General Assembly

16-18 January 2024 – Lecce, Italy

CMCC Headquarter in Lecce, via Marco Biagi 5

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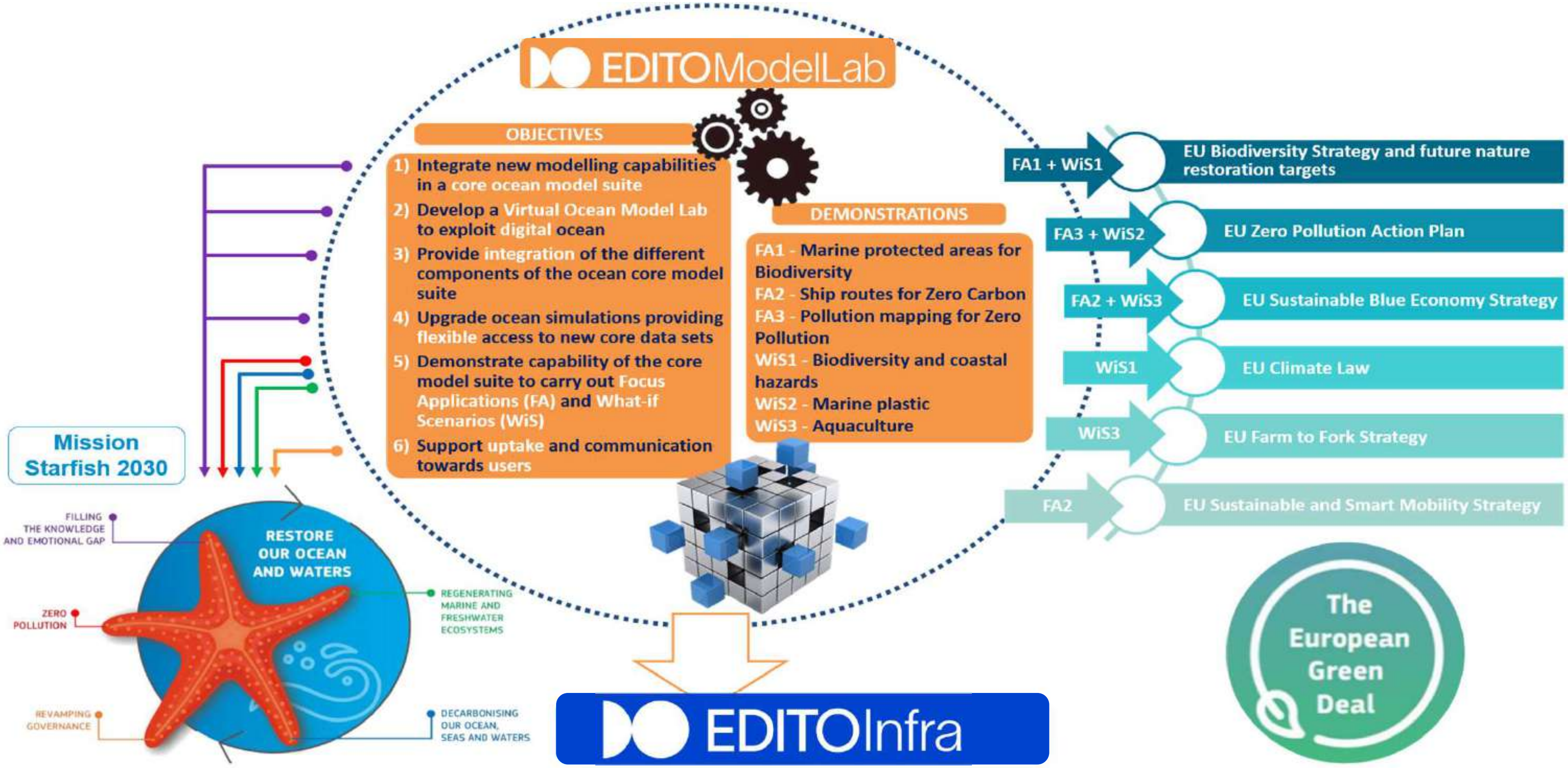
MERCATOR OCEAN INTERNATIONAL

EDITO Model Lab : Underlying Models for Digital Twin Ocean



EDITOModelLab

To ensure an operational European Digital Twin Ocean (EDITO) core infrastructure by 2024, the building blocks of the initiative are underway through the Horizon Europe-funded sister projects:

EDITOInfra

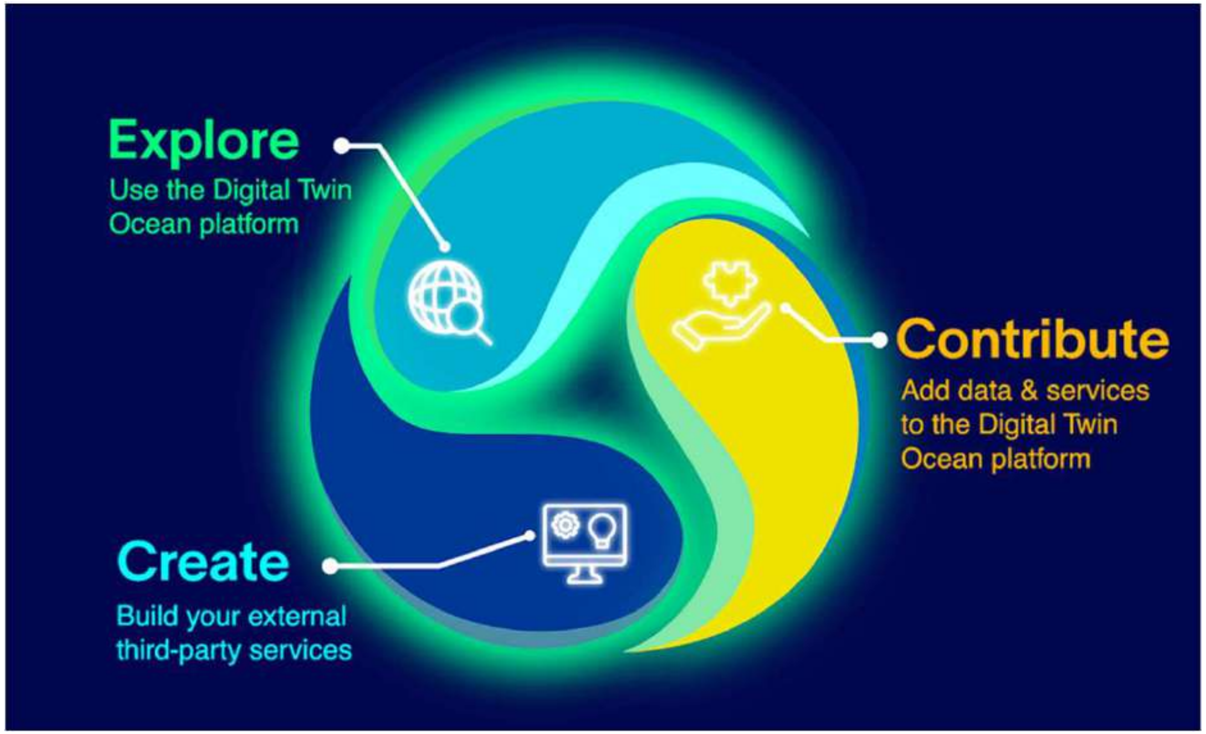
EDITOModelLab

Together, these two projects will build the Digital Twin Ocean platform, incorporating a data lake, processing engine and virtual simulation environment.

What EDITO will deliver ?

An integrated platform

New services



EDITOModelLab

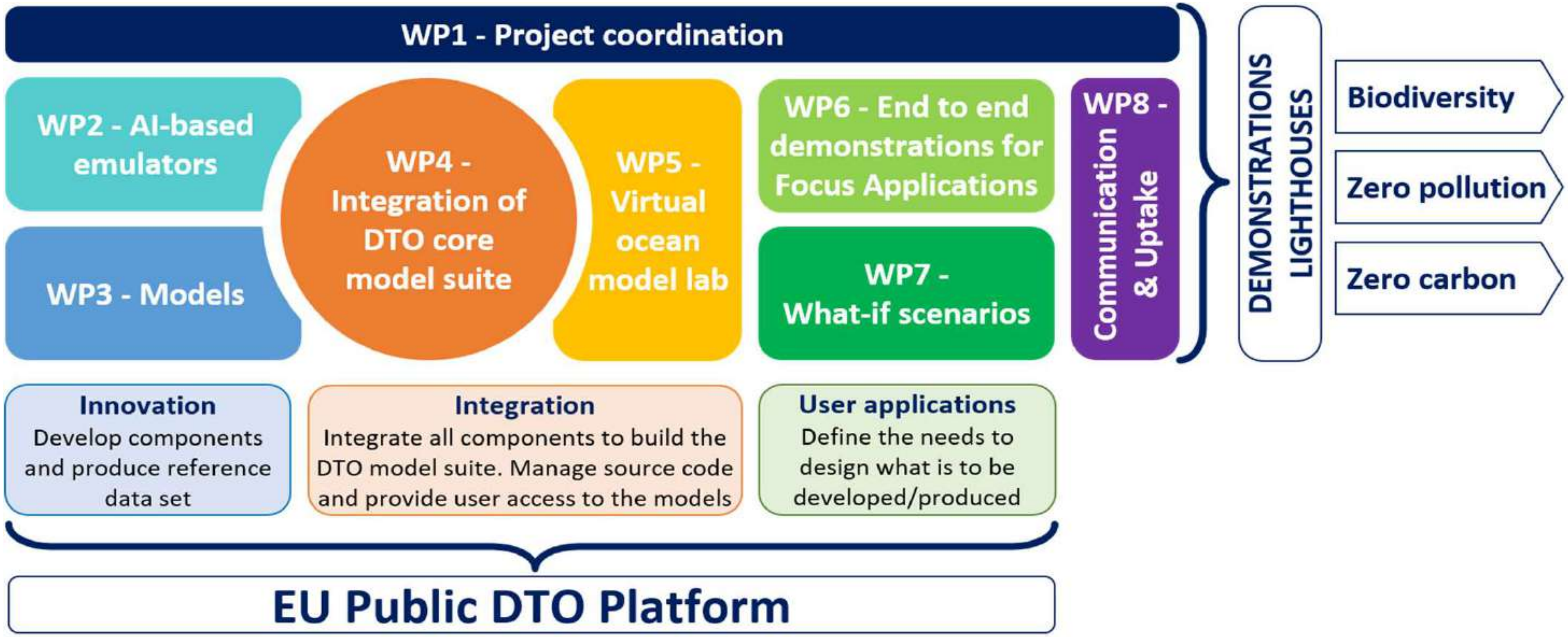
A consortium based on ocean modeling expertise

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



Project status

Review of main achievements performed yesderday
Co design phase is finalised
Integration phase is started
Demonstration is planned for 2025

Development are on going as presented yesterday :

- We have first emulators
- We have a large diversity of model configurations from global to coastal
- We have a co development environment based on EDITO platform
- We started to develop the demonstrators that are the showcase of EDITO project.

