)

Prototype toolbox for seamless uptake of CMEMS products in downstream monitoring systems

IMMERSE Interfaces will be the result of the integration of state-of-the-art procedures and novel ones for building new advanced numerical models based on NEMO
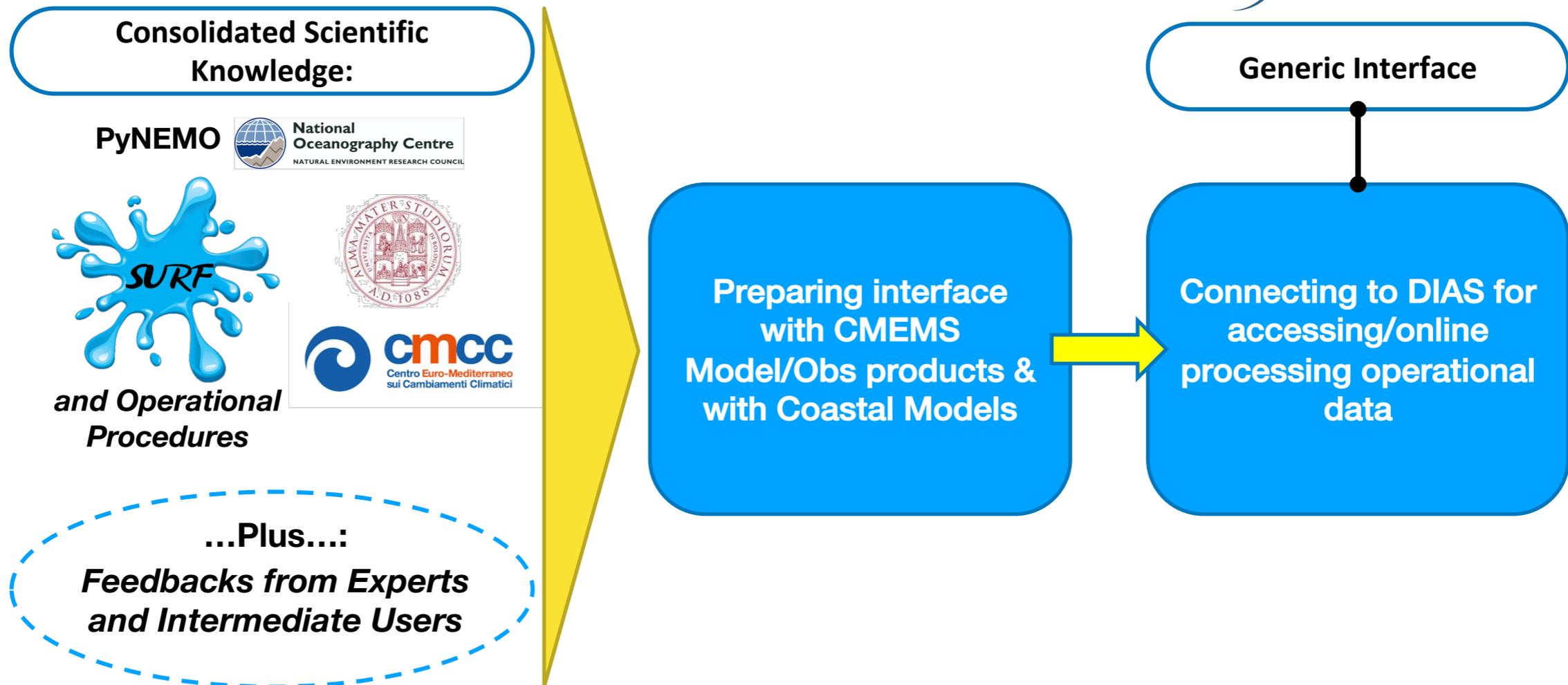
NEMO LAB: PyNEMO as example

Building on a NEMO regional configuration toolbox:

- *Generation of open boundary conditions*
    Straight line
    Depth contour following
    Shelf-break following

