Ocean Predict

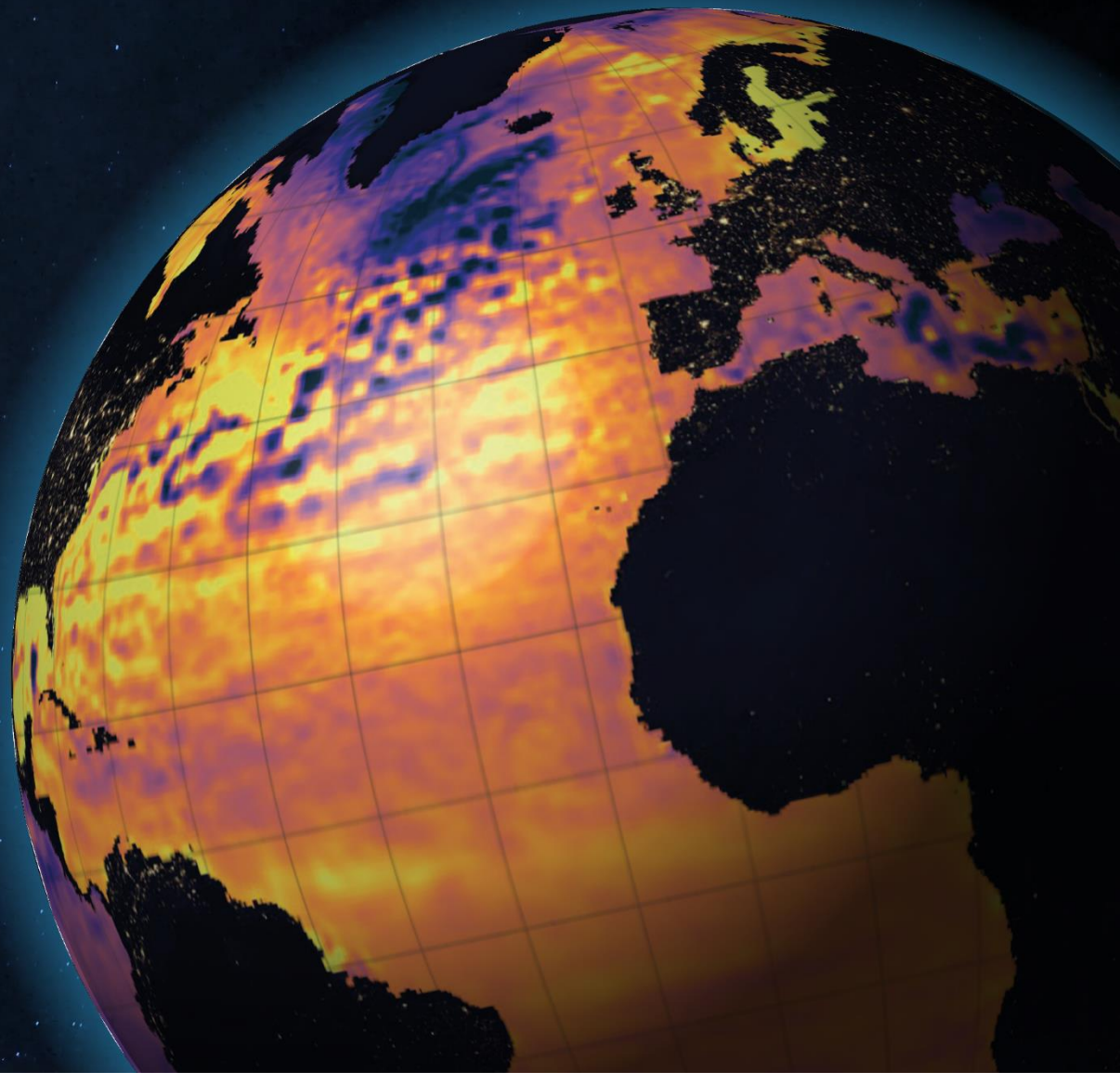
SYMPOSIUM OP'24

In partnership with unesco Intergovernmental Oceanographic Commission

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

EDITO-Model Lab: towards the next generation of ocean numerical models

Yann Drillet, Mercator Ocean International and EDITO Model Lab Partners



Plan

- Digital twin Ocean
- EDITO Model Lab project
- Model development
- Applications and Demonstrations

