Copernicus Marine Service

COPERNICUS MARINE
8th GENERAL ASSEMBLY

Ocean Modeling capabilities in EU DTO

EDITO Model Lab Horizon Europe project

European Digital Twin Ocean

EU MISSIONS
RESTORE OUR OCEAN & WATERS
#EUmissions #HorizonEU #MissionOcean

in cooperation with EDITO

Copernicus Marine Service

PROGRAMME OF THE EUROPEAN UNION

Copernicus
Europe's eyes on Earth

implemented by MERCATOR OCEAN INTERNATIONAL

The project

European Digital Twin Ocean

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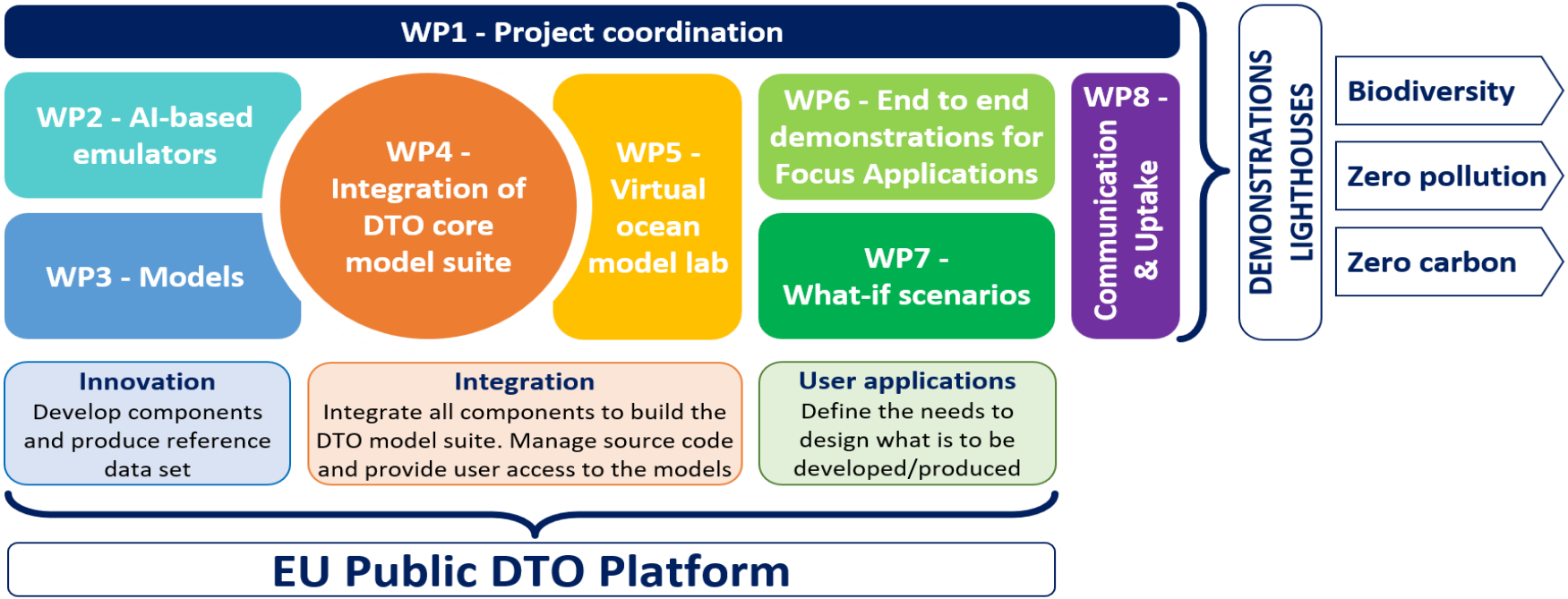
A consortium based on ocean modeling expertise

7M€
3-year project
Kickoff meeting 21-22 Feb 2023

13 partners from 8 countries with expertise in :

- **Ocean modeling from global scale to coastal, for ocean physics, biogeochemistry and marine environment**
- **Supercomputing including experts from computing centers**
- **Artificial Intelligence applied to ocean application**
- **Software development, model and tools co-development**
- **Operational oceanography with strong links with Copernicus Marine, Ocean Predict and UN decade**
- **Intermediate to final User applications**