*Use of local or remote data sources
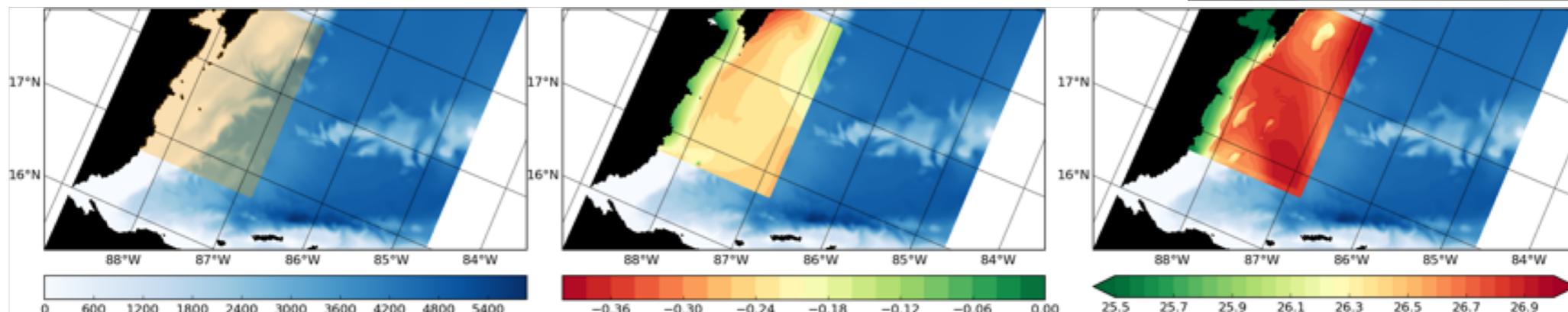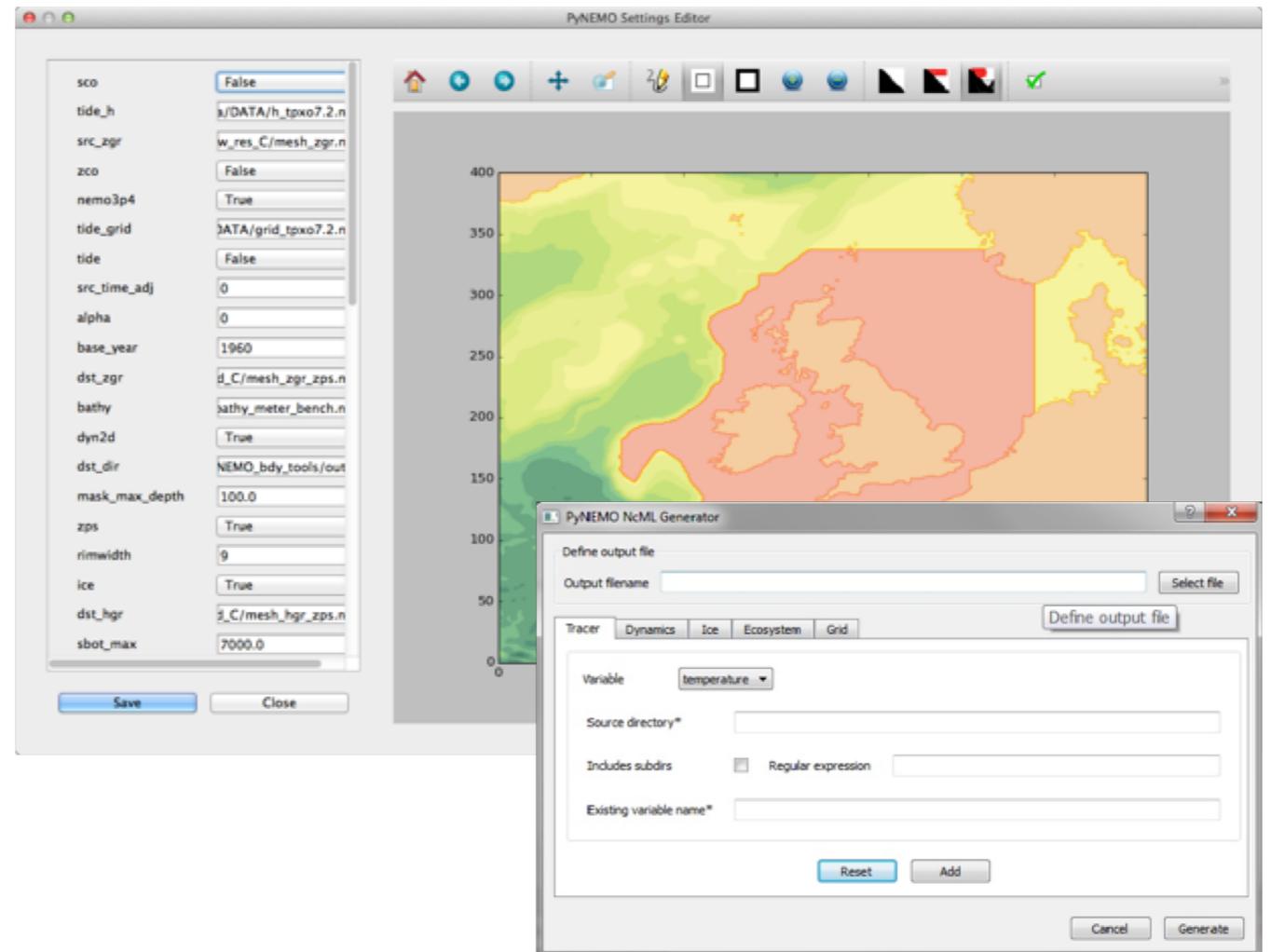   *Native or none native NEMO data (e.g. could use CMIP data)*
    openDAP or local directory scanning

