



CONNECT: Tagus river-to-ocean collaboratory for thematic digital twins and collaborative management

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CONNECT - local COastal moNitoriNg sErviCe for PorTugal

Copernicus Marine – User – EU Coastal Monitoring Pilot Demonstrations (22050-COP-INNO USER)

Goals CONNECT

Develop Digital Twins to:

- Support the evaluation of the ecological status of estuaries (WFD)
- Quantify land inputs to the adjacent coastal waters (MSFD)
- Anticipate inundation events (Floods Directive)
- Build tailor-made products and facilitate access to them





CONNECT in a nut shell: Seamless Coastal Marine Service

FORECASTS



IN-SITU OBSERVATIONS



SATELLITE



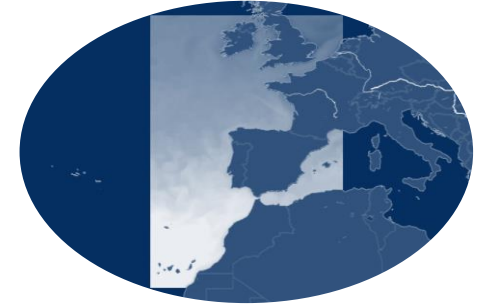
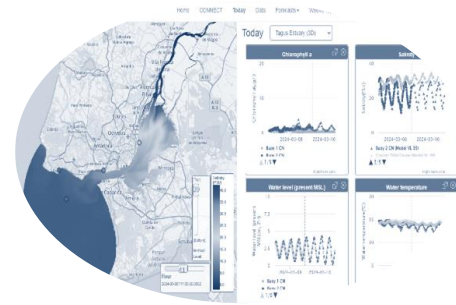
CONNECT delivers a local, high-resolution, coastal service that seamlessly integrates model-based forecasts and observations to provide blue (physical) and green (biogeochemical) data on Portuguese estuaries to CMEMS

DT Co-design with users

- Address user's requirements and feedback on the coastal service through inquiries and interviews
- Dedicated actions with users for DT dissemination with detail improvement and future actions goals



CONNECT DT building blocks



High-resolution operational modelling of estuarine - coastal circulation and water quality, forced by CMEMS regional models
Built using OPENCoastS

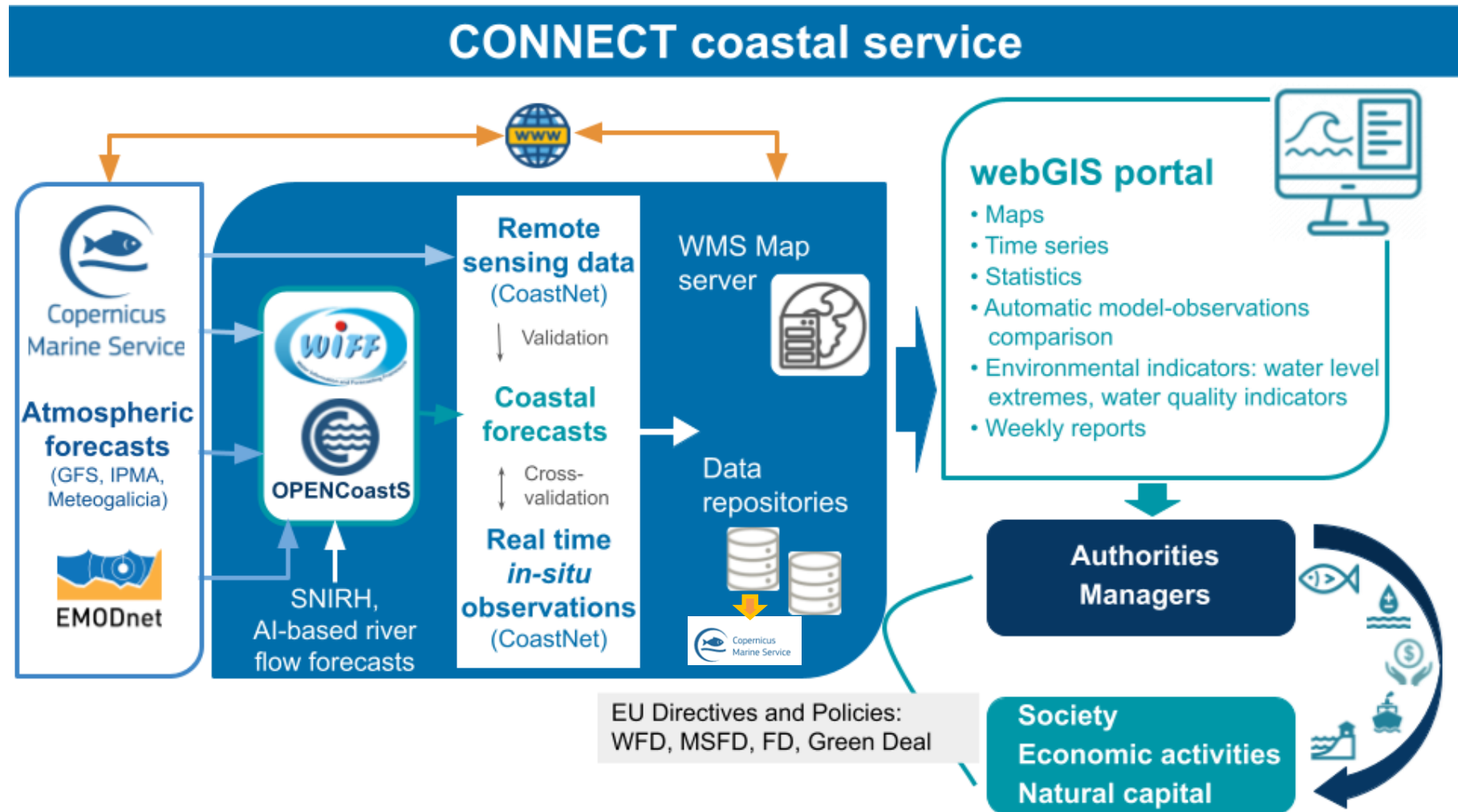
Near-real time *in-situ* data acquisition and Earth-observation data
From CoastNet