Ocean Predict

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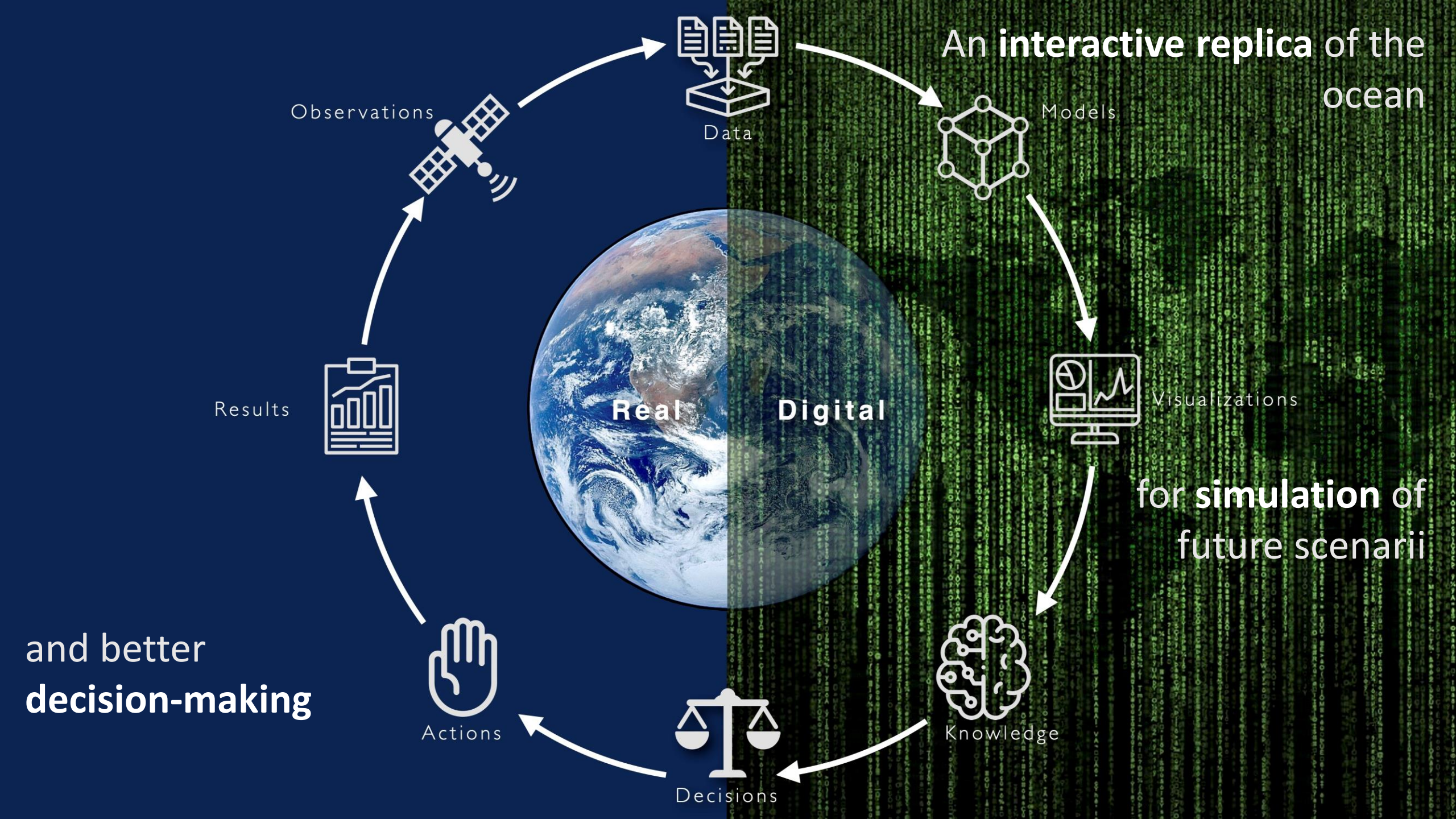
2021 2030 United Nations Decade of Ocean Science for Sustainable Development

An **interactive replica** of the ocean



for **simulation** of future scenarii

and better **decision-making**

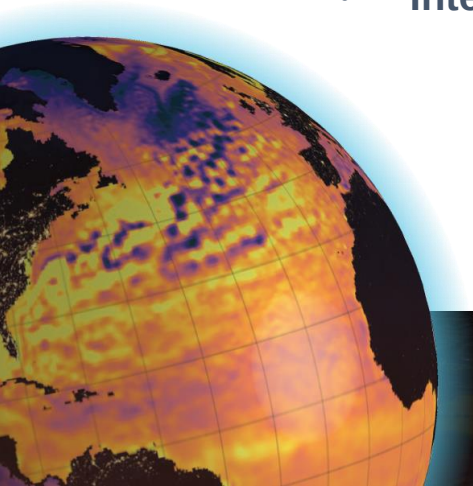
European Digital Twin of the Ocean

A leap in ocean knowledge
and sustainable action

EDITO Model Lab : A consortium based on ocean modeling expertise

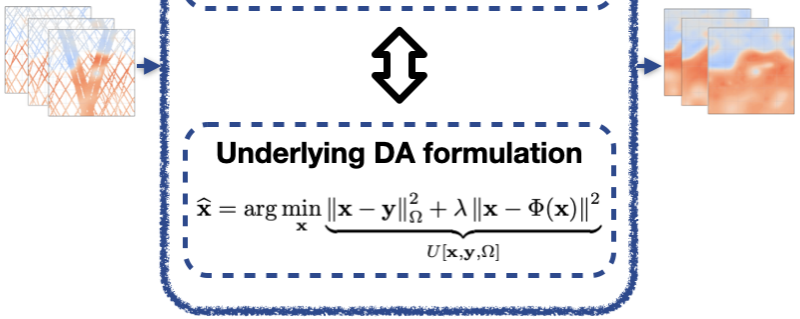
13 partners from 8 countries with expertise in :