Plan:
Generalize output for alternative target models
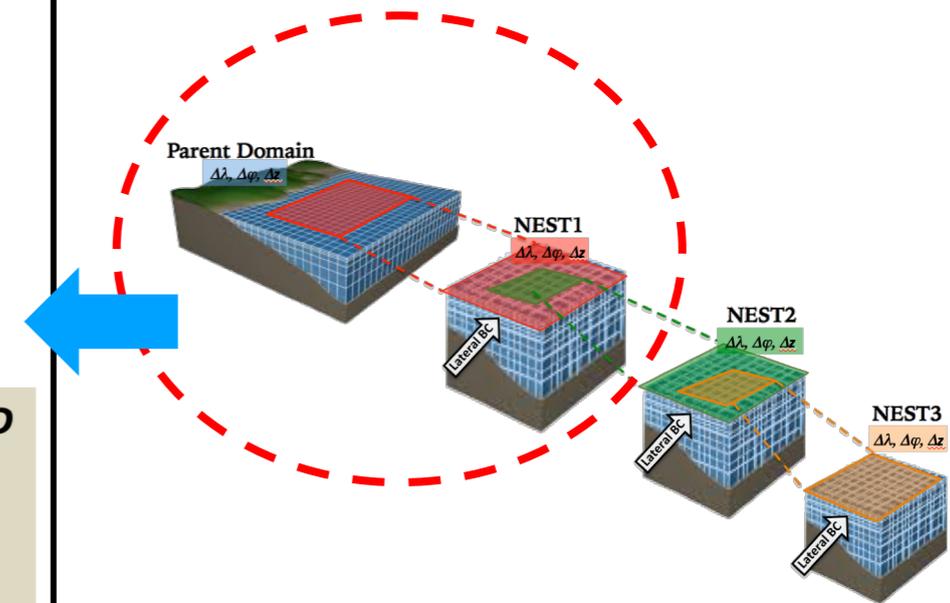*Enhance functionality*
Enhance user experience

Credits: J. Harle

Structured and Unstructured grid Relocatable ocean platform for Forecast

- SURF is an open-source *numerical platform* for hindcasting and short-time forecasting at high spatial and temporal resolution.
- It can be *easily and quickly* deployed in any region of a large-scale Ocean Forecasting System via *one-way nesting procedure*: the coarse-grid (parent) model provides *initial and lateral boundary condition* to the fine-grid (child) model.
- SURF *pre-processing module* is open-source and provides state-of-the-art and advanced numerical procedures for **Computational Grid Generation** and **Data Re-gridding** that can be exploited for setting up new interfaces with CMEMS products (models & observations).

SURF

GEBCO dataset

NOAA Coastlines

OCEAN SIMULATION PARAMETERS

SWAN SIMULATION PARAMETERS

NCEP, ECWMF

INPUT DATA

BATHY

ATMOSPHERIC FORCING

COASTLINE

COARSE RESOL MODEL

Ocean Forecasting Sytems by CMEMS and others

PRE-PROCESSING

COMPUTATIONAL GRID GENERATION

HORIZ & VERTICAL MESH-MASK

DATA REGRIDDING

BATHY

OCEAN INITIAL CONDITION

ATMOSPHERIC FORCING

LATERAL OPEN BOUNDARY

OCEAN SIMULATION

OUTPUT-DATA Temperature, Salinity, SSH, Zonal-Meridional Velocity

WAVE SIMULATION

OUTPUT-DATA Wave Height, Wave Period, Wave Direction

POST-PROCESSING

MODEL DIAGNOSTICS

OUTPUT FORMAT CONVERSION

VISUALIZATION

STRUCTURED GRID

latitude

longitude

FINITE DIFFERENCE (NEMO)