WebGIS portal to access physical and biogeochemical 2-day forecasts and observations
Using Collaboratory infrastructure for societal uptake

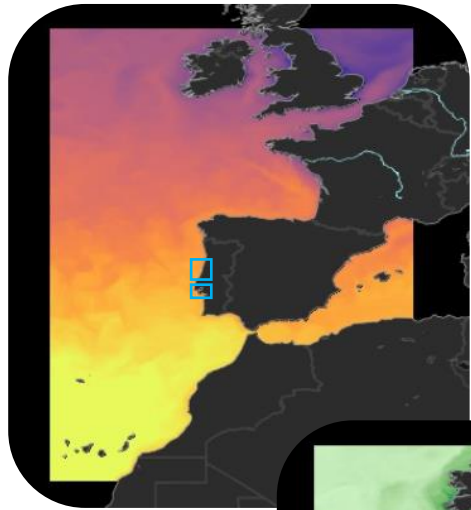
Seamless integration and provisioning of products to CMEMS



CONNECT Digital Twin architecture

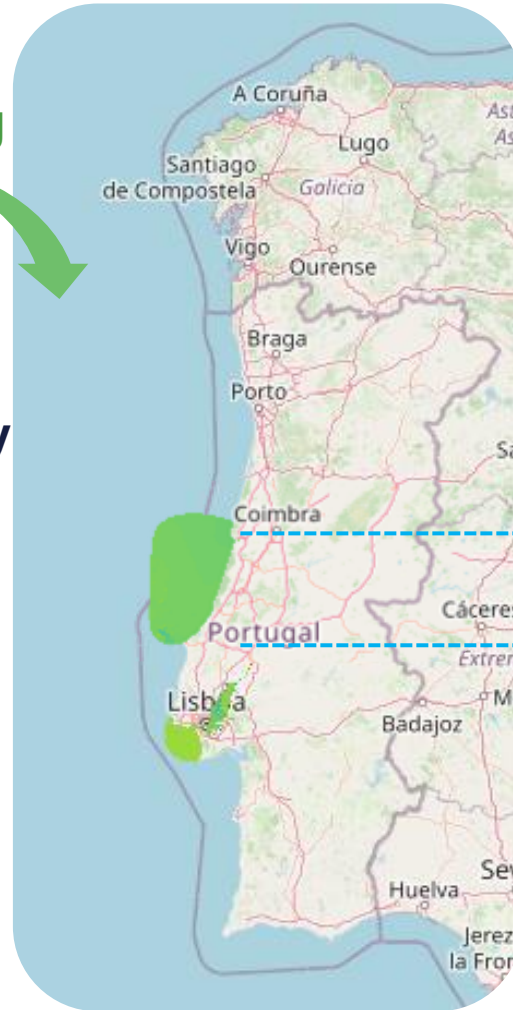


Building the model cascade in the DT



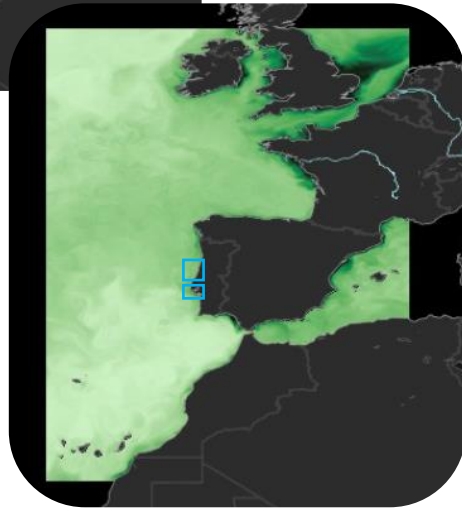
IBI Physics
IBI Biogeochemistry

Downscaling



Mondego estuary
Horizontal resolution:
5-5000m
Vertical grid:
25 SZ levels

Horizontal
resolution:
1/36°
Vertical grid:
50 levels



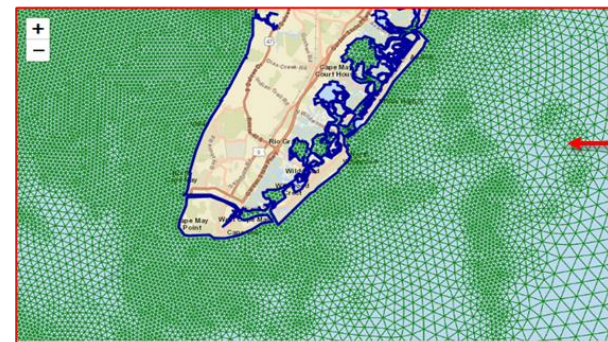
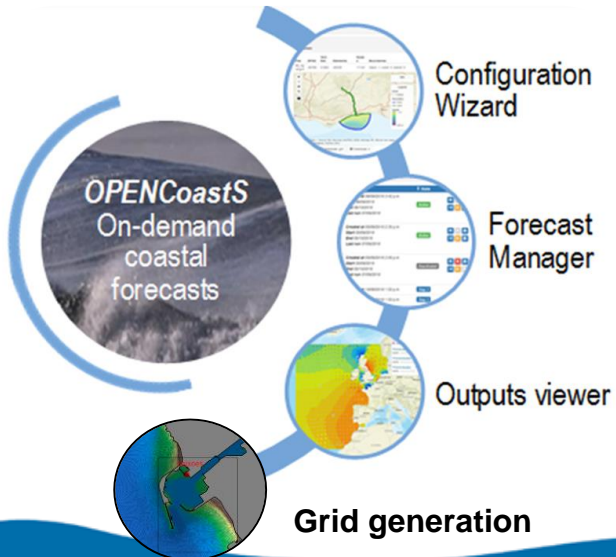
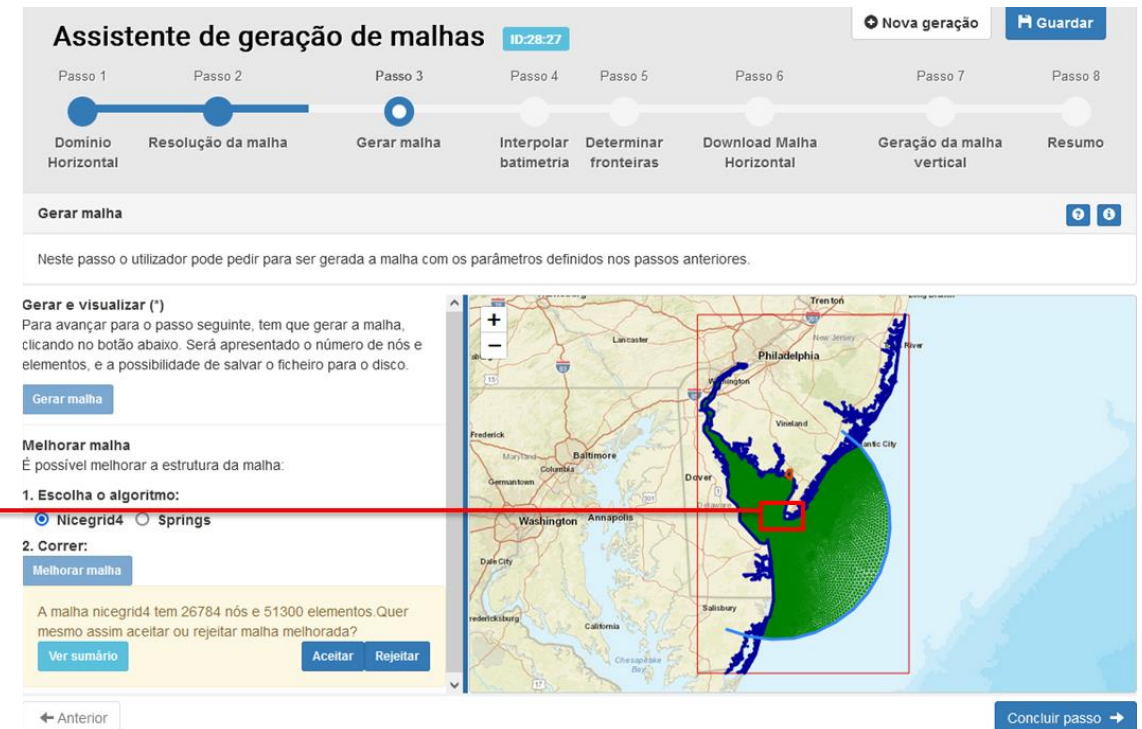
Tagus estuary
Horizontal resolution:
3/5-1600m
Vertical levels:
39 SZ levels



OPENCoastS: build the operational deployments

- Create and maintain an operational forecast for the user selected coastal area
 - Interaction with a simple Web interface
 - Allow choice of model, forcings, parameters and data sources
 - Integrate with external forecasts (AI model for the Tagus river)
 - Easy replication of deployments for fast calibration

• Whole forecast cycle: create grid, configure, manage, outputs viewer

The screenshot displays the 'Assistente de geração de malhas' (Grid Generation Wizard) web interface. The interface is divided into several sections:

- Progress Bar:** Shows eight steps: Passo 1 (Domínio Horizontal), Passo 2 (Resolução da malha), Passo 3 (Gerar malha - currently active), Passo 4 (Interpolair batimetria), Passo 5 (Determinar fronteiras), Passo 6 (Download Malha Horizontal), Passo 7 (Geração da malha vertical), and Passo 8 (Resumo).
- Gerar malha:** The current step, with instructions: 'Neste passo o utilizador pode pedir para ser gerada a malha com os parâmetros definidos nos passos anteriores.'
- Gerar e visualizar (*):** Instructions: 'Para avançar para o passo seguinte, tem que gerar a malha, clicando no botão abaixo. Será apresentado o número de nós e elementos, e a possibilidade de salvar o ficheiro para o disco.'
- Melhorar malha:** A section for improving the grid structure, with options:
 - Escolha o algoritmo:** Radio buttons for 'Nicegrid4' (selected) and 'Springs'.
 - Correr:** A button to execute the grid generation.