- **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**



DDEs for simulation and forecasting

End-to-end emulator

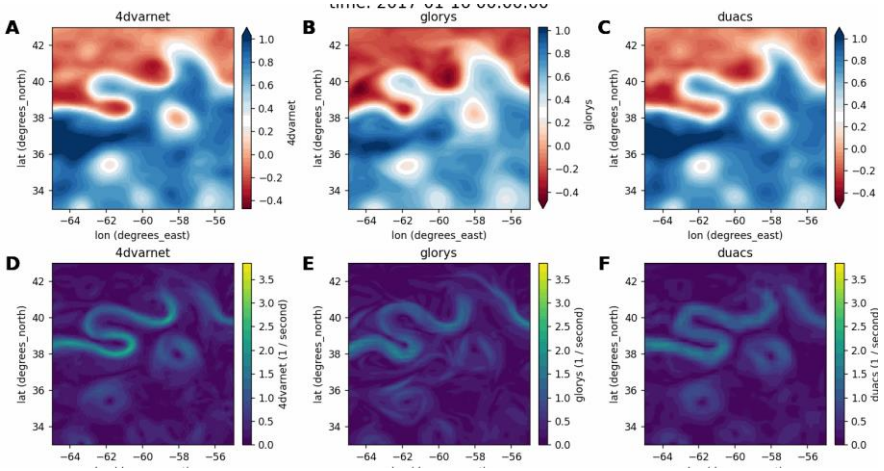


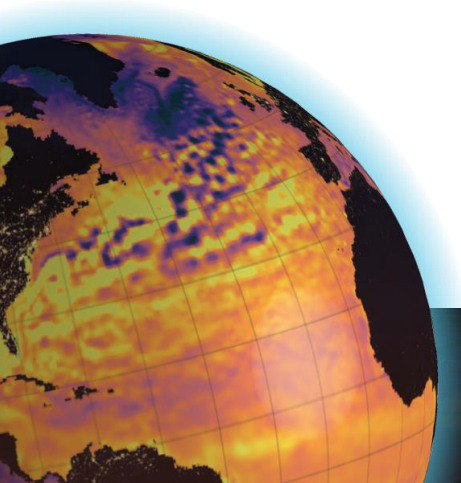
End-to-end neural solver

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

Underlying DA formulation

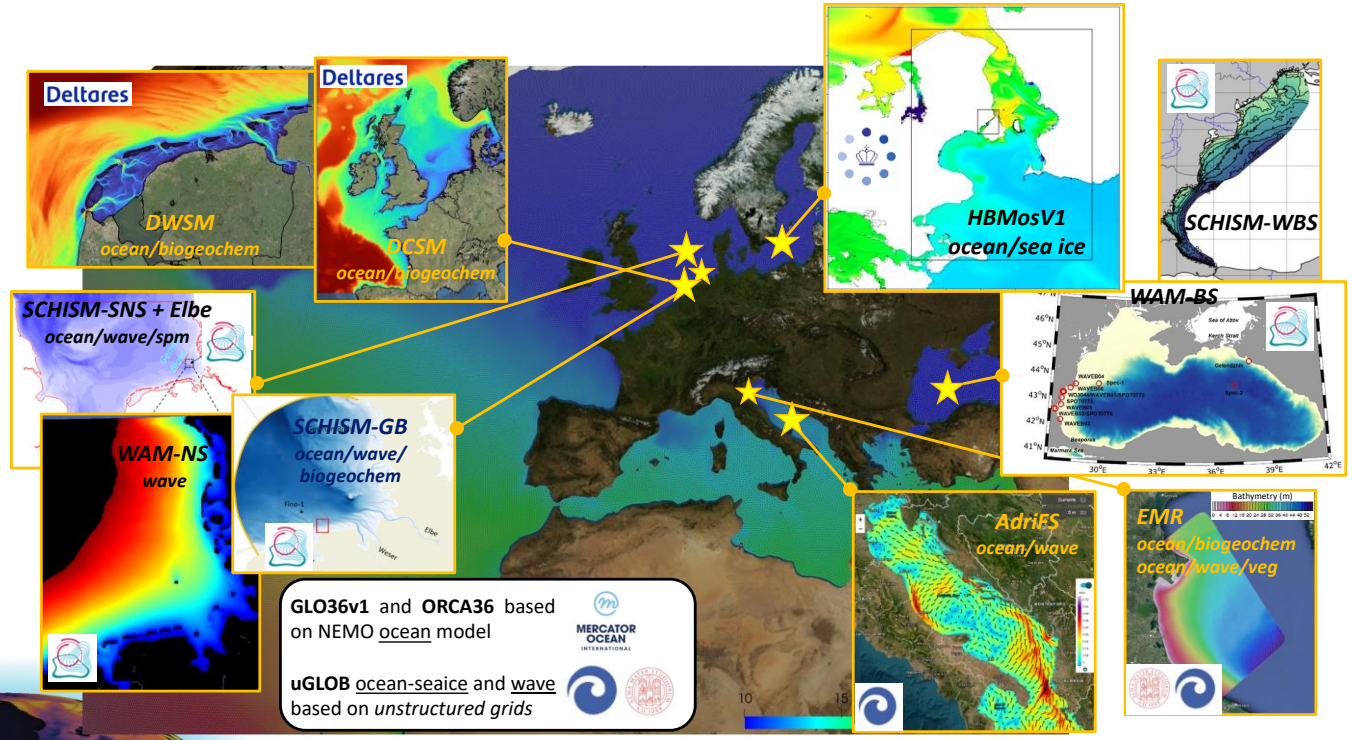
$$\hat{\mathbf{x}} = \arg\min_{\mathbf{x}} \underbrace{\|\mathbf{x}-\mathbf{y}\|_{\Omega}^{2} + \lambda \|\mathbf{x}-\Phi(\mathbf{x})\|^{2}}_{U[\mathbf{x},\mathbf{y},\Omega]}$$