Project organisation



Models and environment

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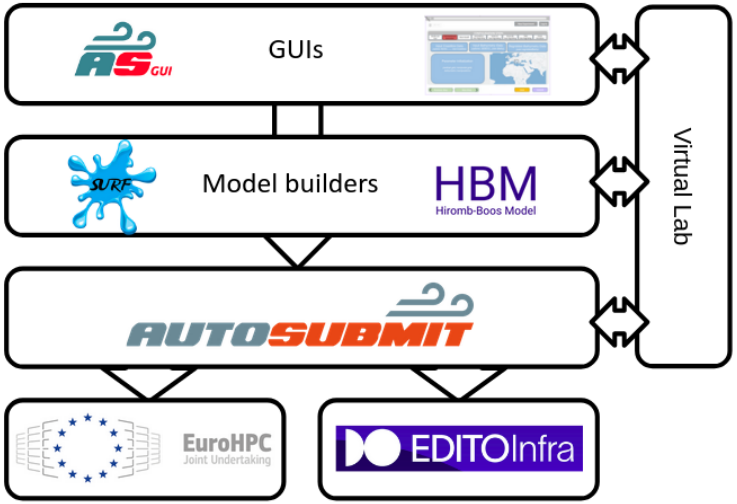
Virtual Ocean Model Lab : co development environment

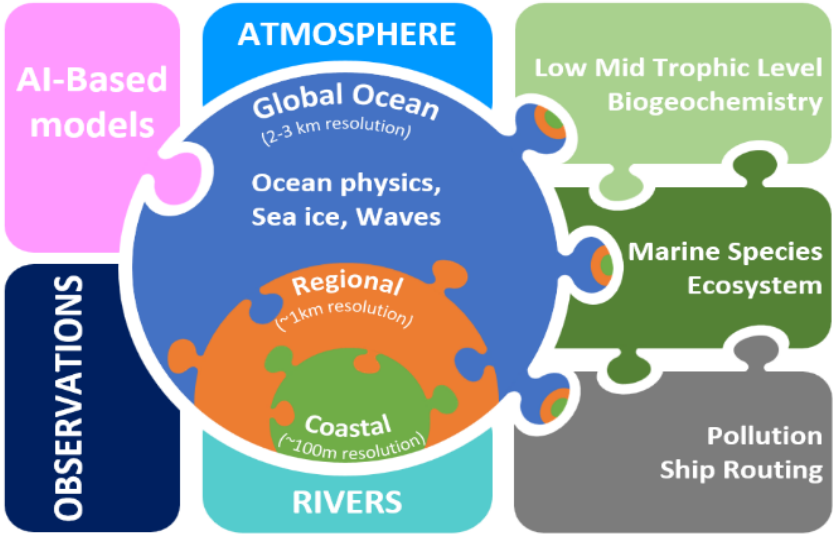
VOML is a comprehensive system that brings together a **development subsystem** and an advanced **computing infrastructure**, creating a comprehensive environment for **optimising** and **managing** diverse computing **resources**.



Modeling suite

Deep Differentiable Emulators (DDEs) for ocean modelling and forecasting that will provide native AI building blocks for the hybrid digital twins of the ocean

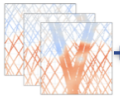
Numerical models for hydrodynamics and waves and develop the next generation of ocean model configurations optimised for European HPC hardware and the Digital Twin usage.