Agenda – DAY 2

DAY 2 morning – USER SESSIONS

Wednesday	17 January 2024	Ground floor, Conference Room	
9:30 - 10:30	User Session 1 WiS#1 - Nature Based Solutions for Biodiversity and coastal hazards 1-Presentation of Application 2-Demo 3-Discussion with users	CMCC, DMI, HEREON, UniBO	Advisory Board External Users
10:30-10:50	User Session 2 WiS#2/FA#3 – Zero Pollution 1-Presentation of Application	CMCC, UniBO, DMI	Advisory Board External Users
10:50-11:15	*Break with cofree (Ground floor, Coffee Break Room)*		
11:20-12:00	User Session 2 WiS#2/FA#3 – Zero Pollution 2-Demo 3-Discussion with users	MOi	Advisory Board External Users
12:00-12:40	User Session 3 FA#1 – Marine Protected Areas for Biodiversity 1-Presentation of Application 2-Demo 3-Discussion with users	Deltares	Advisory Board External Users

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DAY 2 User Sessions – Participants (39)

Your name	Your organization / Your project
Christine Pequignet	Met Office
Giulio Ceriola	Planetek Italia
Aditi Goswami	Boeing/ AI in Aerospace
Marta Rodrigues	LNEC - Laboratório Nacional de Engenharia Civil / Project: CONNECT
Marcos G Sotillo	NOW Systems
Manuela D'Amen	ISPRA - ITALY
Fearghal O'Donncha	IBM Research Ireland
Stefania Ciliberti	NOW Systems
Janaka de Silva	IUCN
Luc Vandenbulcke	seamod.ro / SYROCO
Katerina Spanoudaki	FORTH
GEORGIOS SYLAIOS	DEMOCRITUS UNIVERSITY OF THRACE / ILIAD
Barış Salihoğlu	BRIDGE-BS / Middle East Technical University
Pınar Uygurer	BRIDGE-BS / Middle East Technical University
Ute Brönner	SINTEF Ocean / Iliad Digital Twins of the Ocean
Thomas Geenen	ECMWF DestinE
Patricia Cabrera	VLIZ-BlueCloud2026
Lawrence Whatley	VLIZ
Manuel García	NOW Systems
Derval Corinne	Copernicus Marine, Mercator Ocean
Gideon Gal	IOLR
Arne J. Berre	SINTEF
Christophe BRIERE	REST-COAST

Your name	Your organization / Your project
Daiga Cepite-Frisfelde	Hywasport
Audrey Hasson	GEO Blue Planet, Mercator Ocean
Stefania Ciliberti	NOW Systems
Elena Osipova	European Environment Agency
Francesco de Franco	Torre Guaceto MPA
Paolo D'Ambrosio	Porto Cesareo MPA
Nicola Ungaro	Environmental Agency of Apulia Region
Comandante di Vascello Francesco Perrotti	Capitaneria di Porto di Gallipoli
Tenente di Vascello Francesco Walter di Marco	Capitaneria di Porto di Otranto
Prof. Alberto Basset	University of Salento
Prof. Stefano Piraino	University of Salento
Prof. Francesco Mastrototaro	University of Bari
Gaetano Internò	Port Authority of Taranto
Francesco Ronco	Apulia Region
Valentina De Pinto	Apulia Region
Carmelo Calamia	Province of Lecce

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USER SESSION 1

WiS#1 - Nature Based Solutions for Biodiversity and coastal hazards

Moderator: CMCC (G Coppini)

USER SESSION 1 - Nature Based Solutions

1-PRESENTATIONS

1-Presentation of Application

- What-if-Scenario in Nature Based Solutions: On-demand modelling for coastal Hazards, HEREON (W Chen) (10’)
- Nature Based Solutions for Coastal Hazards In Northern Adriatic Sea, UniBO/CMCC (J. Alessandri) (10’)

What-if-Scenario in Nature Based Solutions: On-demand modelling for coastal hazards

Helmholtz-Zentrum Hereon (W Chen, B Jacob, J Staneva)

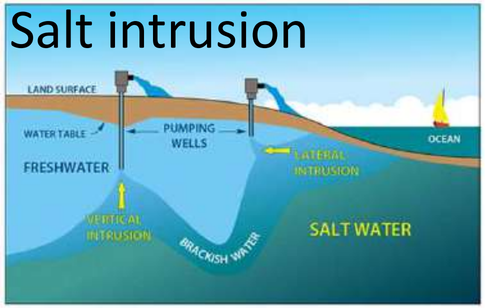
- Introduction: Coastal erosion & nature-based solutions
- Region and motivation
- Models (Associated tools): SCHISM-WWM-XBeach
- Prototype example and results

Helmholtz-Zentrum hereon EDITOModelLab

What-if seagrass for coastal erosion mitigation

Coastal hazard

...



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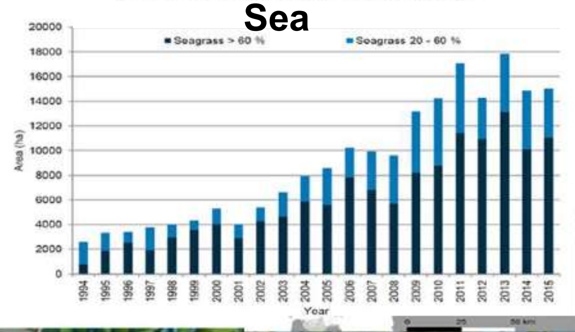
Region(s)

Wadden Sea

- **15,000 km2 => 73% protected areas**
- **UNESCO World Heritage Site since 2009**
- **Diverse hydrological, morphological and ecological characteristics**
  - Very fertile feeding, nursery and breeding grounds for fish, mammals and birds
  - 10,000 faunal species
  - 40 fish species
  - 6 mio migratory birds present at all times
- **a macrotidal environment with varying geometry**
- **difficult-to-couple interactions between the variety of meteo-oceanographic and morphodynamic factors acting on a limited area**

Mangroves in the Ghana coast

Seagrass in the German Wadden Sea



Seagrass meadows are an example of nature-based solutions for coastal resilience that will be addressed

Enable **relocatable** Setups on EDITO platform

with configurable NBS (seagrass, mangroves)

Models (tools)

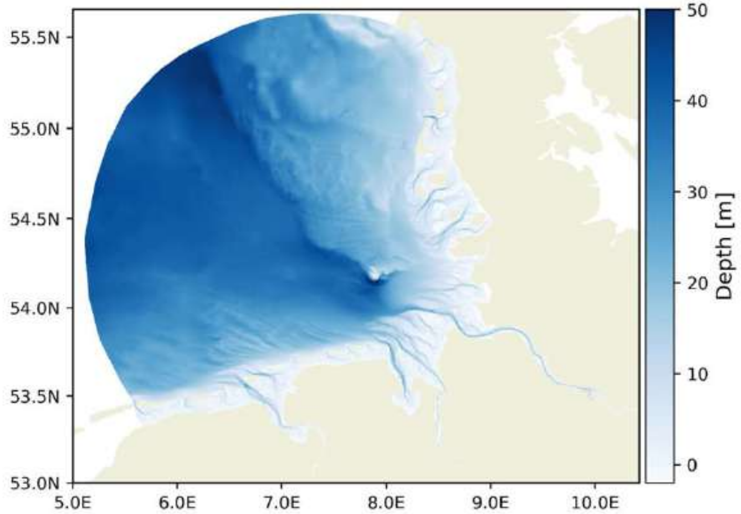
Hydro-model
(SCHISM-WWM)

Hydrodynamics

>1000 cores

Provides water level,
wave spectrum as
boundary forcing

SCHISM-WWM model domain



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Models (tools)

Hydro-model (SCHISM-WWM)

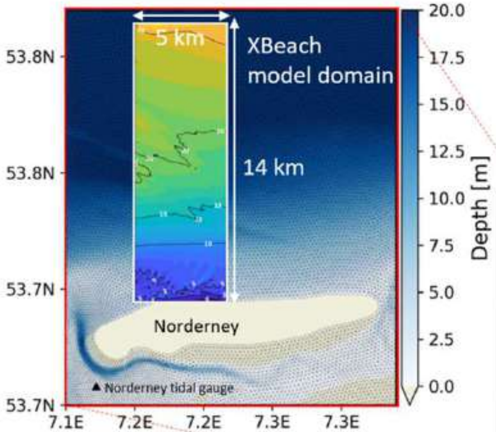
Hydrodynamics

>1000 cores
+
>100 cores

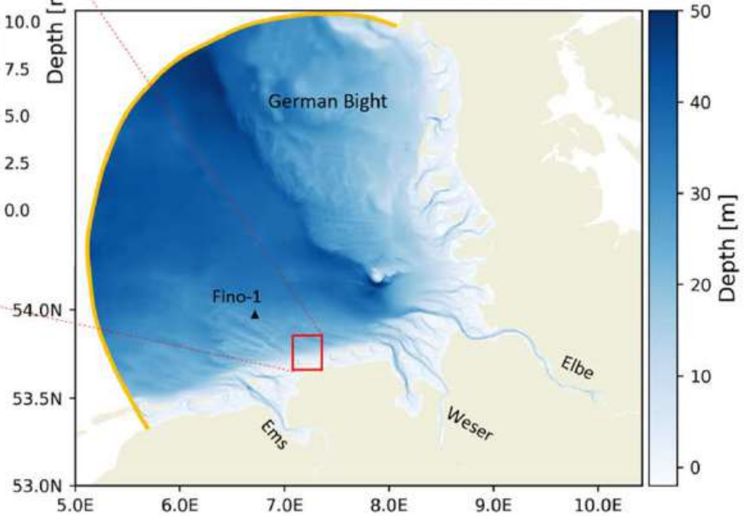
Provides water level, wave spectrum as boundary forcing

Morph-model (XBeach)