- 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

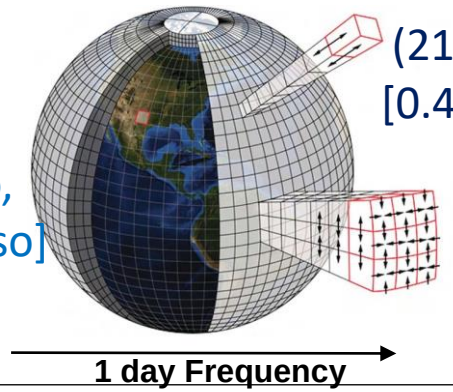
NN global forecasting system

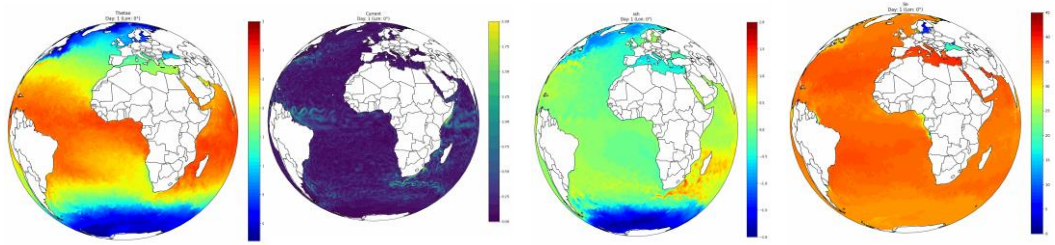
Glonet [1/4] Configuration

Training Setup

- **GLORY12**
  - Training [1993~2020]
  - Validation [2021]
  - Testing [GLO12]

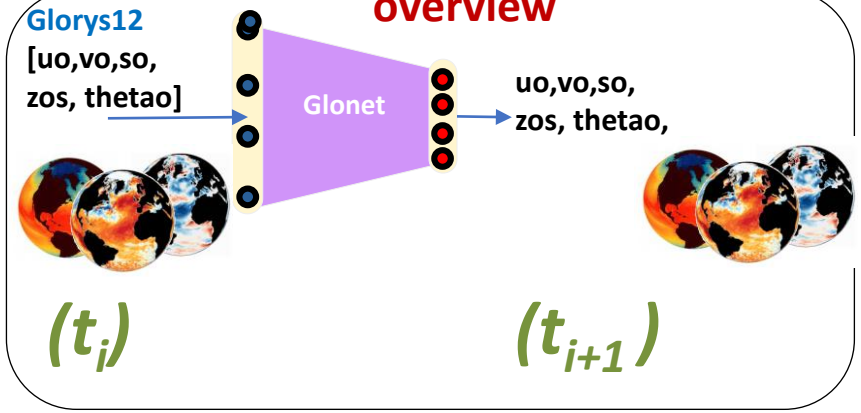
Vars:
zos
[thetao,
uo,vo, so]