DDEs for simulation and forecasting

Why : (End-to-end) DL approaches to forecasting and reconstruction problem

End-to-end emulator



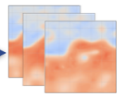
End-to-end neural solver

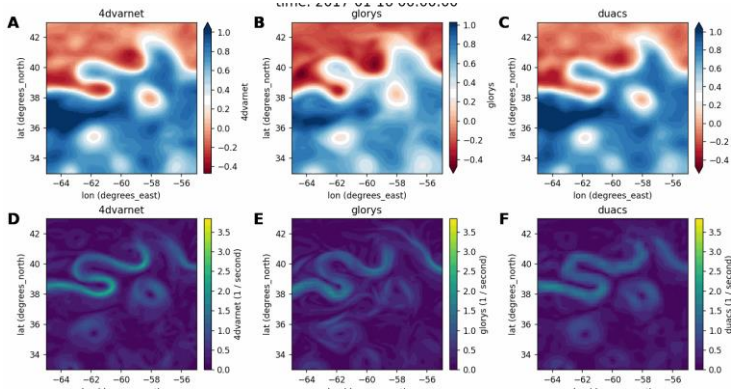
$$\mathbf{x}^{(k)} = \mathbf{x}^{(k-1)} + \mathcal{R}\left(\nabla_{\mathbf{x}} U\left[\mathbf{x}^{(k)}, \mathbf{y}, \Omega\right]\right)$$

⇕

Underlying DA formulation

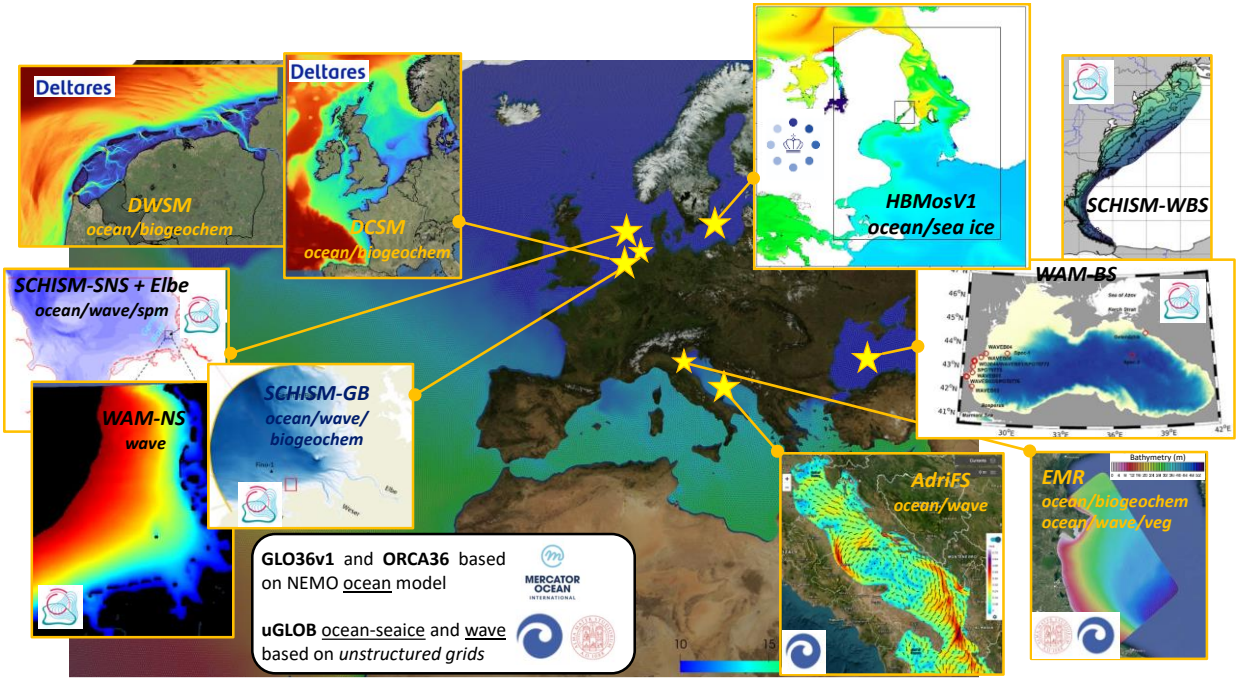
$$\widehat{\mathbf{x}} = \arg\min_{\mathbf{x}} \underbrace{\|\mathbf{x}-\mathbf{y}\|_{\Omega}^{2} + \lambda \|\mathbf{x}-\Phi(\mathbf{x})\|^{2}}_{U[\mathbf{x},\mathbf{y},\Omega]}$$