A message states: 'A malha nicegrid4 tem 26784 nós e 51300 elementos. Quer mesmo assim aceitar ou rejeitar malha melhorada?' with 'Ver sumário', 'Aceitar', and 'Rejeitar' buttons.
- Map:** A map of the coastal area with a red box indicating the selected region.
- Navigation:** 'Anterior' and 'Concluir passo' buttons.

CONNECT DT Products designed for specific themes

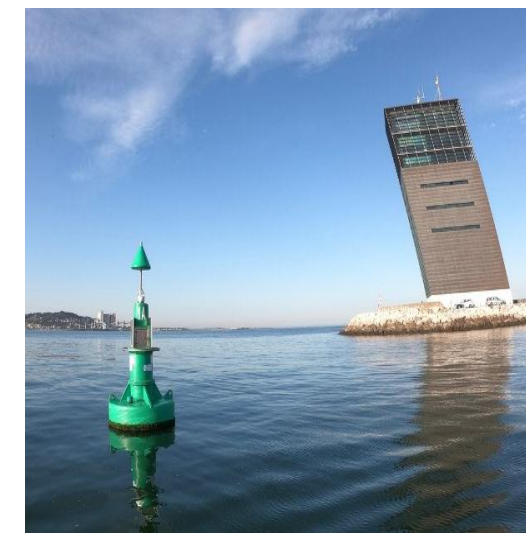
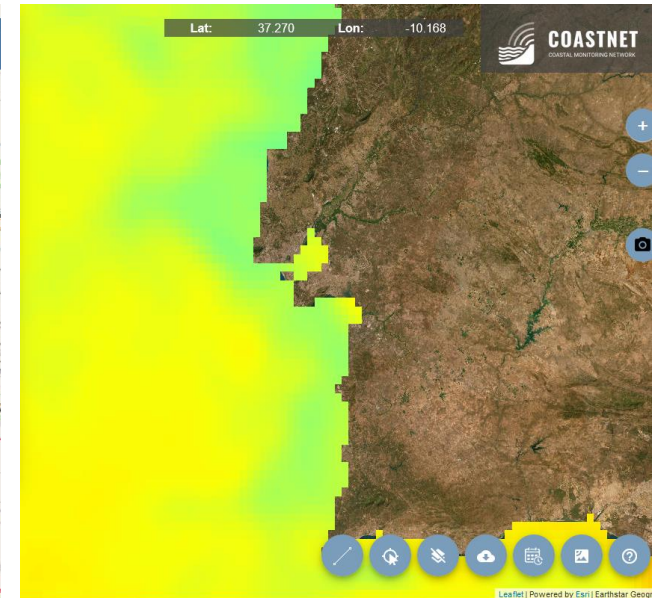
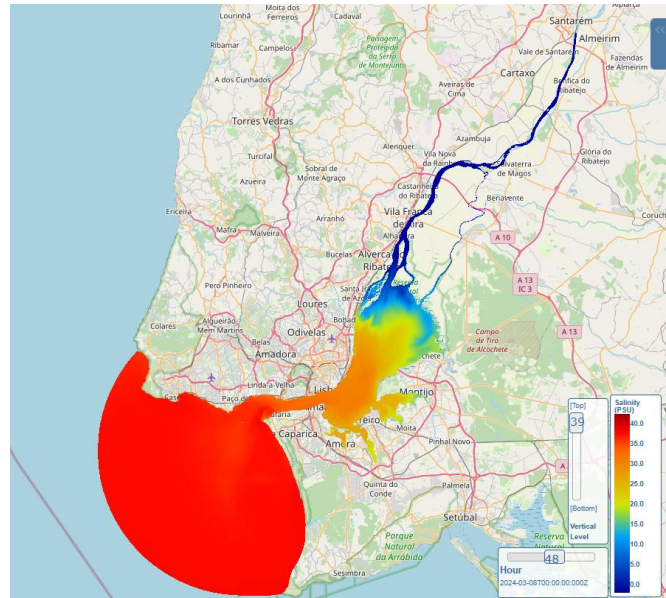
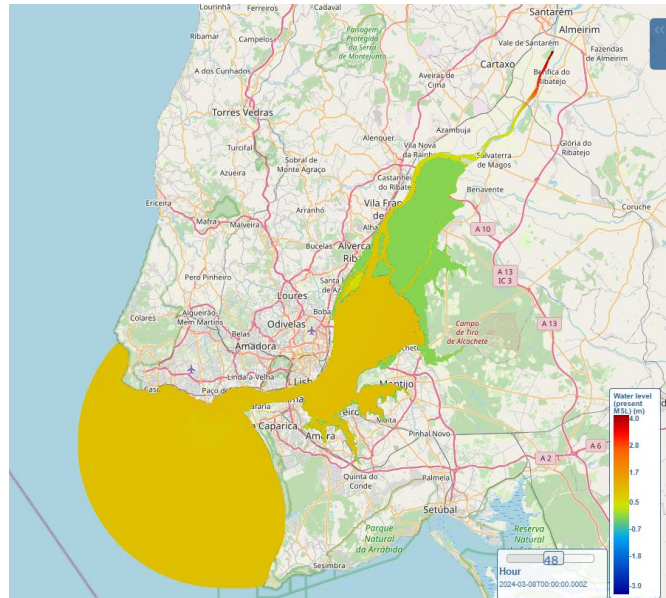