Morphodynamics



SCHISM-WWM model domain



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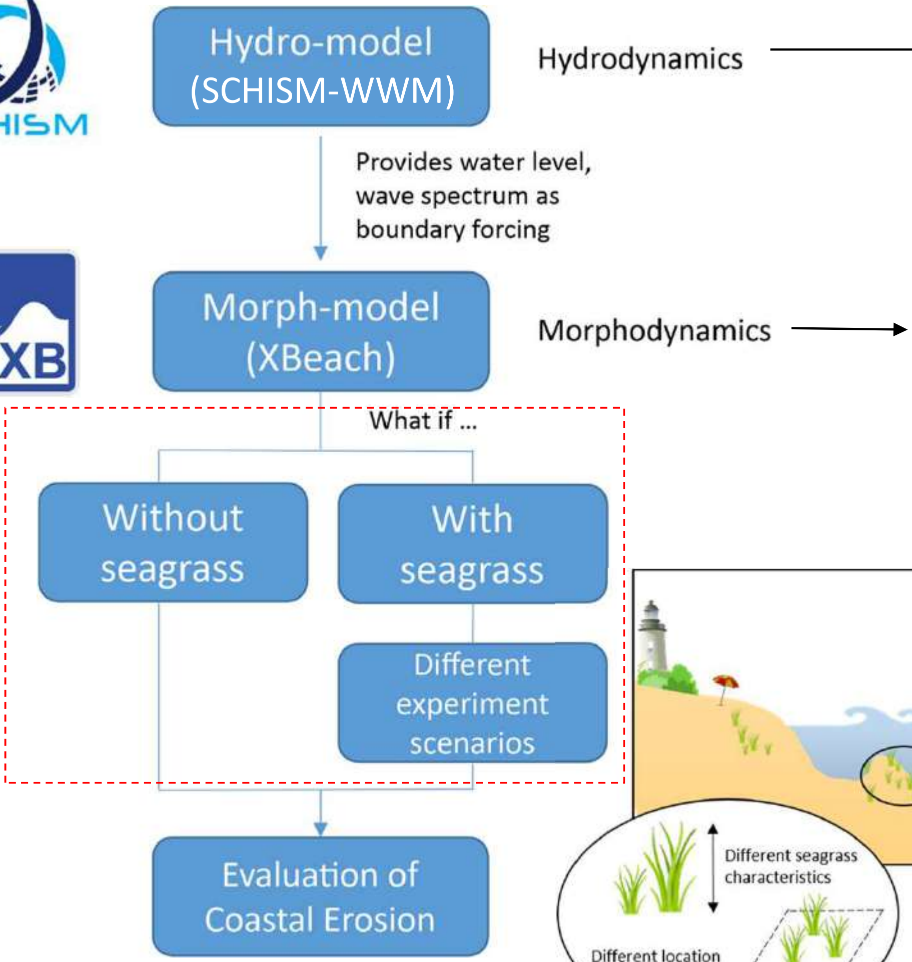
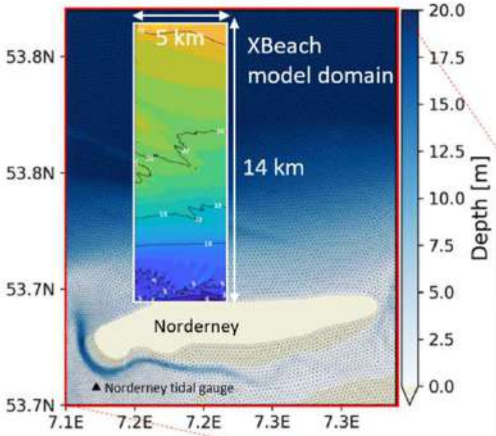
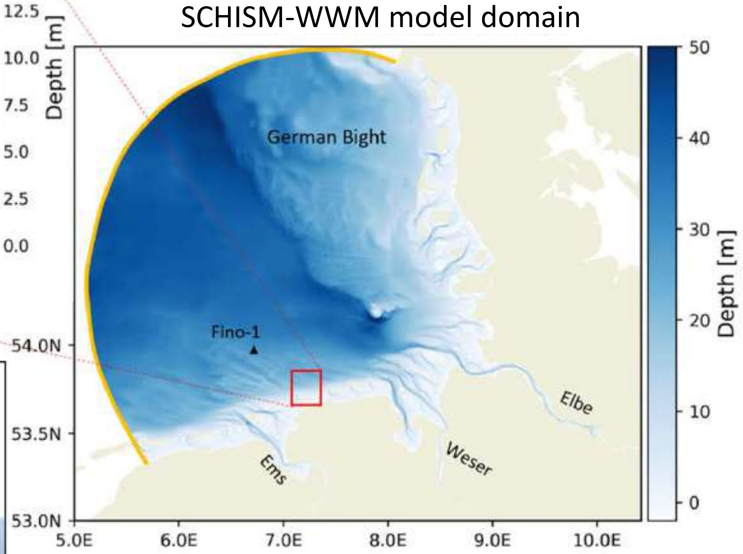
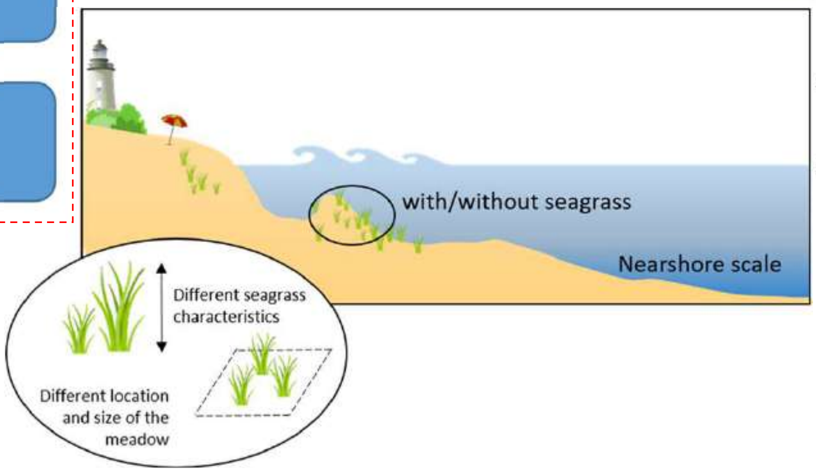
Models (tools)



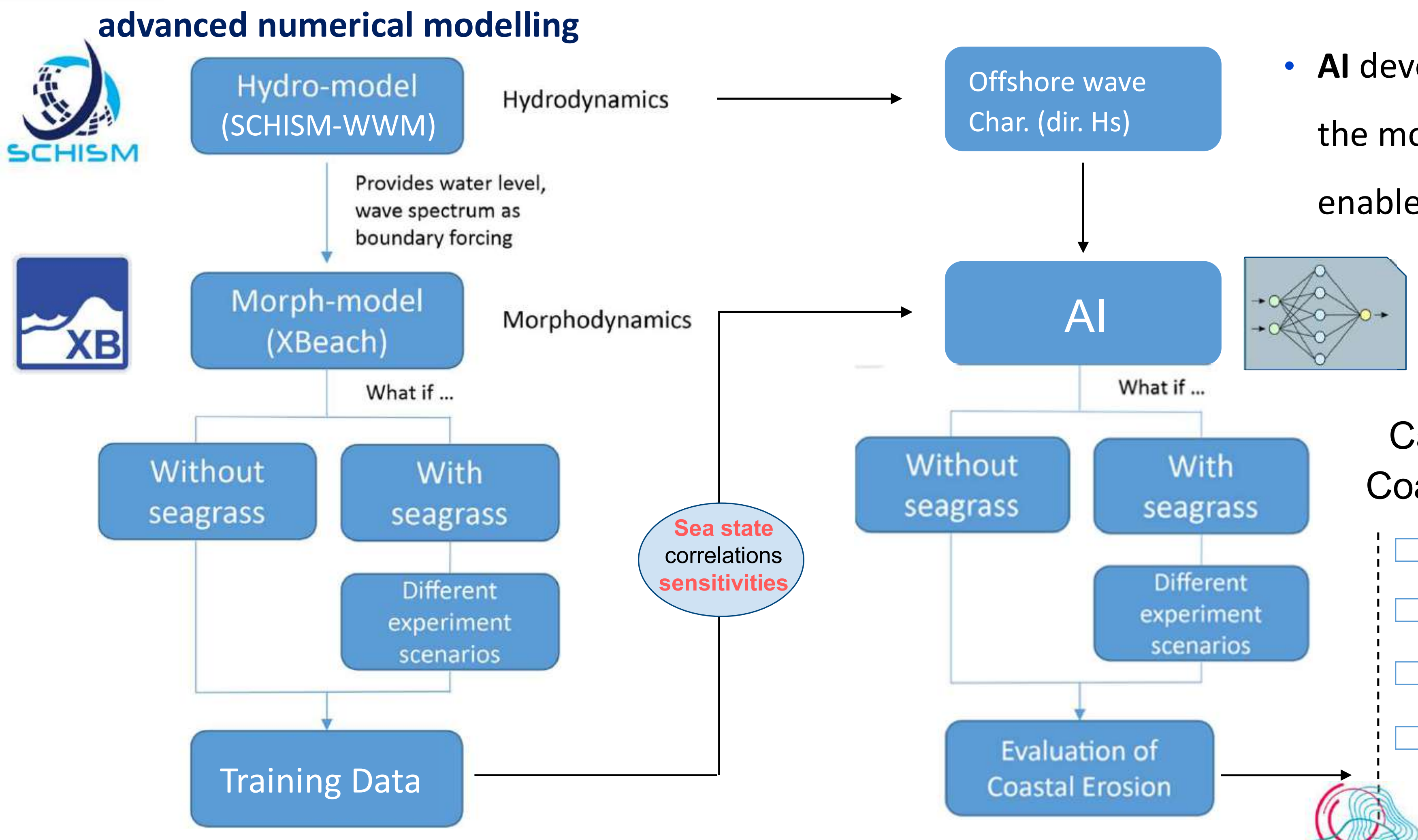
>1000 cores
+
>100 cores



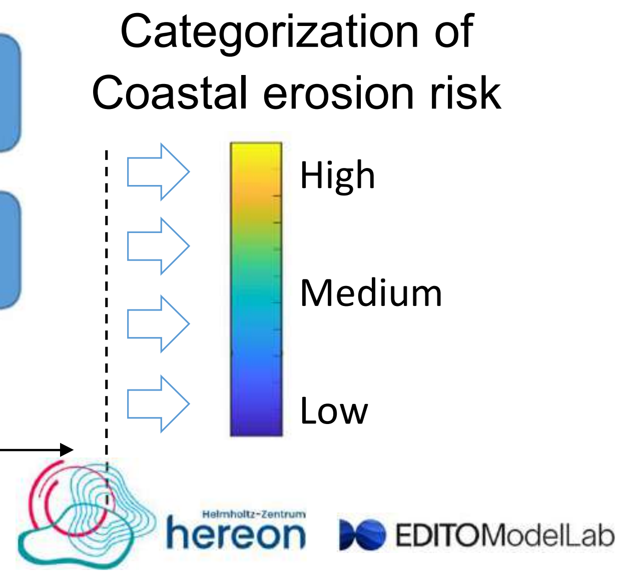




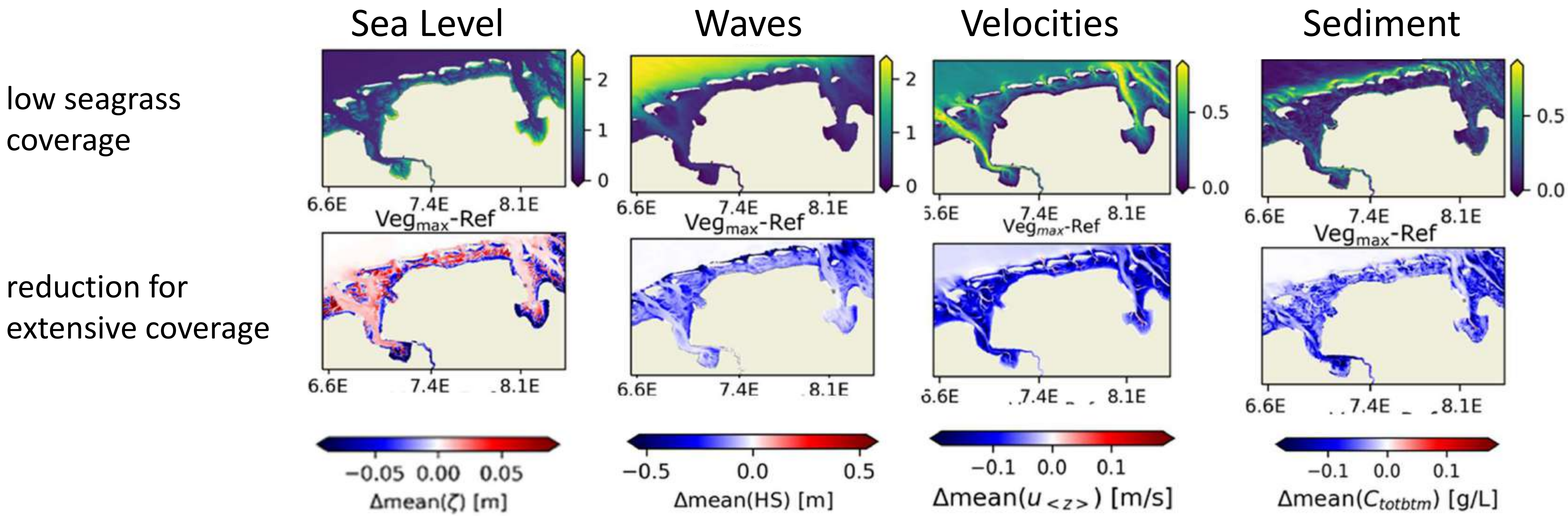
Hybrid model chain (EDITO Model Lab will integrate **NM,** powered by **AI** and operating on **HPC**.)