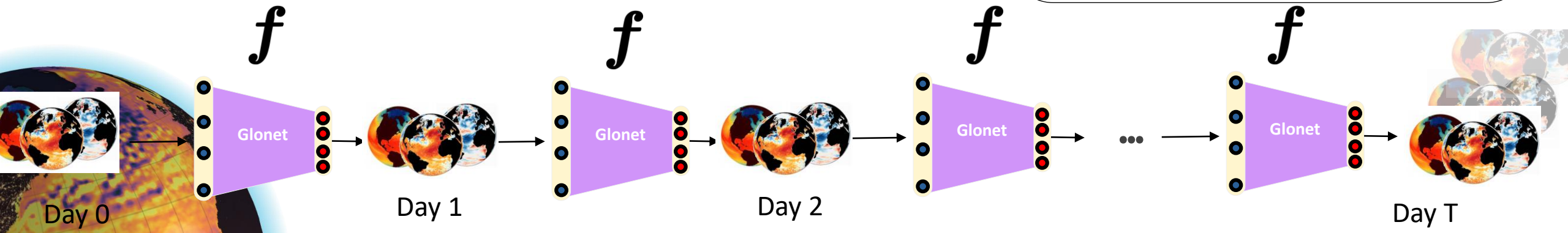




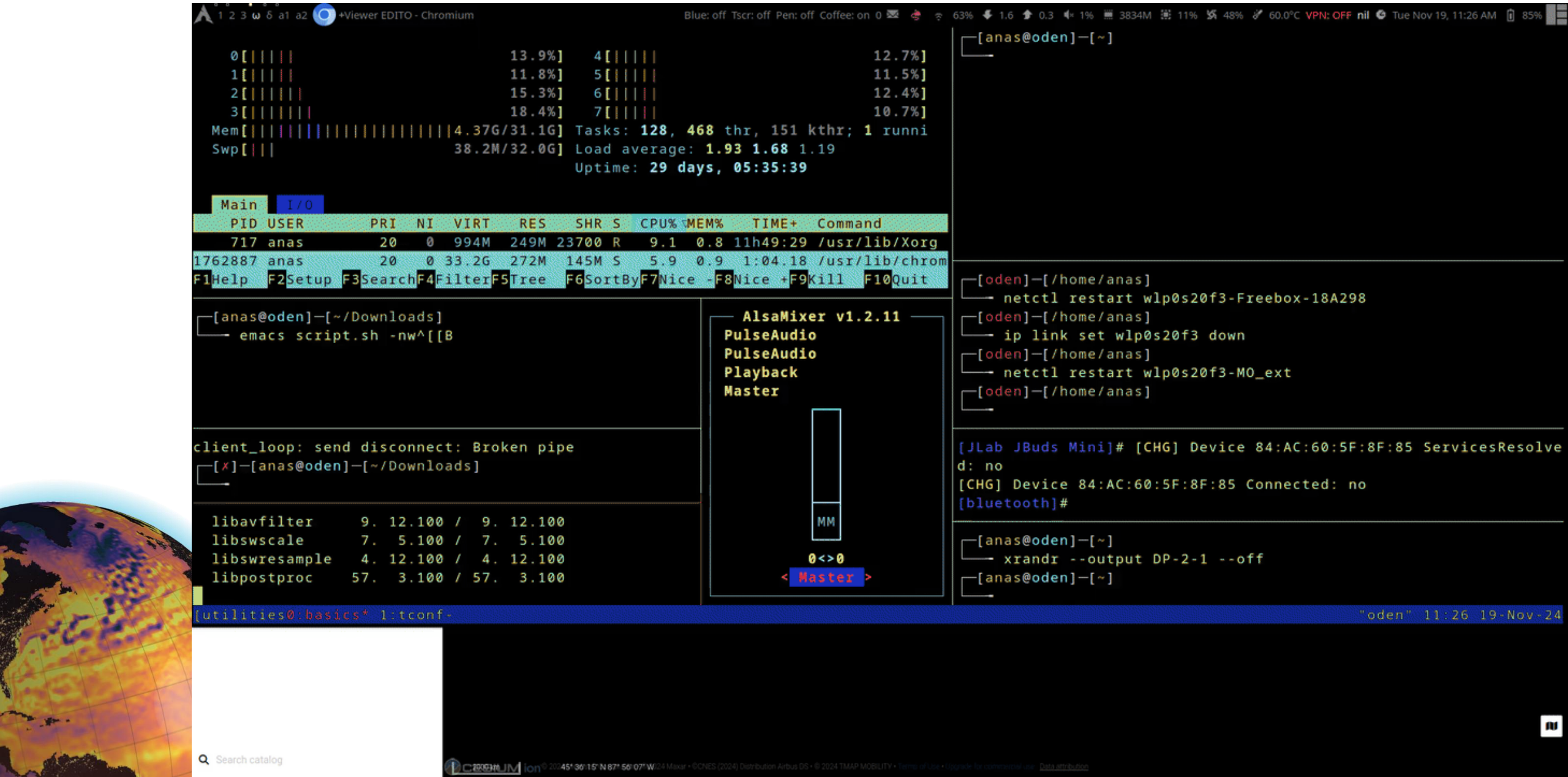
Ressources

- ECP: 8 nodes, 32xA100 GPUs
- Several days of training





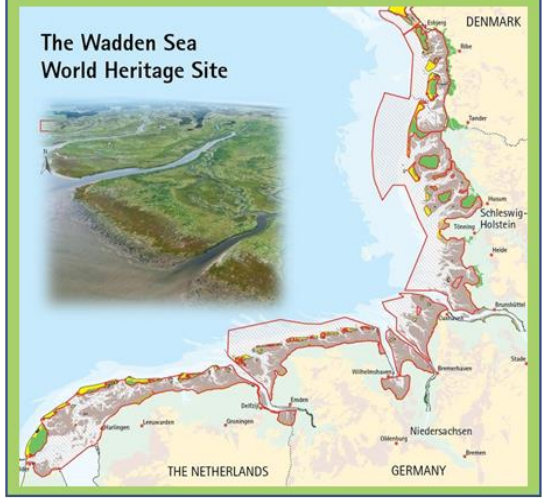
Glonet provides daily Forecasts on Edito platform



Demonstrations based on Focus Applications

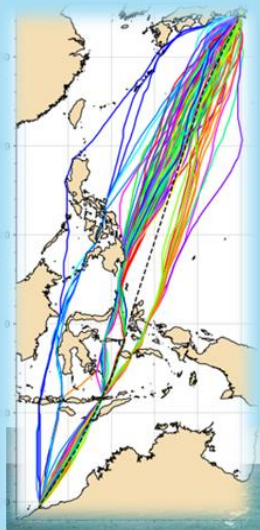
1. Marine Protected Areas for Biodiversity

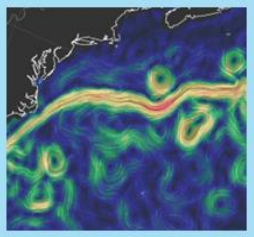
Mapping habitat suitability ranges for protected species.



2. Ship routing optimization for Zero Carbon

Using ocean forecasts to reduce CO_2 emmissions

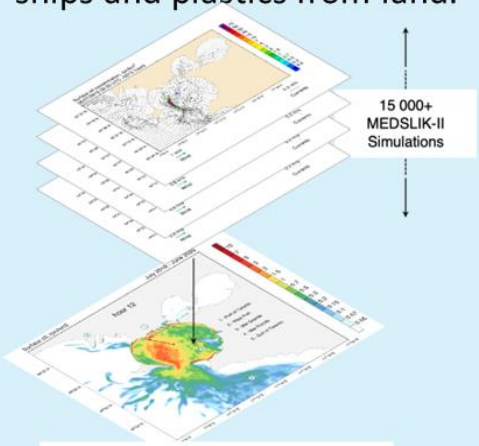




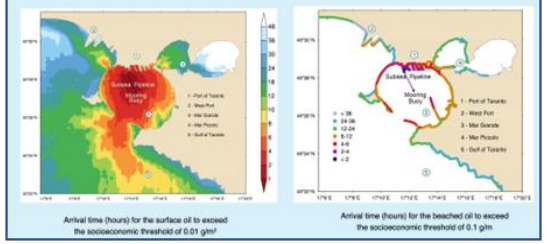
<output of VISIR-II ship routing model for green corridor Japan-Australia

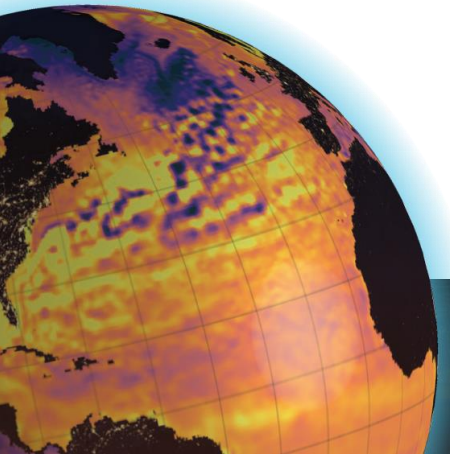
3. Oil spill modelling for Zero Pollution

Simulating release of oil from ships and plastics from land.