Tagus estuary:
2D barotropic model,
waves-currents interaction
- inundation

Tagus estuary: 3D
baroclinic model, coupled
circulation-biogeochemistry
- water quality

Remote sensing:
Copernicus Marine
Service

**NRT in-situ
monitoring
network**



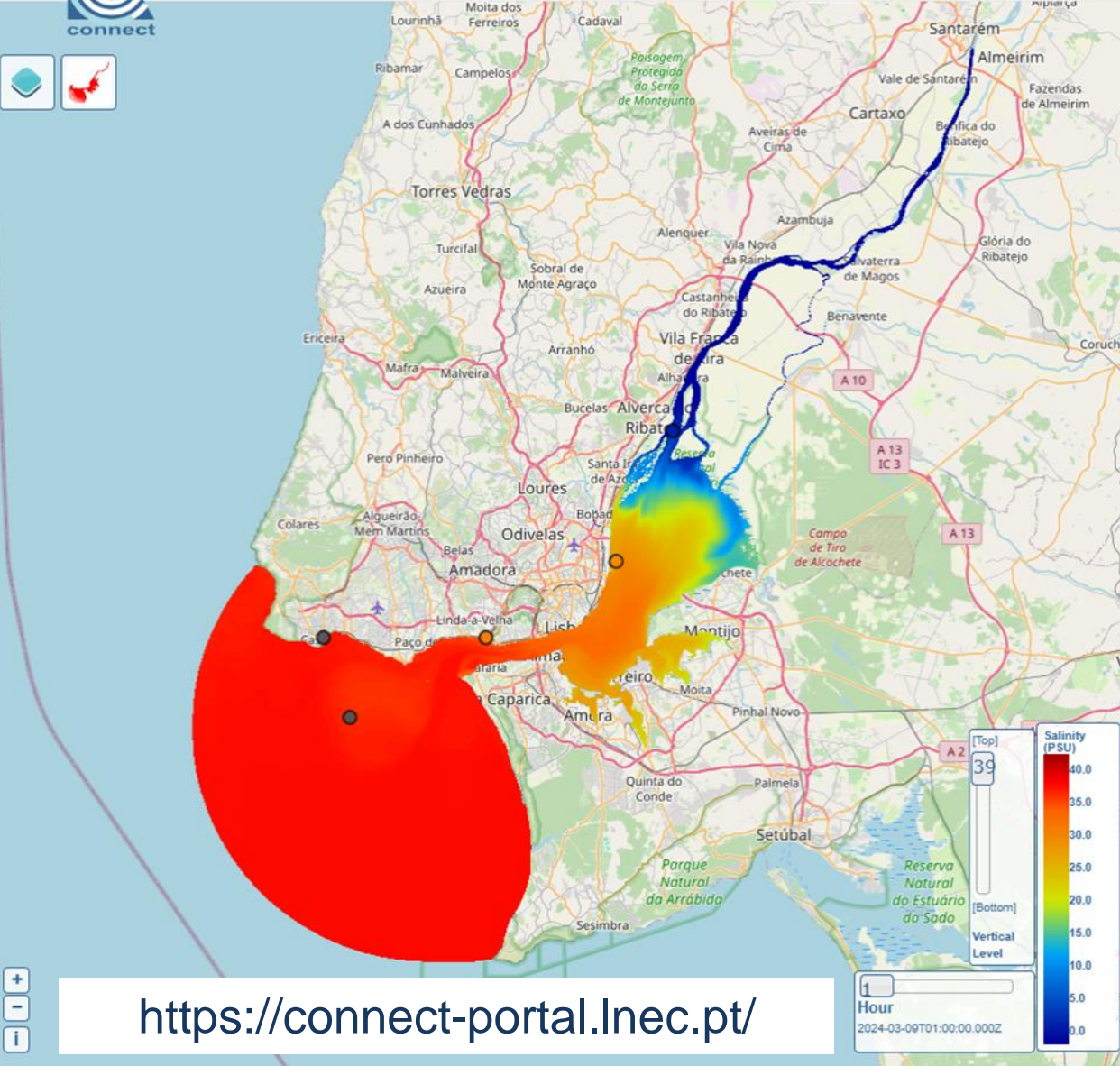
Water levels, Velocity,
Waves (Significant wave height,
Mean period, Direction)

Water levels, Velocity, Salinity,
Temperature, Ammonium,
Nitrate, Phosphate, Silicate,
Dissolved oxygen, Chlorophyll-a