- **AI** developments as part of the modelling system to enable faster simulations

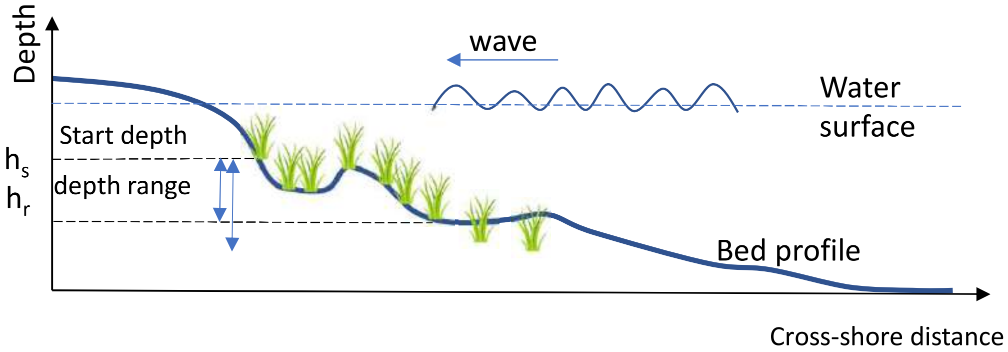


What-if Scenarios: Example of results

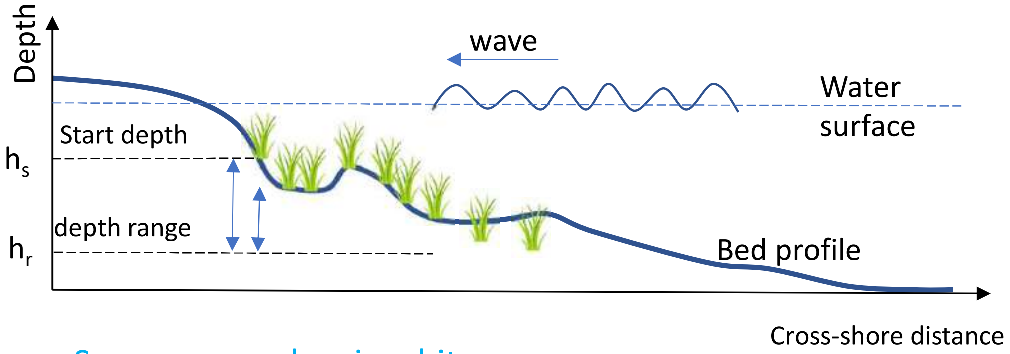


- seagrass can efficiently reduce kinematics (30-80%) and resulting sediment mobilisation
- Seagrass has a limited direct effect on flooding, but can contribute implicitly via sediment accumulation

Address the question: the best seagrass layout and landscaping for optimal coastal protection.

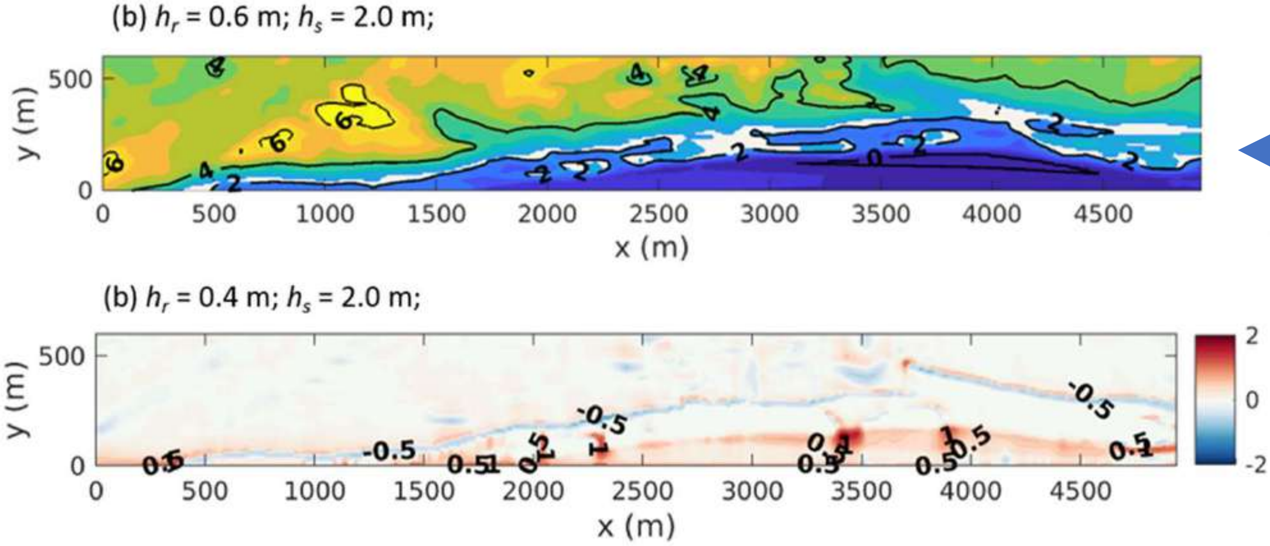


<u>Address the question</u>: the best seagrass layout and landscaping for optimal coastal protection.

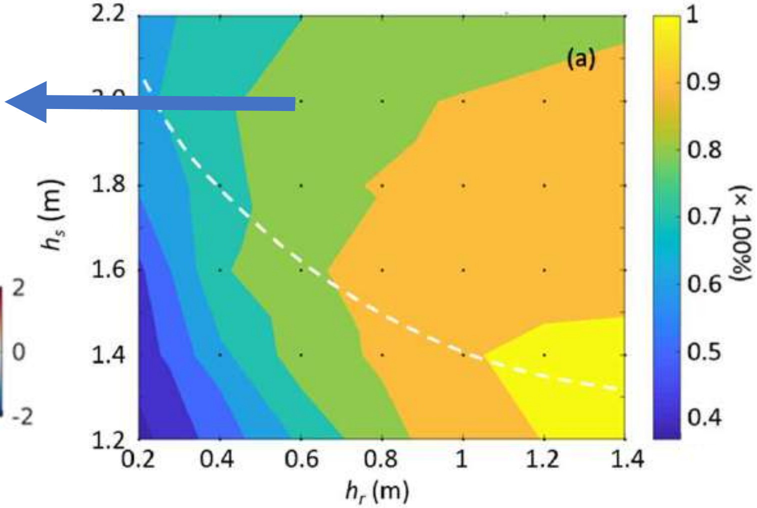


- ➢ Different meadow sizes and locations, depending on the combination of the controlling parameters yield varied erosion volumes.

Seagrass meadow in white area



Reduced erosion volume



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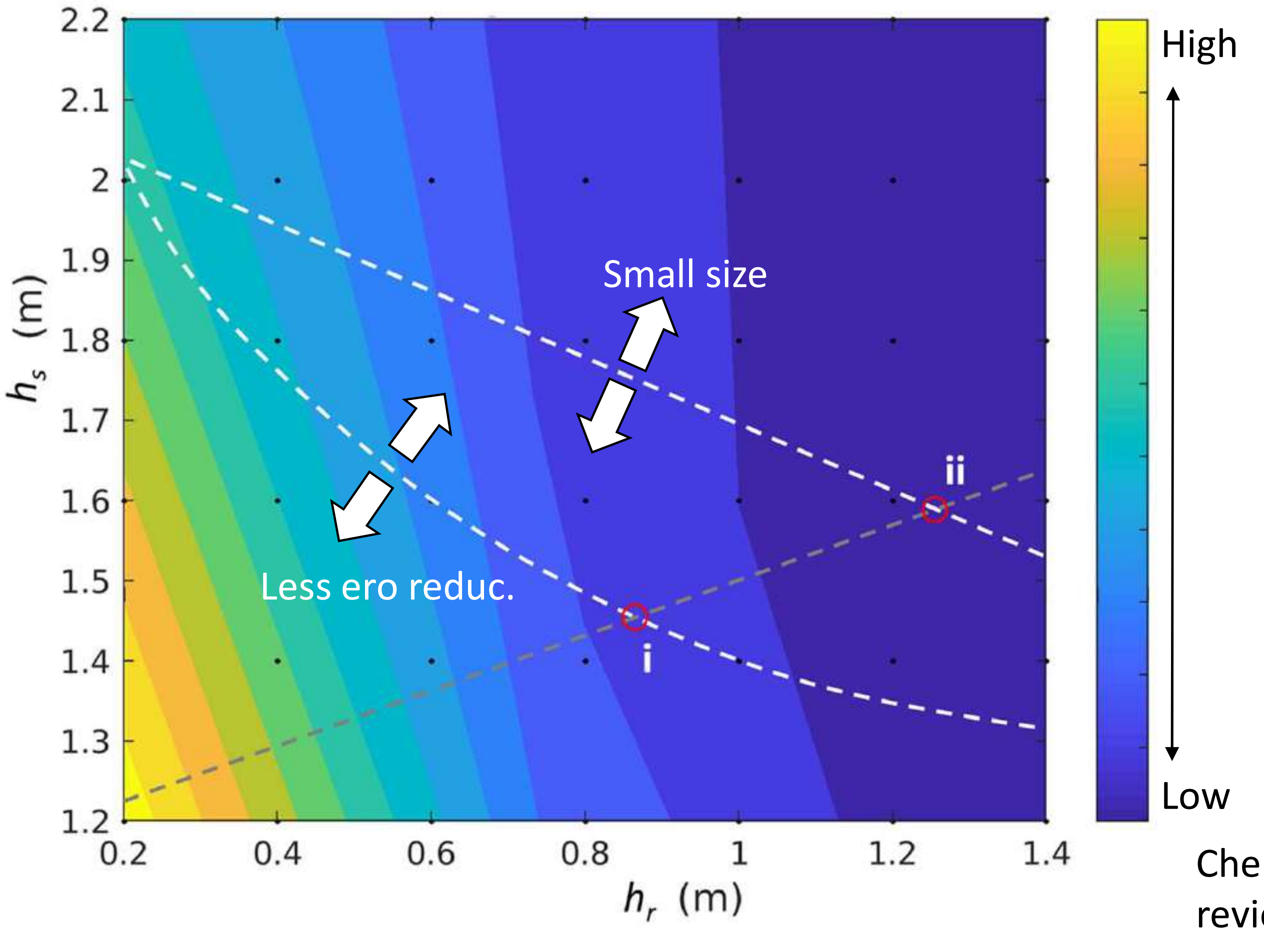
Results: Efficiency index of seagrass meadow on mitigating erosion



i: Optimal size h_r-h_s combination

ii: potential size h_r-h_s combination

- ➢ the most significant reduction is not found at the h_r-h_s combination where meadow size is the maximum.