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

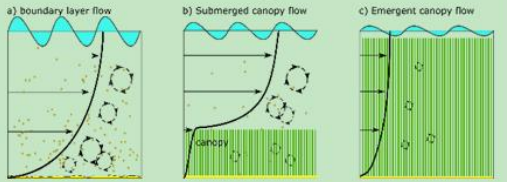


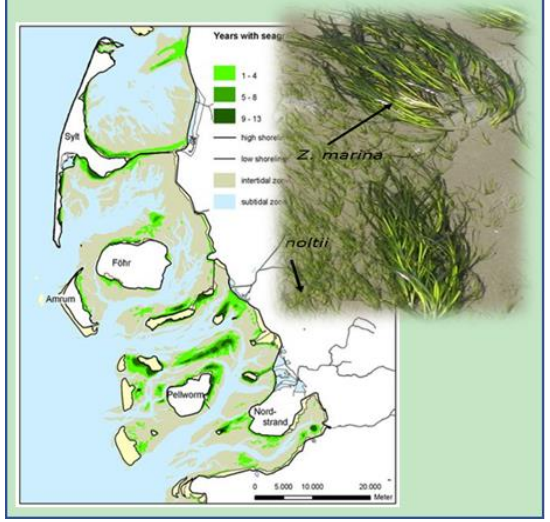


Demonstrations based on What-if-Scenarios

1. Nature based solution for coastal erosion

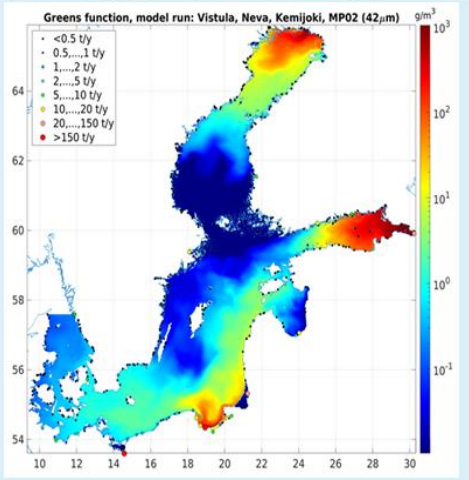
What if we reconstruct seagrass to absorb wave energy?





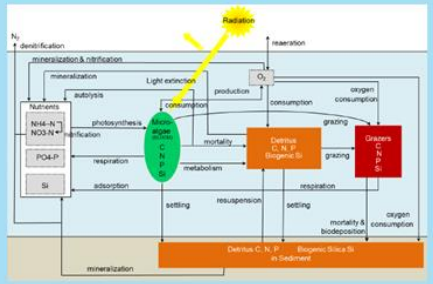
2. Marine Plastics for zero pollution

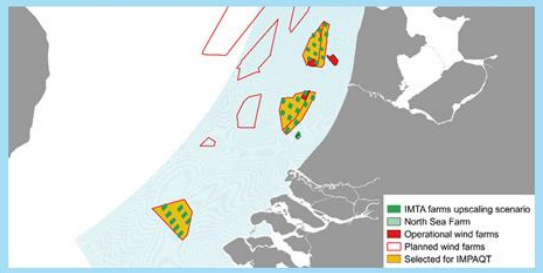
What if we capture plastics before they reach our seas? Modelling circulation & drift.