Water temperature, Chlorophyll-a

Salinity, Temperature,
pH, Dissolved oxygen,
Chlorophyll-a, Turbidity

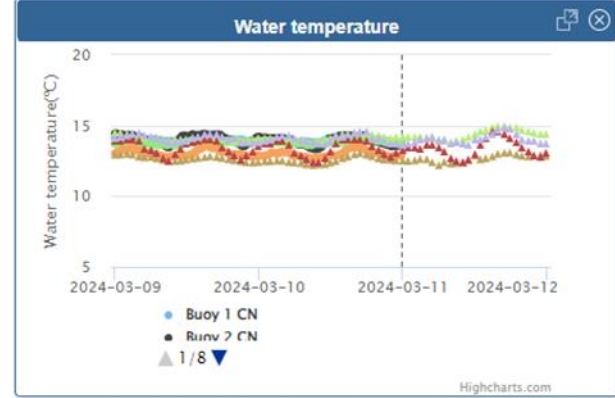
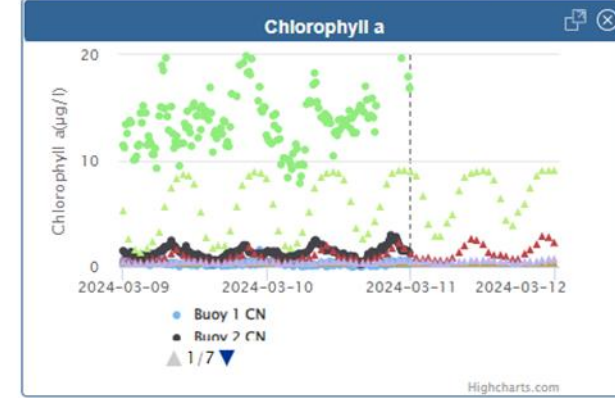
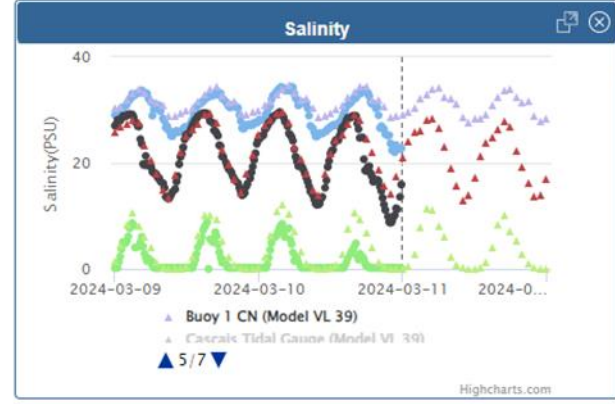
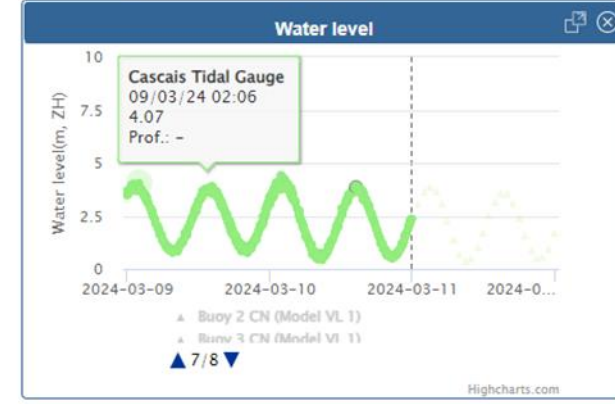
CONNECT DT WebGIS portal: Application of the Collaboratory infrastructure



<https://connect-portal.inec.pt/>

Home CONNECT Today Data Forecasts Weekly reports Indicators Documentation English

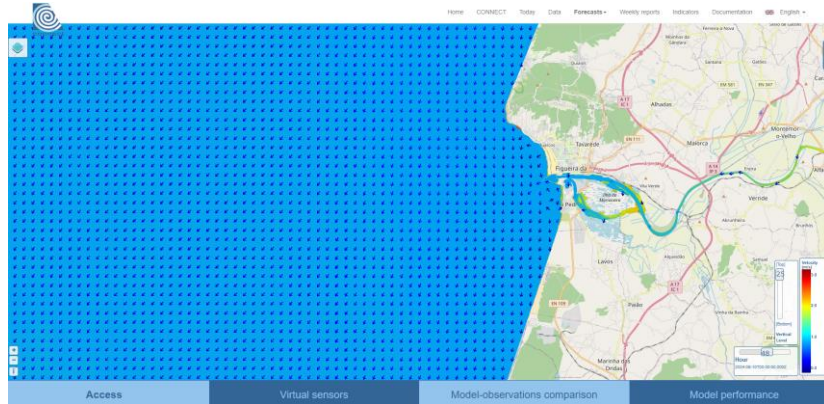
Today Tagus Estuary (3D)



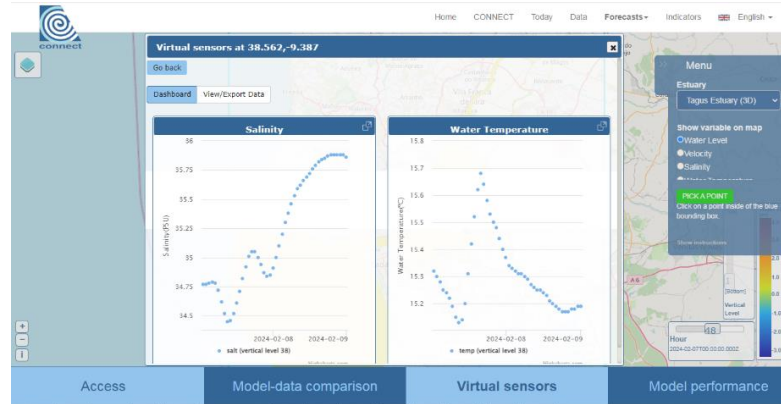
Collaboratory building

- Operational dashboard with a snapshot of the current state of the coastal system, built for the end-user requirements compliance
- Information quality: data/model comparison