Chen, W., B. Jacob, J. Staneva. Sci. Total Environ. (under review)

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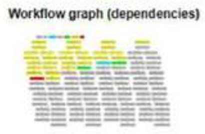
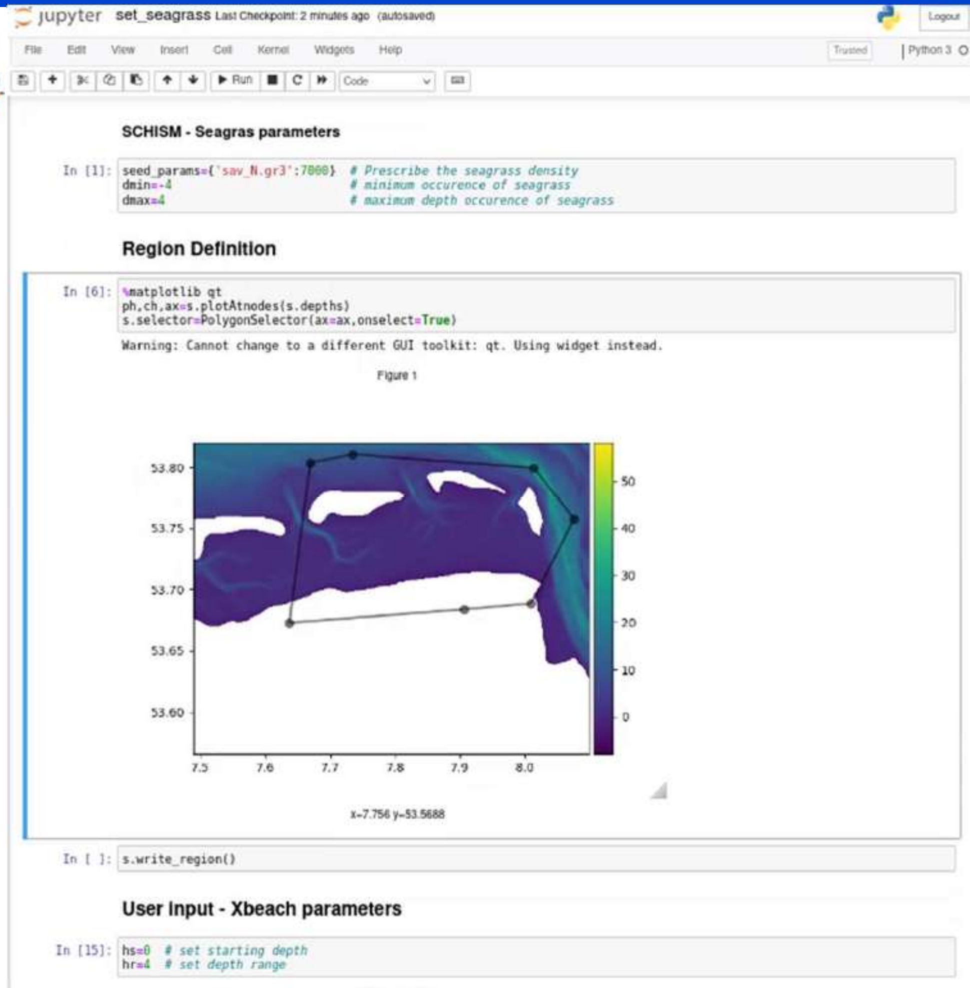
What-if Scenarios #1

User scenarios

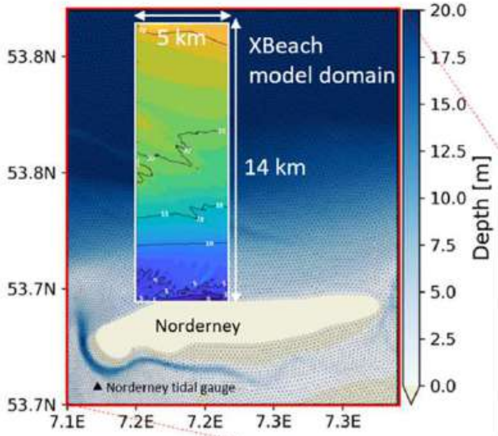
1) Definition of seagrass scenarios
   Parameters and distribution:
   density, diameter, drag,height

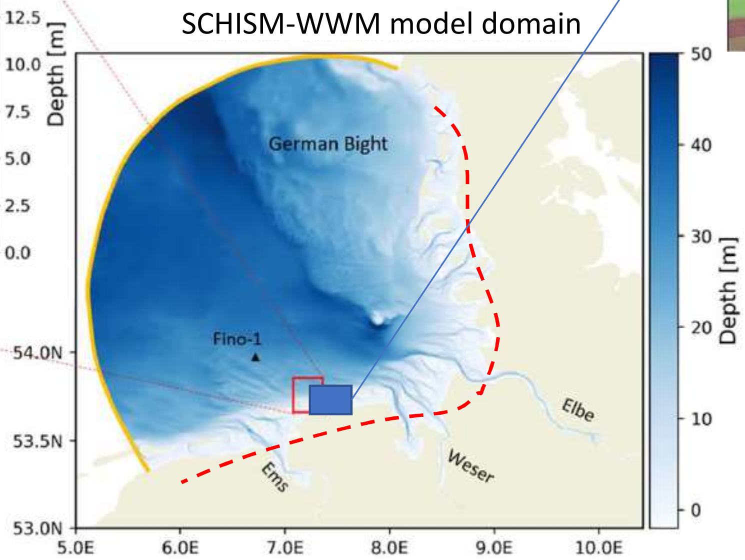
1) Simulations and analysis on Edito infrastructure
2) Exploration of results





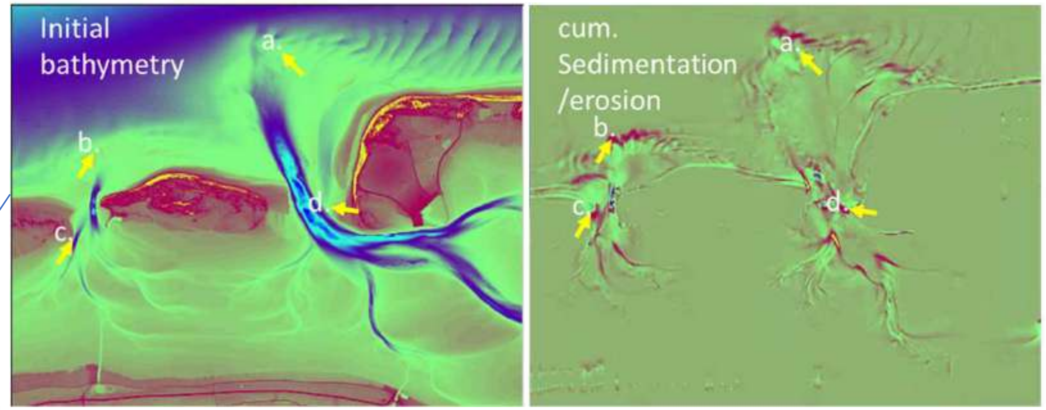
User interaction

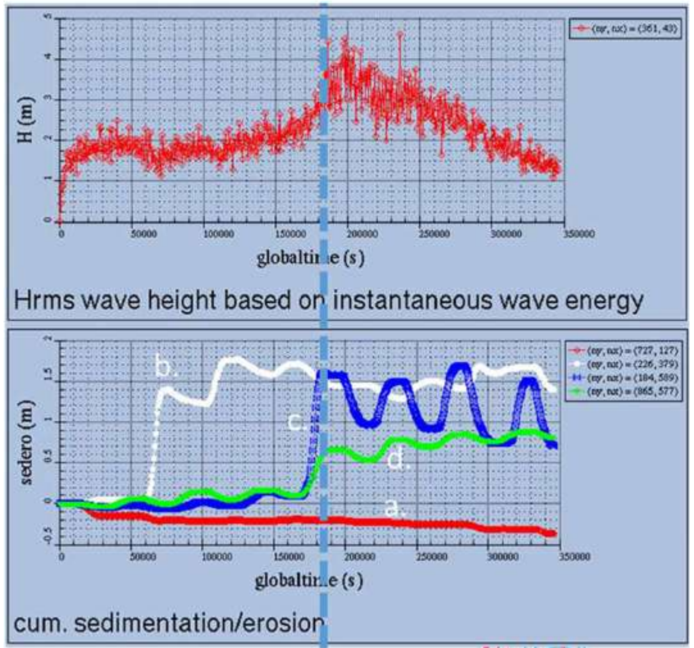




Length >500 km

Storms with different intensities and angels





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European Digital Twin Ocean

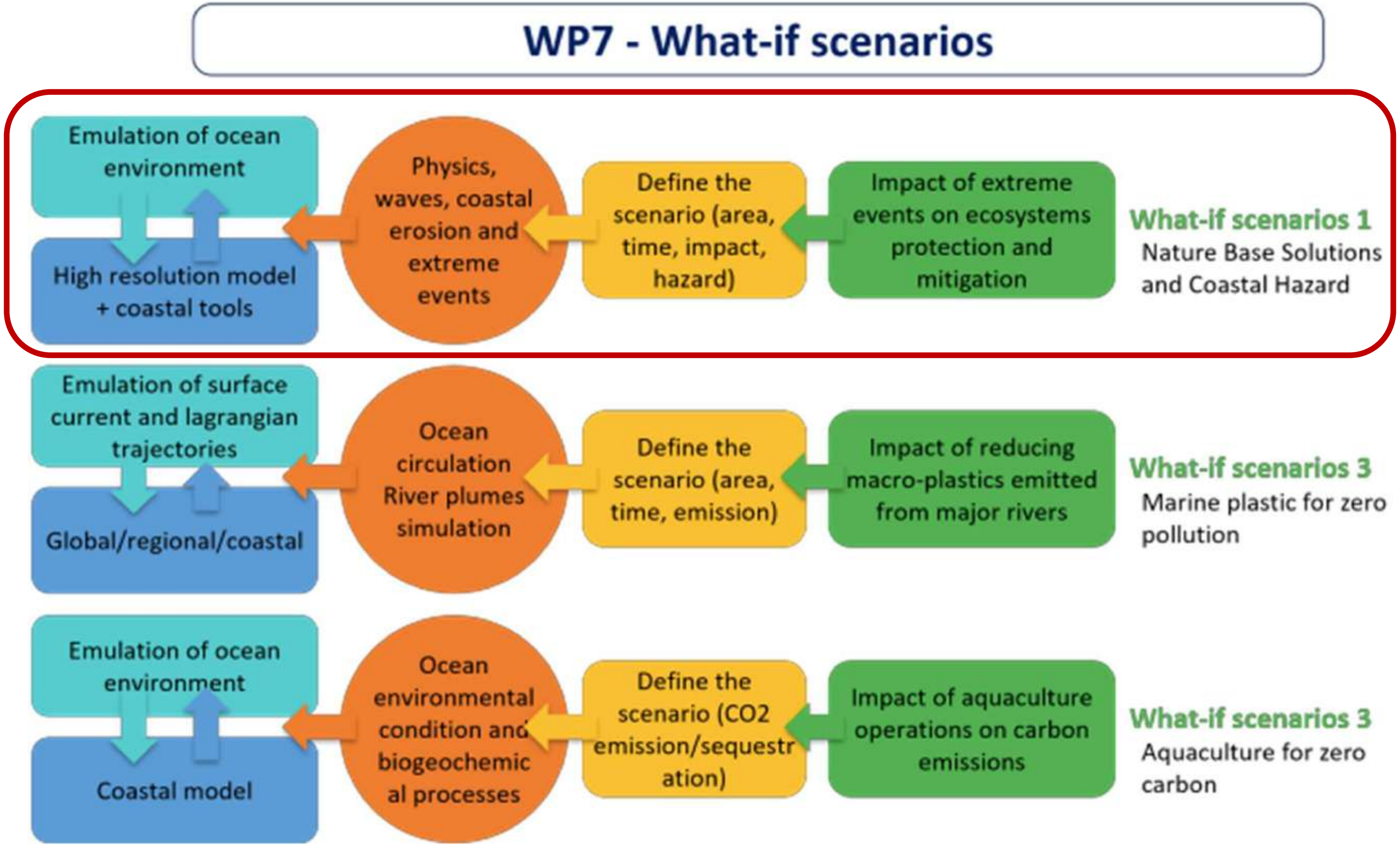
WP7
What-If scenarios

WiS#1 - Nature Based Solutions for Coastal Hazards In Northern Adriatic Sea

J. Alessandri (UNIBO)
I. Federico (CMCC)
S. Causio (CMCC)
N. Pinardi (UNIBO)
G. Coppini (CMCC)

EDITO Model Lab – General Assembly
16-18 January 2024, Lecce, Italy

What-if Scenarios in EDITO Model Lab



WiS#1

Seagrass as NBS to reduce coastal hazard

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Study site and related hazards

The Emilia-Romagna (ER) coast has a valuable natural environment, with unique ecosystems, composed by pine forests, wetlands, dunes and beaches interacting with the sea. The coast has also a hig economical value due to beach tourism, phishing activity and resources exploitation.