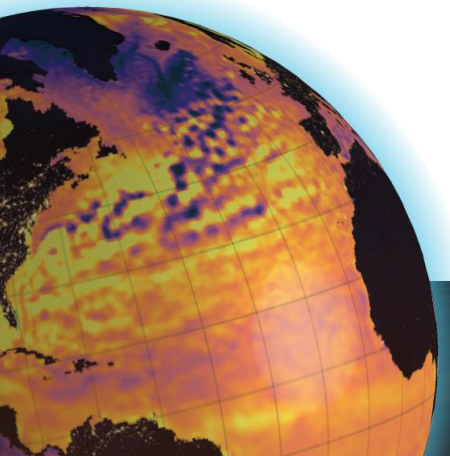


3. Aquaculture for Zero Carbon

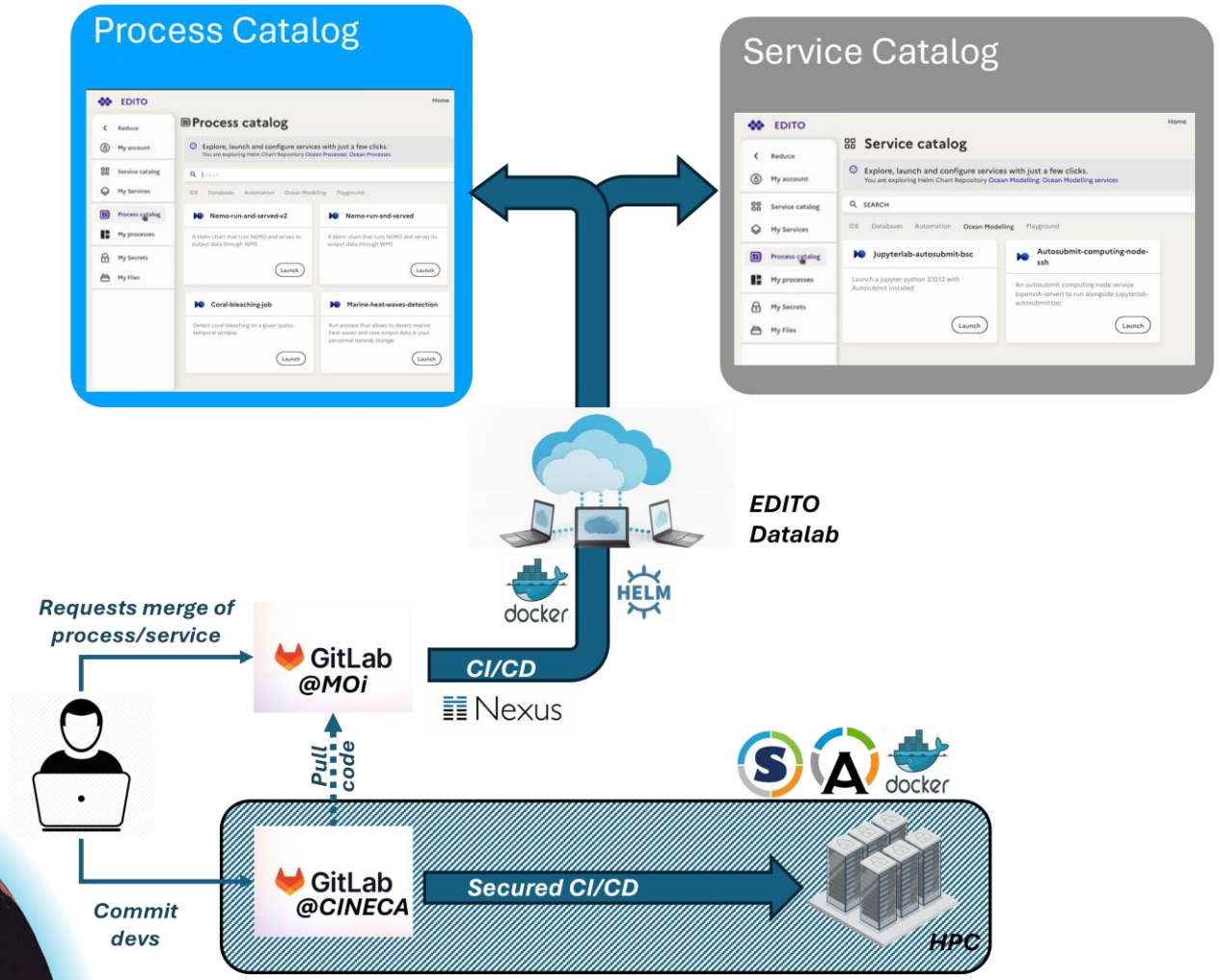
What if we implement large scale aquaculture? Modelling the impact on the carbon cycle.







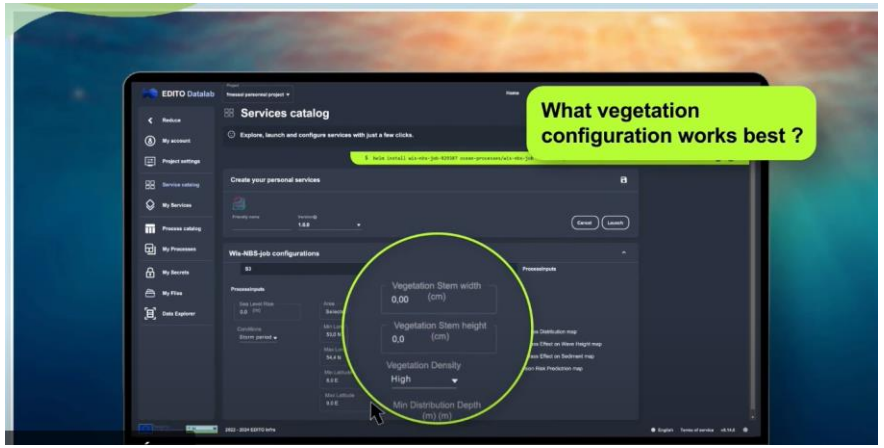
Integration on EDITO platform

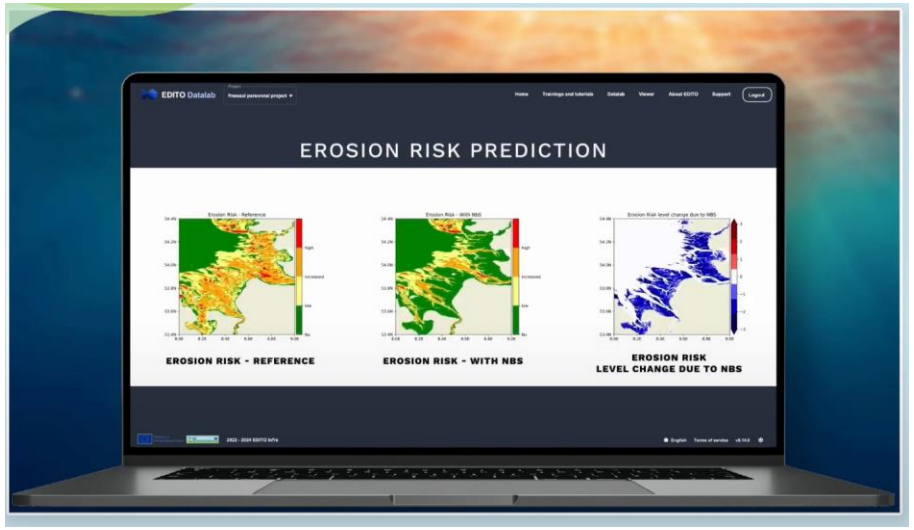


- Access to new **dataset** and simulations (eg ORCA36 subsample)
- Access to **modeling** tools In EDITO Virtual Ocean Model Lab
- Access to new **process** and **services** (eg EDITO Model Lab focus applications and what-if scenario and other projects)