- Lagrangian drift simulation
- Mapping and short-term forecasting of sea surface dynamics (SSH, SSC)
- Mapping of turbidity dynamics

Ocean configurations for DTO models



PARTNER(S) INVOLVED	NAME OF THE OCEAN CONFIGURATION	GEOGRAPHICAL REGION	MODEL(S)
MOI	**GLO36V1**	Global	NEMO
MOI	**ORCA36 free runs**	Global	NEMO
CMCC/UNIBO	**uGLOBocean**	Global	SHYFEM-MPI/SeaIce
CMCC/UNIBO	**uGLOBwave**	Global	WW3
CMCC	**AdriFs**	Adriatic Sea	SHYFEM-MPI/WW3
UNIBO	**ERM-biogeo**	Northern Adriatic Sea	SHYFEM-MPI
UNIBO/CMCC	**ERM-veg**	Northern Adriatic Sea	SHYFEM-MPI/WW3
DMI	**HBMosV1**	Baltic-North Sea	HBM
Deltares	**DCSM** (Dutch Continental Shelf Model)	North Sea	Delft3D-FM
Deltares	**DWSM** (Dutch Wadden Sea Model)	Wadden Sea	Delft3D-FM
Hereon	**SCHISM-GB**	German Bight	SCHISM/WWM/SED3D
Hereon	**SCHISM-SNS + Elbe**	southern North Sea + Elbe estuary	SCHISM
Hereon	**WAM-NSW**	North Sea	WAM
Hereon	**WAM-BS**	Black Sea	WAM
Hereon	**SCHISM-WBS**	Western Black Sea	SCHISM/WAM

Applications

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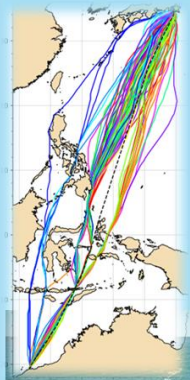
Demonstrations based on Focus Applications VIDEO

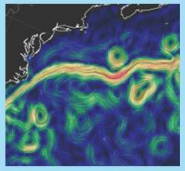
1. Marine Protected Areas for Biodiversity

Mapping habitat suitability ranges for protected species.

2. Ship routing optimization for Zero Carbon

Using ocean forecasts to reduce CO_2 emmissions

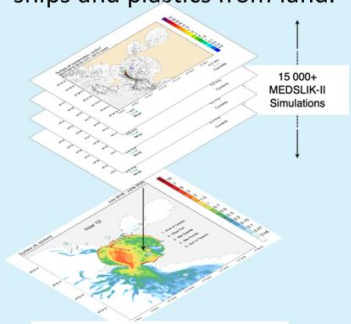




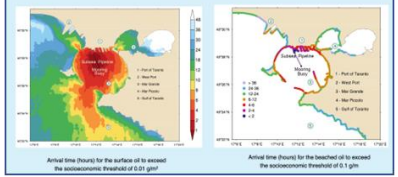
<output of VISIR-II ship routing model for green corridor Japan-Australia

3. Oil spill modelling for Zero Pollution

Simulating release of oil from ships and plastics from land.



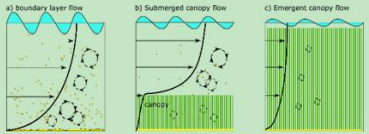
Average oil concentration map (e.g., for 12th hour)
Arrival time

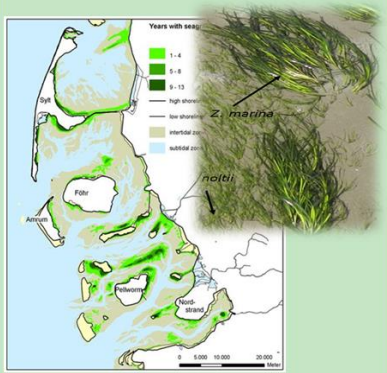


Demonstrations based on What-if-Scenarios VIDEO

1. Nature based solution for coastal erosion

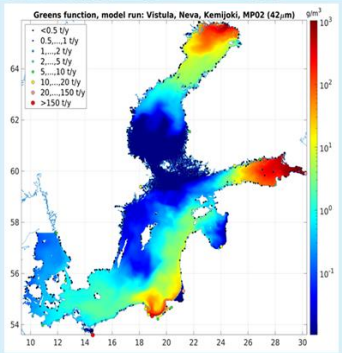
What if we reconstruct seagrass to absorb wave energy?