Hazard along ER coast

Floods

Coastal erosion

Eutrophication

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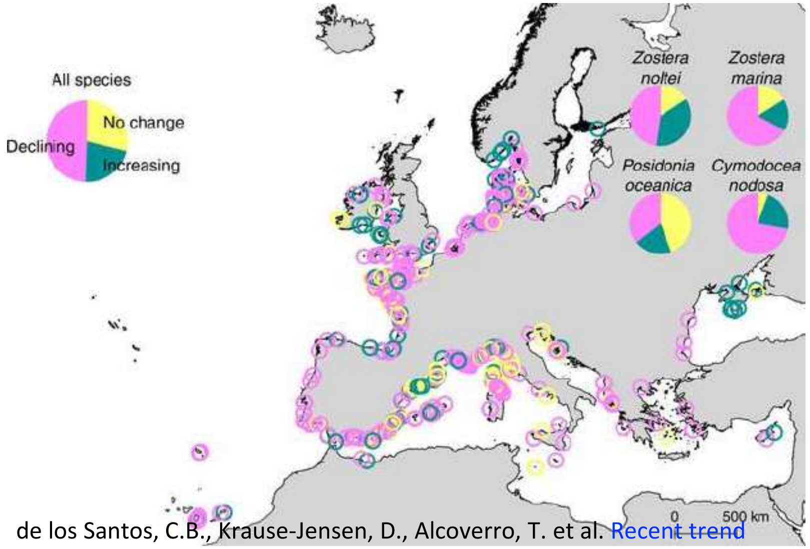
Seagrass and its Ecosystem Services

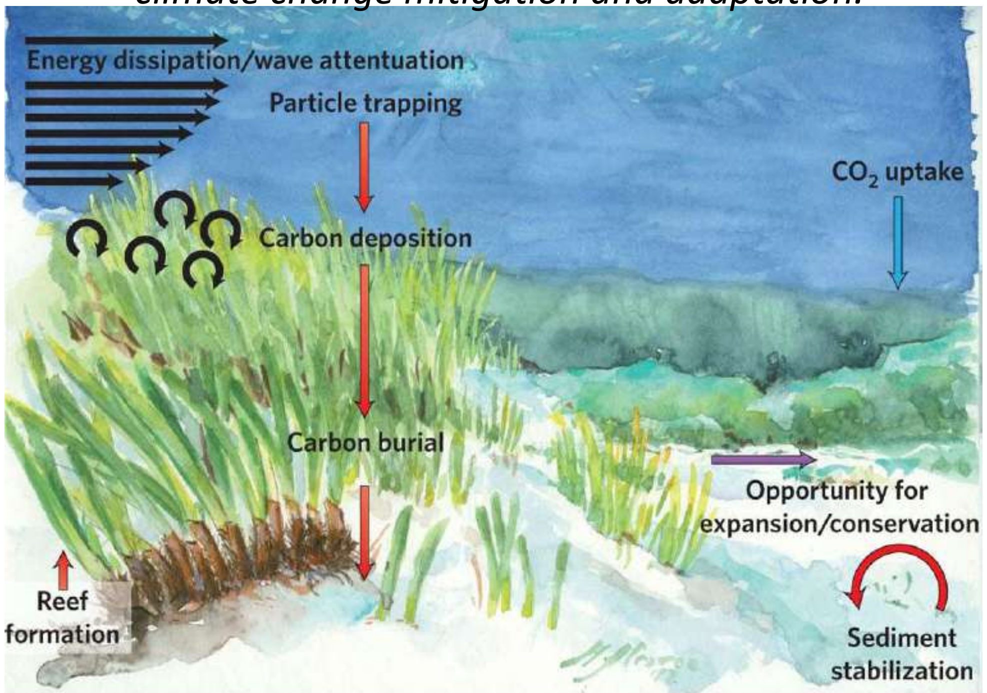


de los Santos, C.B., Krause-Jensen, D., Alcoverro, T. et al. Recent trend reversal for declining European seagrass meadows. Nat Commun 10, 3356 (2019). https://doi.org/10.1038/s41467-019-11340-4.

Distribution and trajectories of seagrass sites in Europe (1896-2016)

4 Fanerogame species along European coasts

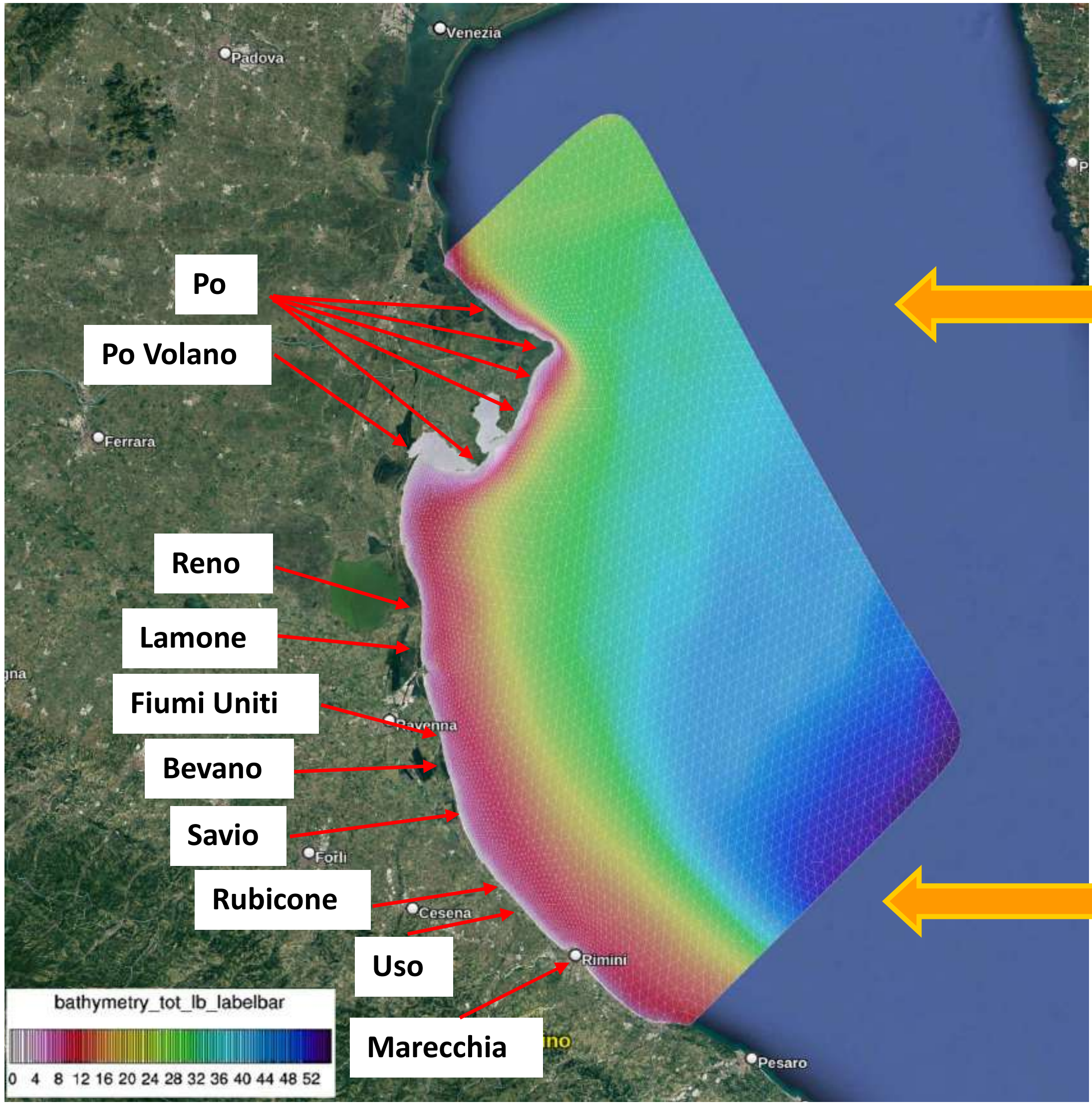
Key processes of vegetated coastal habitats for climate change mitigation and adaptation.



- Climate change adaptation – act as buffers against rising sea level and wave action by dissipating energy and acting as physical barriers.
- Particle trapping and sediment stabilization.
- CO_2 uptake.
- Marine plants are able to grow, self-repair, and adapt.
- Loss of these habitats reduces coastal protection.

Duarte, C., Losada, I., Hendriks, I. et al. The role of coastal plant communities for climate change mitigation and adaptation. Nature Clim Change 3, 961–968 (2013). https://doi.org/10.1038/nclimate1970.

WiS1: Models and domain set-up



SHYFEM
System of HYdrodynamics Finite Element Modules

- ***Meteorological Forcing:*** ECMWF IFS at 9km.
- ***Initial and open boundary conditions:*** CMEMS MFC analysis at 1/24.
- ***Bathymetry:*** Emodnet at 250 m + multibeam observations.
- ***Rivers:*** Observations (Po river) + climatology.
- ***Output:*** *Binary files that are converted into NetCDF (Both unstructured or interpolated on regular grid)*

WaveWatch III ®

- ***Meteorological Forcing:*** ECMWF IFS at 9km.
- ***Open boundary conditions:*** CMEMS waves dataset.
- ***Bathymetry:*** Emodnet at 250 m + multibeam observations.
- ***Output:*** Netcdf files.

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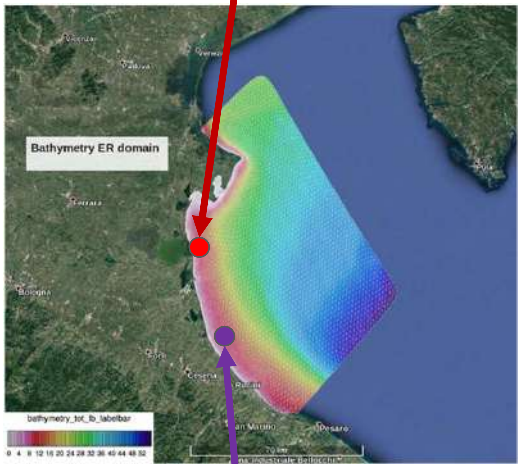
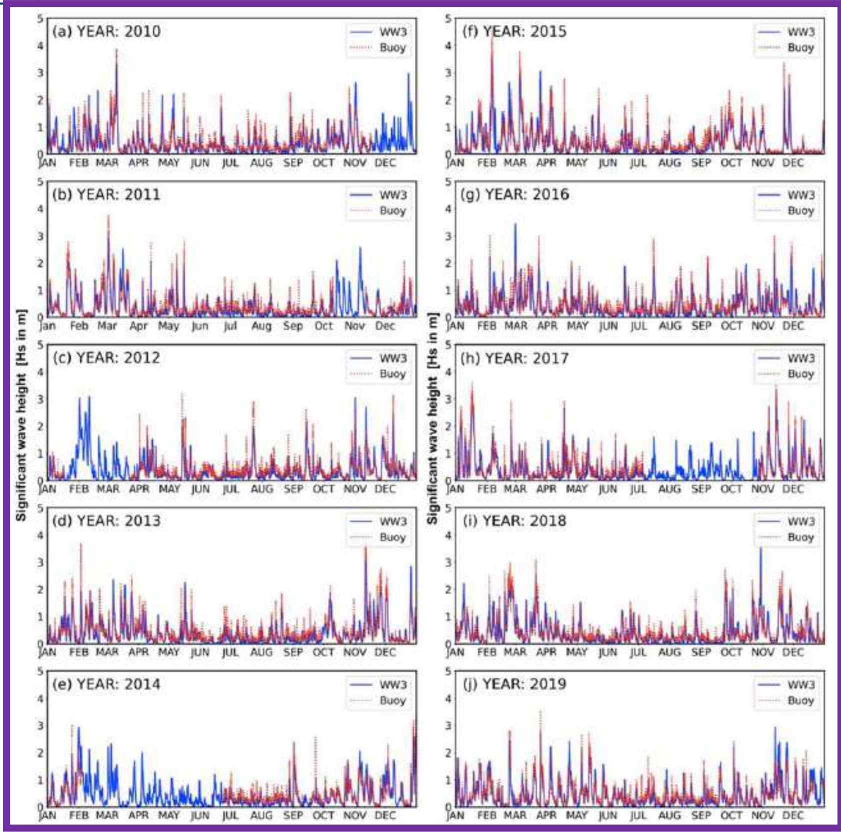
Table of experiments and models validation