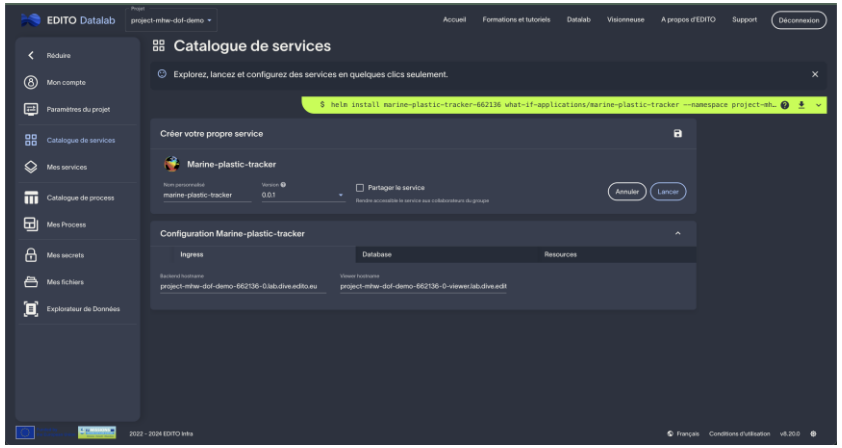
Two examples showcases during DOF#3

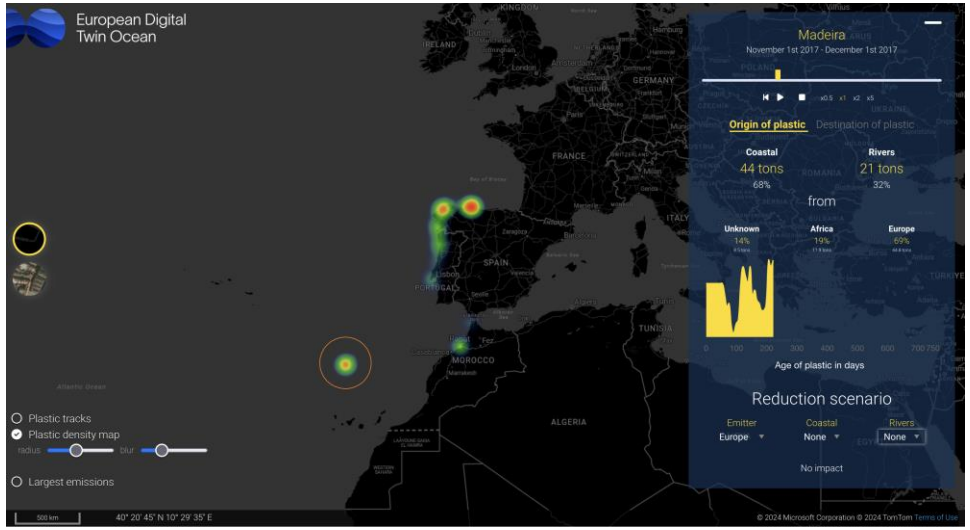
Nature Based Solution :
Scenario for seaweed distribution and impact on current, waves energy and coastal erosion

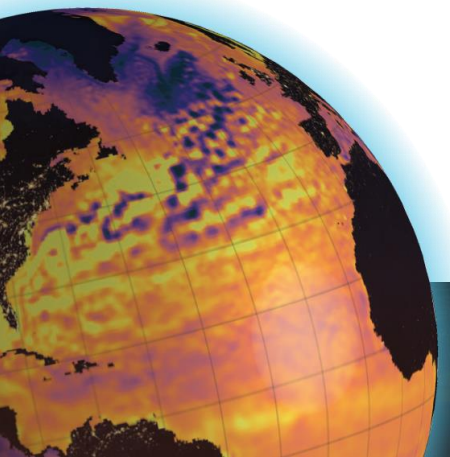




Plastic pollution :
Connectivity and impact of runoff and coastal inputs.







CONCLUSIONS

- 2025 : EDITO Model Lab final integration and demonstration. At least 6 demonstrations integrated as well as other demonstration developed in other framework (Iceberg drift, Sargassum drift ...)
- Development of Emulators : Intercomparison, data challenges and validation protocole. Integration on EDITO and use for dedicated application (lagrangian, diagnostics, turbidity, glonet ...)
- New what-if scenario : observation network impact on reconstruction and forecast, climate change scenario
- Pre/post processing and on demand computing of scores, metrics or indicators
- Sharing new reference experiments on EDITO datalake

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unesco
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SYMPOSIUM OP'24
ADVANCING OCEAN PREDICTION
SCIENCE FOR SOCIETAL BENEFITS
Thank you!
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Copernicus Marine Service
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INTERNATIONAL OCEAN GOVERNANCE
EU COMPONENT TO GLOBAL OCEAN OBSERVATIONS
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Met Office
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Australian Government
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Canada