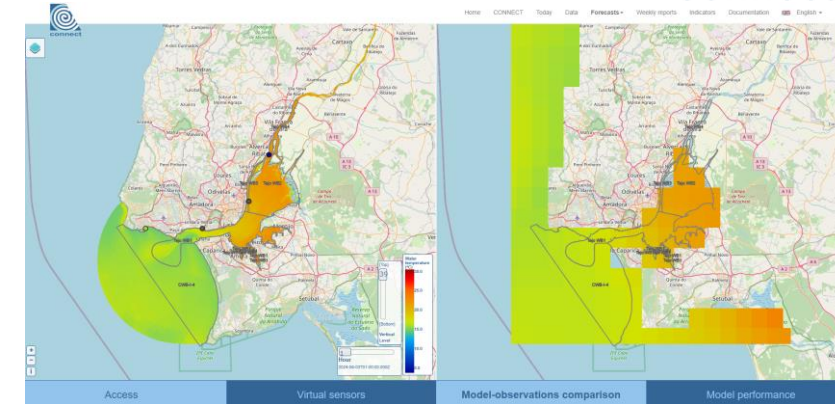
CONNECT webGIS portal: user-tailored services



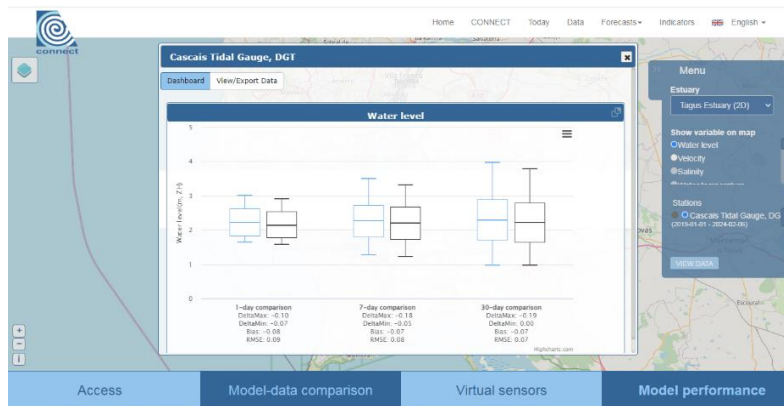
Circulation and water quality forecasts, next 48 hours



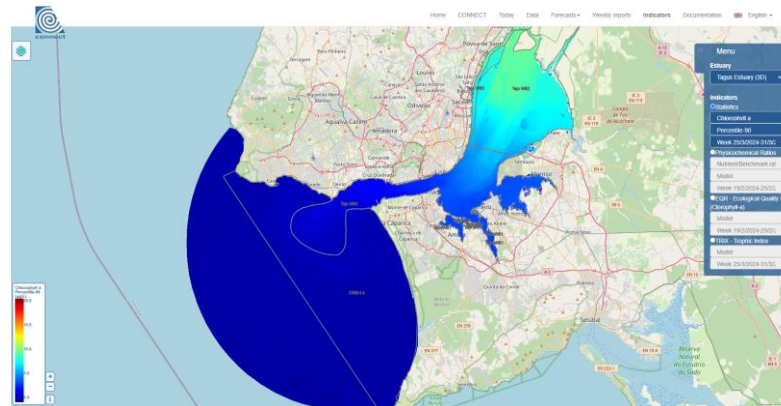
Virtual sensors



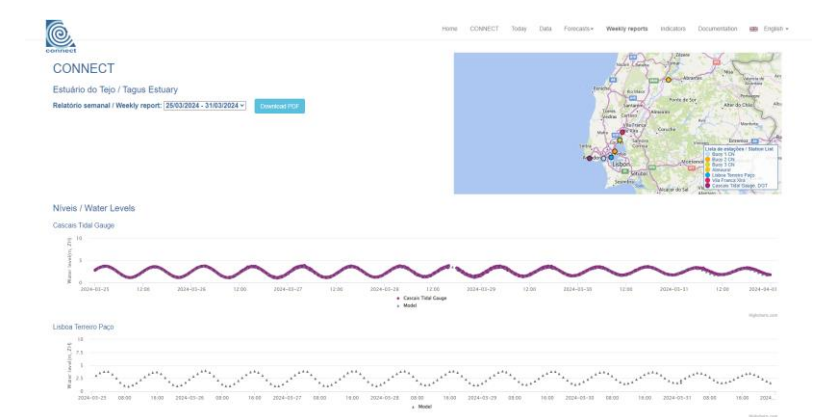
In-situ and satellite observations-model comparison