(3D-FDH model - Arakawa C grid – free surface)

UNSTRUCTURED GRID

latitude

longitude

FINITE ELEMENTs (SHYFEM)

(3D-FEH model – Arakawa B grid – free surface)

Parent Domain Δλ, Δφ, Δz

NEST1 Δλ, Δφ, Δz

NEST2 Δλ, Δφ, Δz

NEST3 Δλ, Δφ, Δz

Lateral BC

in coll. with cmcc Centro Euro-Mediterraneo sui Cambiamenti Climatici

https://surf.sincem.unibo.it/

Credits: F. Trotta, D. Iovino

The questionnaire has the objective of collecting feedbacks from **Experts in Coastal Modelling** and **CMEMS Intermediate Users** on IMMERSE prototype toolbox for seamless uptake of CMEMS products for **downstream monitoring systems**
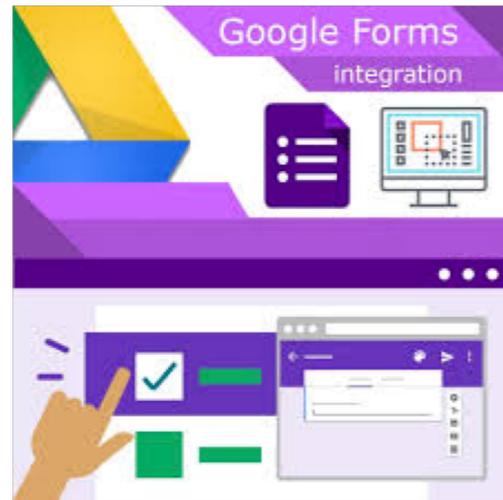
This action is included in a more general framework that aims to **integrate model-based products and high-resolution EO datasets** for downstream applications.

The scopes of the discussion are:
* to ascertain which users/groups are currently using regional/non-conventional NEMO configurations,
* to discuss about methods and tools that are currently employed to perform model setup tasks, including the use of CMEMS data by NEMO and non-NEMO users

The outcomes will be used to assess and refine the general high-level architecture of IMMERSE interface and to define software development plan.

1. Which model configurations do you run (including 'exotics' such as biogeochemistry, ice etc)?

2. Which methods/tools do you use for setting up your configuration? (e.g. custom python script, NCO operators, NEMO gridgen tools or some other native tools in your community model, etc) Would you consider to share these and/or your experience with the wider community?

3. Please, provide specific informations on the methods you use for the following main items:
- initial conditions
- boundary conditions
- geometry and spatial domain

4. Which CMEMS data do you use for setting up your model configuration and performing validation?

5. What methods/tools do you use for manipulating CMEMS data? How do you access CMEMS data?

6. Which procedures do you consider useful to implement as interfaces with CMEMS for facilitating the setup of your model configuration?

7. Could you please provide a short summary of your main research & developments activities with NEMO and/or non-NEMO models?

8. We would continue to keep in touch with you! Please add in the following your contacts! Thanks!

A Google Module Form will be send to Participants in order to have feedbacks and suggestions

IMMERSE Questionnaire for T7.3

This questionnaire has the objective of collecting feedbacks from CMEMS Intermediate Users on a prototype toolbox for seamless uptake of CMEMS products for downstream monitoring systems, developed in the frame of IMMERSE H2020 project. This action is included in a more general framework that aims to integrate model-based products and high-resolution EO datasets for downstream applications.

The scopes of the User Remote webinar are:
to ascertain which users/groups are currently using regional/non-conventional NEMO configurations,
to discuss about methods and tools that are currently employed to perform model setup tasks, including the use of CMEMS data by NEMO and non-NEMO users
The outcomes will be used to assess and refine the general high-level architecture of IMMERSE interface and to define the development plan of the software.

If you or others within your group have time to consider the following, we would be grateful. Any feedback/guidance will be highly helpful.

*Campo obbligatorio

https://docs.google.com/forms/d/1VdymVnjMI_eV_zpvEevv-P-CrT9Nmo9MGBl4jFgOvqQ/edit

Thank You

To participate in the Q&A Session, please use the "Questions" menu provided by the Go-to-Webinar system

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If you have any further question about the webinar, please email: webinar@cmcc.it