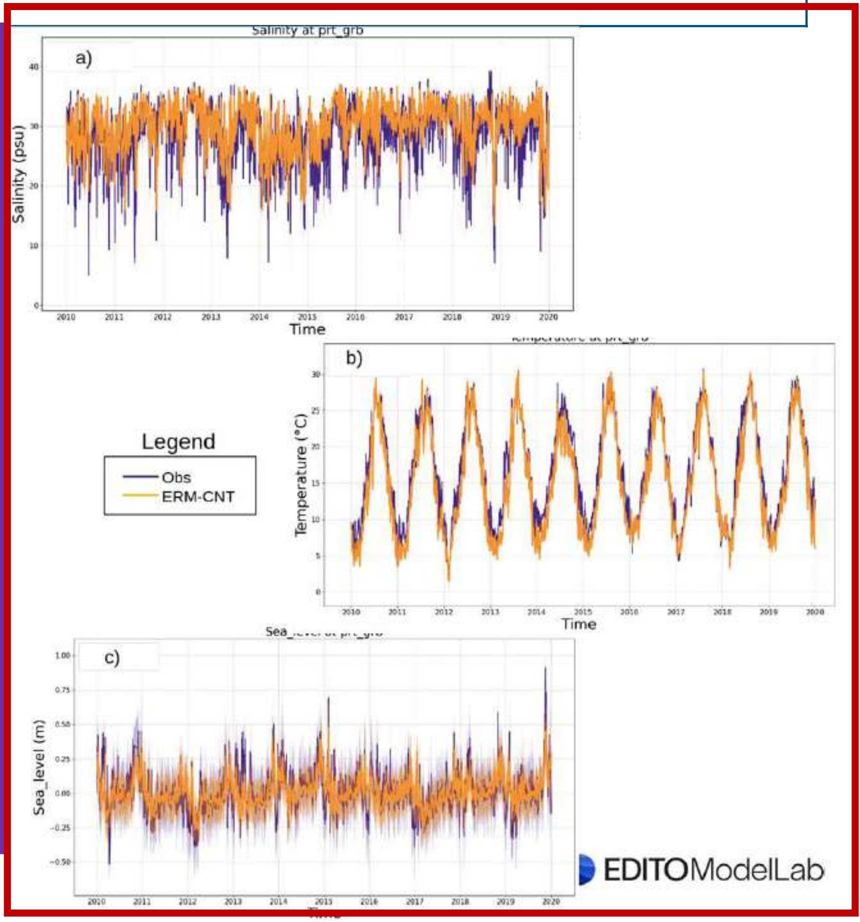
Period of simulation	WW3	SHYFEM
2010 - 2019	WITH & WITHOUT NBS	WITH & WITHOUT NBS

- Porto Garibaldi station



- Cesenatico wave buoy





Ayyappan Pillai, U., et al.,: Wind-wave characteristics and extremes along the Emilia-Romagna coast, Nat. Hazards Earth Syst. Sci., 22, 3413–3433, https://doi.org/10.5194/nhess-22-3413-2022, 2022.

Seagrass parameterization

WaveWatch III ®

$$S_{\mathrm{ds,veg}} = -\sqrt{\frac{2}{\pi}}g^2\tilde{C}_{\mathrm{D}}b_{\mathrm{v}}N_{\mathrm{v}}\left(\frac{\tilde{k}}{\tilde{\bar{\sigma}}}\right)^3\frac{\sinh^3\tilde{k}\alpha h + 3\sinh\tilde{k}\alpha h}{3k\cosh^3\tilde{k}h}\sqrt{E_{\mathrm{tot}}}E(\sigma,\theta)$$

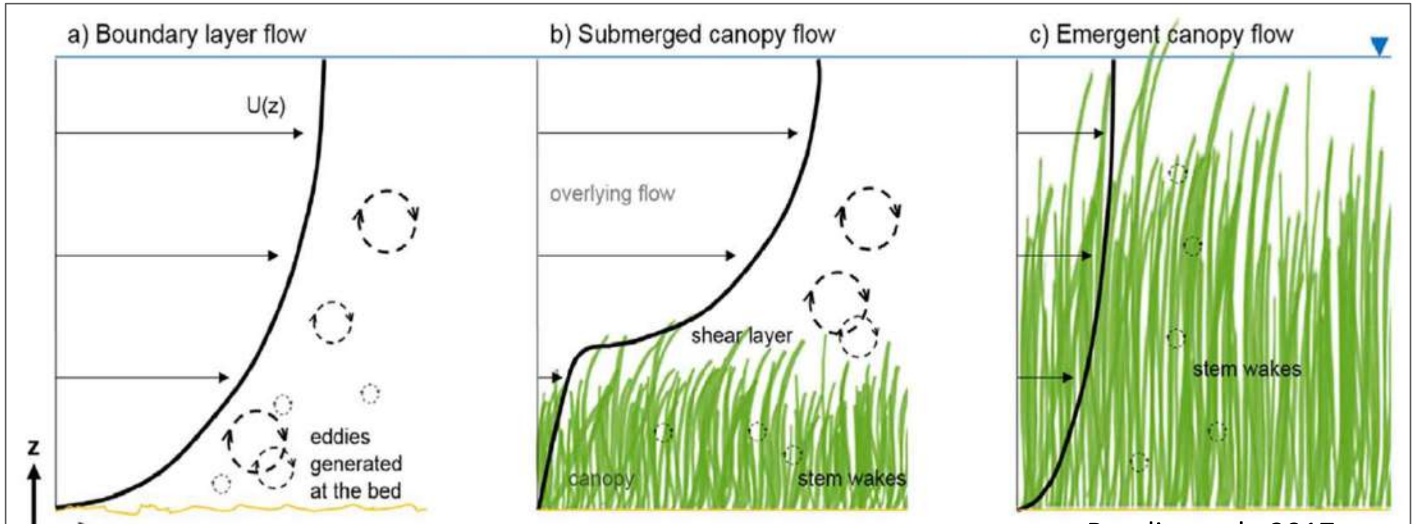
Mendez and Losada, 2004

Méndez, F.J., Losada, I.J., 2004. An empirical model to estimate the propagation of random breaking and nonbreaking waves over vegetation fields. *Coast. Eng.* 51, 103–118.

SHYFEM
System of HYdrodynamics Finite Element Modules

$$\frac{\partial U_l}{\partial t} + u_l\frac{\partial U_l}{\partial x} + v_l\frac{\partial U_l}{\partial y} + \int_{z_l}^{z_{l-1}} w\frac{\partial u}{\partial z}dz - fV_l = -gh_l\frac{\partial \zeta}{\partial x} - \frac{gh_l}{\rho_0}\int_{H_l}^{0}\frac{\partial \rho'}{\partial x}dz - \frac{h_l}{\rho_0}\frac{\partial P_a}{\partial x} + \nabla_h\cdot\left(A_H\nabla_h U_l\right) + \int_{z_l}^{z_{l-1}}\frac{\partial \tau_{xz}}{\partial z}dz - \int_{z_l}^{z_{l-1}}\mathcal{H}\left(z_l - z_v\right)F_{veg,x}dz$$

Beudin et al., 2017; Zhang et al., 2019



Beudin et al., 2017

Where: $$F_{veg,x} = \frac{1}{2}C_{Dv}D_vN_v|\vec{u}|u$$

Turbulence model

$$\frac{\partial k}{\partial t} + \vec{U}\cdot\nabla k = \frac{\partial}{\partial z}\left(\frac{A_v}{\sigma_k}\frac{\partial k}{\partial z}\right) + P_s + P_d + B - \epsilon$$

$$\frac{\partial \epsilon}{\partial t} + \vec{U}\cdot\nabla\epsilon = \frac{\partial}{\partial z}\left(\frac{A_v}{\sigma_\epsilon}\frac{\partial \epsilon}{\partial z}\right) + \frac{\epsilon}{k}\left(c_{\epsilon 1}P_s + c_{\epsilon 4}P_d + c_{\epsilon 3}B - c_{\epsilon 2}\epsilon\right)$$

Beudin, A., Kalra, T.S., Ganju, N.K., Warner, J.C., 2017. Development of a coupled waveflow-vegetation interaction model. *Comput. Geosci.* 100, 76–86.

Zhang, Y.J., Gerdts, N. et al. 2019. Simulating vegetation effects on flows in 3d using an unstructured grid model: model development and validation. Ocean Dyn. 70 (2), 213230.