Model performance

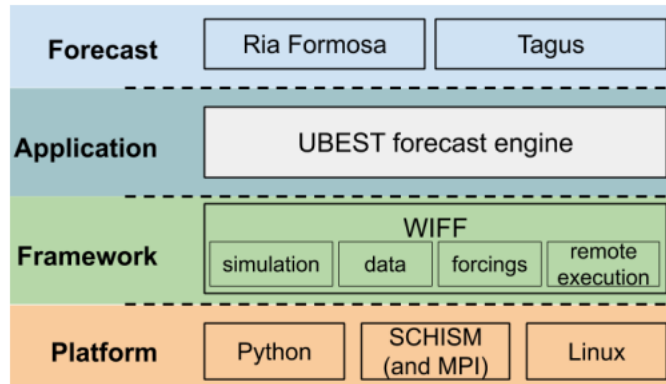


Indicators

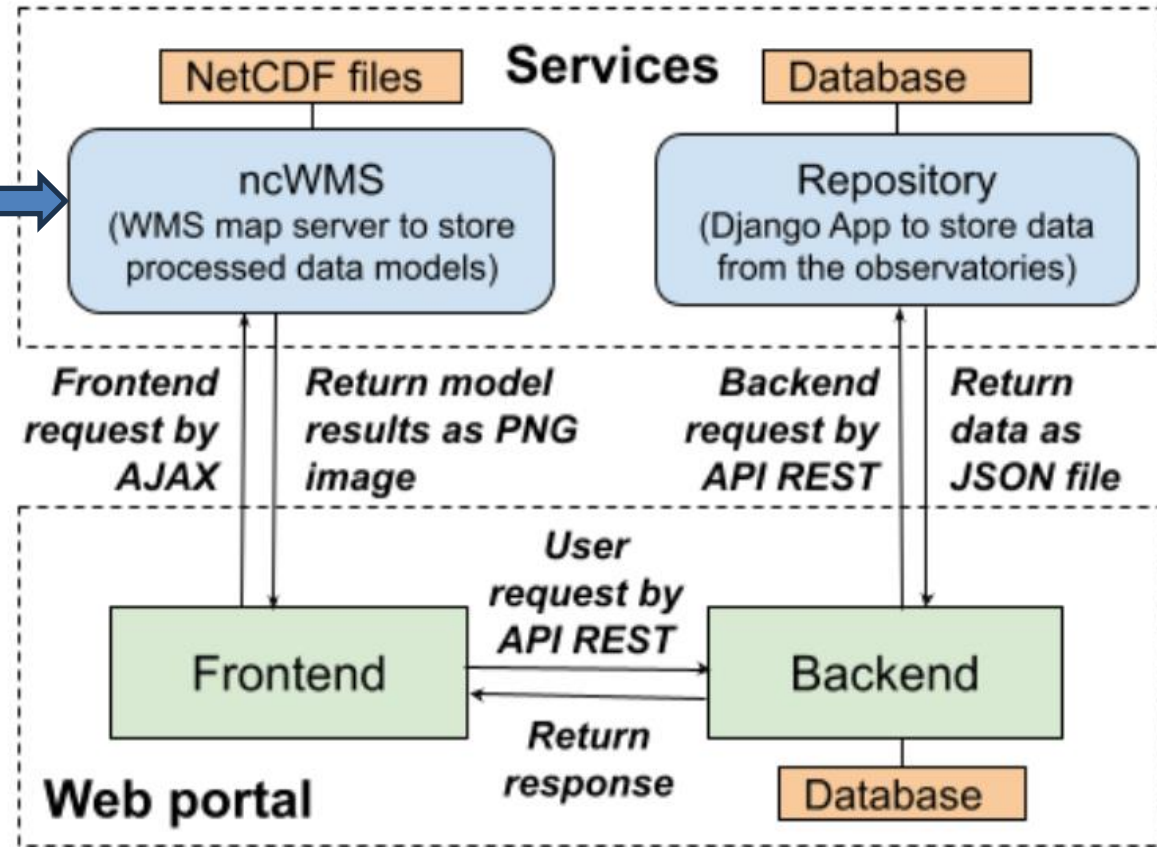


Automatic weekly reports

CONNECT webGIS collaboratory: behind the scenes



Forecast engine: software stack



Collaboratory architecture

- web portal: Django, a Python web framework for full-stack web development
- Frontend: provides the HTML pages for the user interactions
- Backend (with PostgreSQL Database): processes the user requests

Future developments in DT

Integrate “what-if” scenarios using the collaboratory infrastructure

- Climate change
- User-defined interventions

Enhance user interaction to build products and create sharable outputs

- Capacity to interact with data
- Capacity to build (simple) tools

Build consensus tools to support conflicting uses decisions

Implement the DT Collaboratory for distinct user requirements challenges:



WOLLF - Pilot Digital Twins for Water Pollution in Africa - UN Decade project

Duration: 2023-2026 (36 months)



**2021
2030** United Nations Decade
of Ocean Science
for Sustainable Development

WOLLF – Key expected outcomes

-
-
- The first Digital Twin for Africa focused on pollution and related areas, built through co-design
- The demonstration of this tool in two coastal regions of Africa (Nigeria and Cape Verde)
- An open source, relocatable tool that can be applied anywhere and be adapted to other challenges in the future
- An open platform for local communities' engagement through sharing knowledge and experience
- Training and learning materials regarding coastal dynamics, forecast systems and Digital Twins
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Acknowledgements



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More info here:
connect.Inec.pt

Thank you for your attention!
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