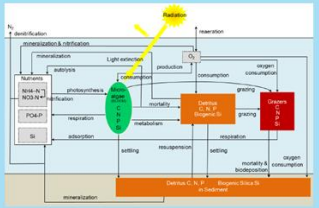
2. Marine Plastics for zero pollution

What if we capture plastics before they reach our seas? Modelling circulation & drift.



3. Aquaculture for Zero Carbon

What if we implement large scale aquaculture? Modelling the impact on the carbon cycle.



Digital Ocean Forum 2024

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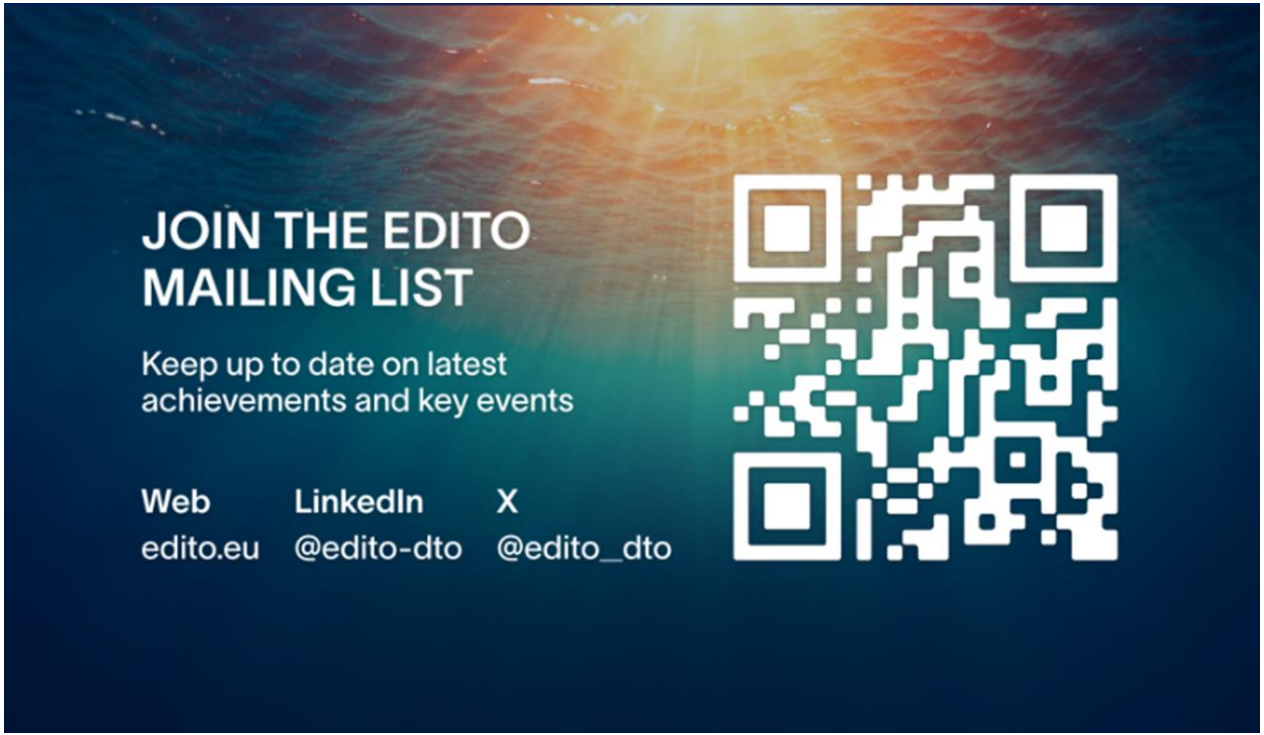
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