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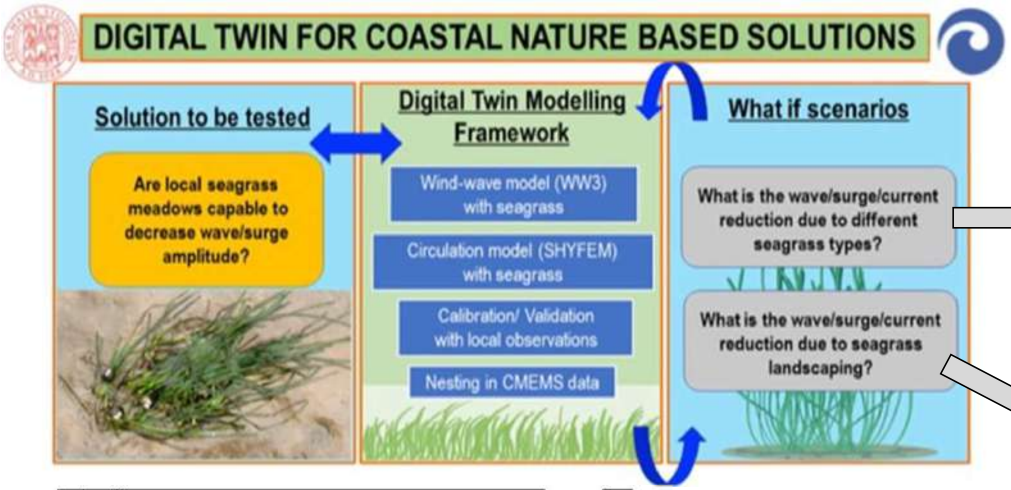
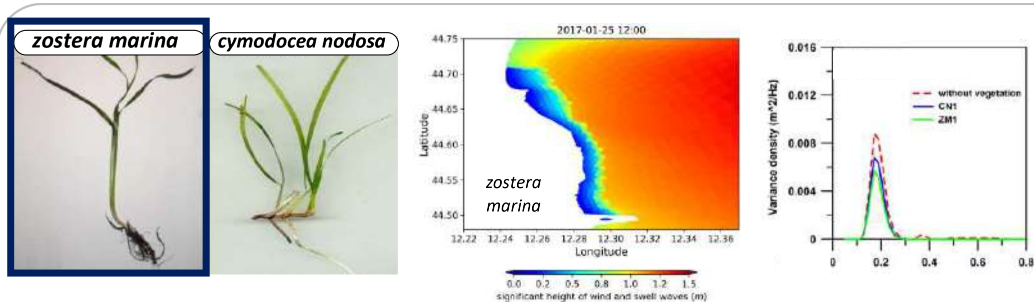
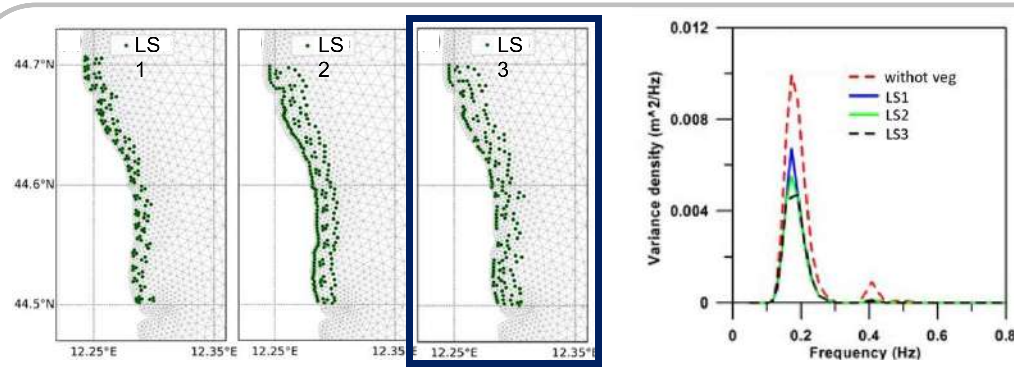
Seagrass as NBS for wave energy reduction

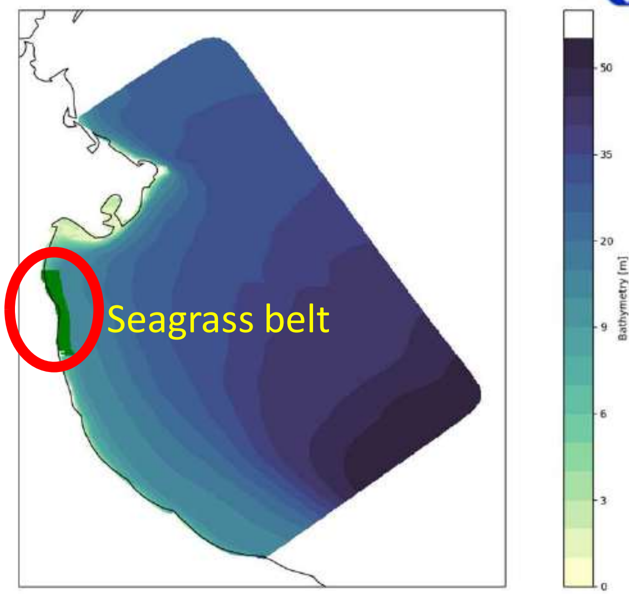




Greater attenuation using *Zostera marina*



Higher attenuations obtained with the broken strips along with the cluster arrangement



Seagrass belt position in the Bellocchio beach

Umesh, P.A.P., Pinardi, N., Alessandri, J., Federico, I., Causio, S., Unguendoli, S., Valentini, A., Staneva, J., 2022. A digital twin modelling framework for the assessment of seagrass nature based solutions against storm surges. Sci. Total Environ. 847, 157603. https://doi.org/10.1016/j.scitotenv.2022.157603

WaveWatch III ®

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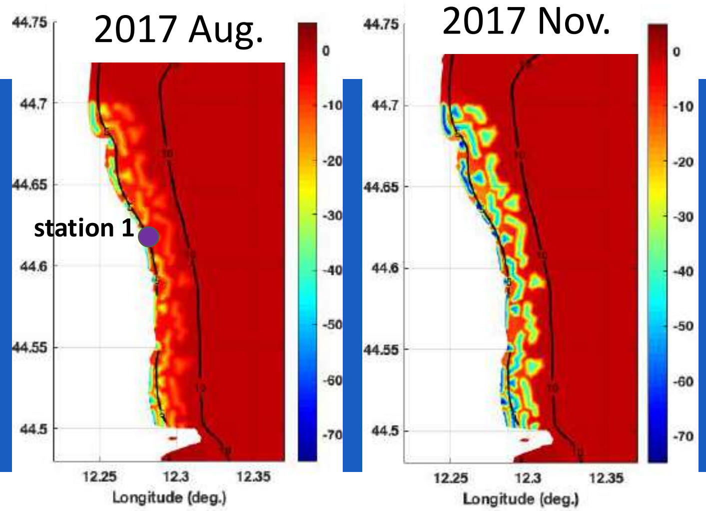
Seagrass as NBS for wave energy reduction

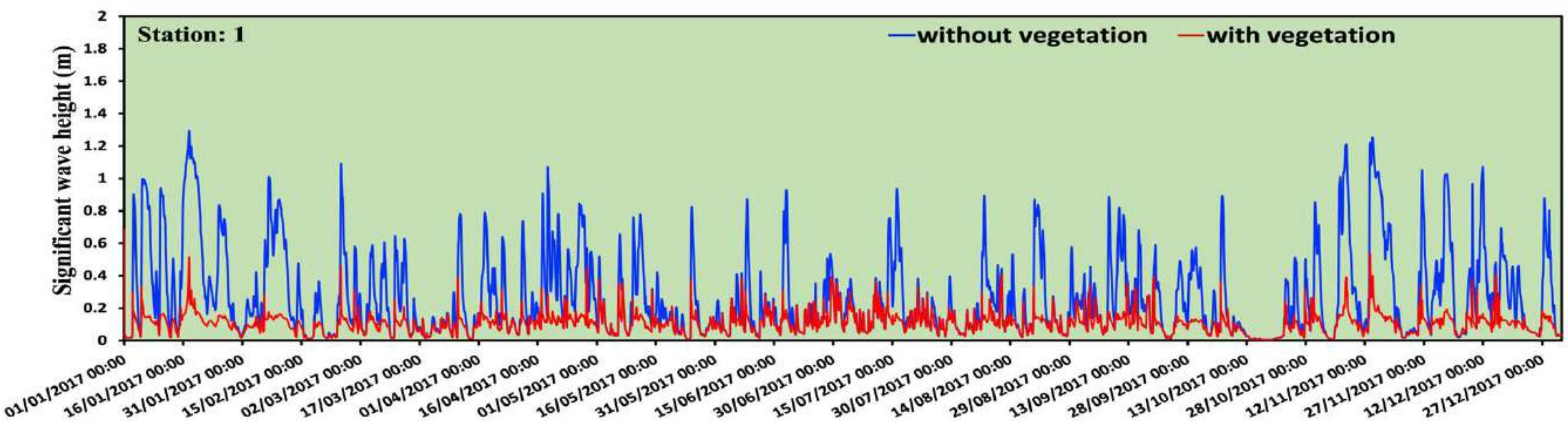
Mean monthly % variation of Hs

Strong **seasonality** in the wave energy reduction.



The inclusion of vegetation term in WW3 induced a strong **Energy dissipation**

Time-series comparison of Hs at Station 1



WaveWatch III ®

Umesh, P.A.P., Pinardi, N., Alessandri, J., Federico, I., Causio, S., Unguendoli, S., Valentini, A., Staneva, J., 2022. A digital twin modelling framework for the assessment of seagrass nature based solutions against storm surges. Sci. Total Environ. 847, 157603. https://doi. org/10.1016/j.scitotenv.2022.157603

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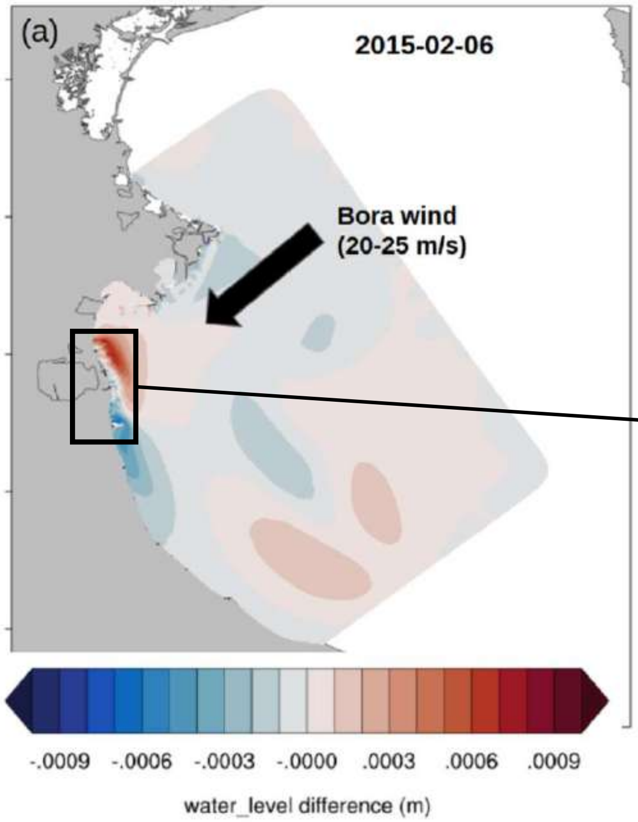
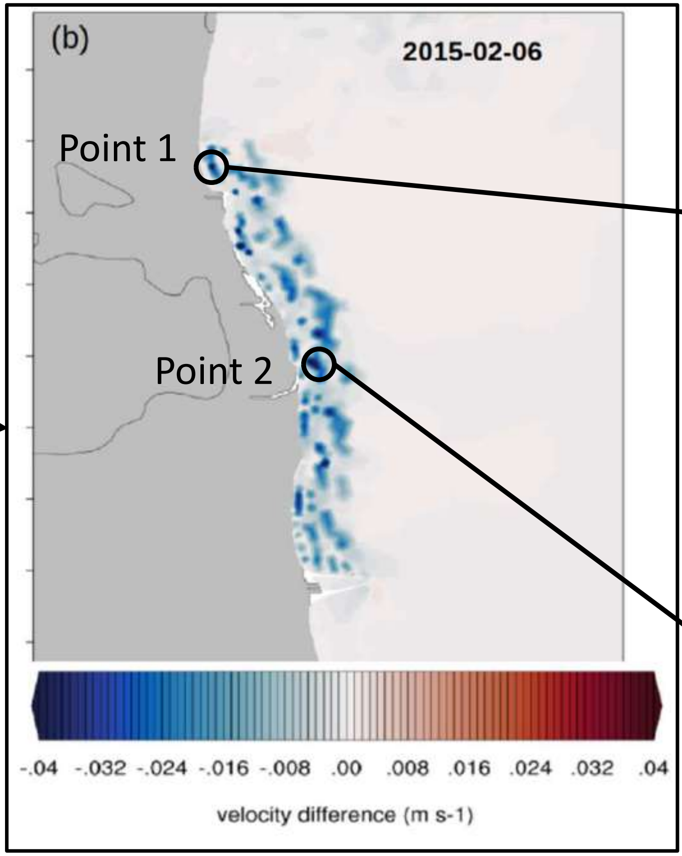
Seagrass as NBS for flow energy reduction

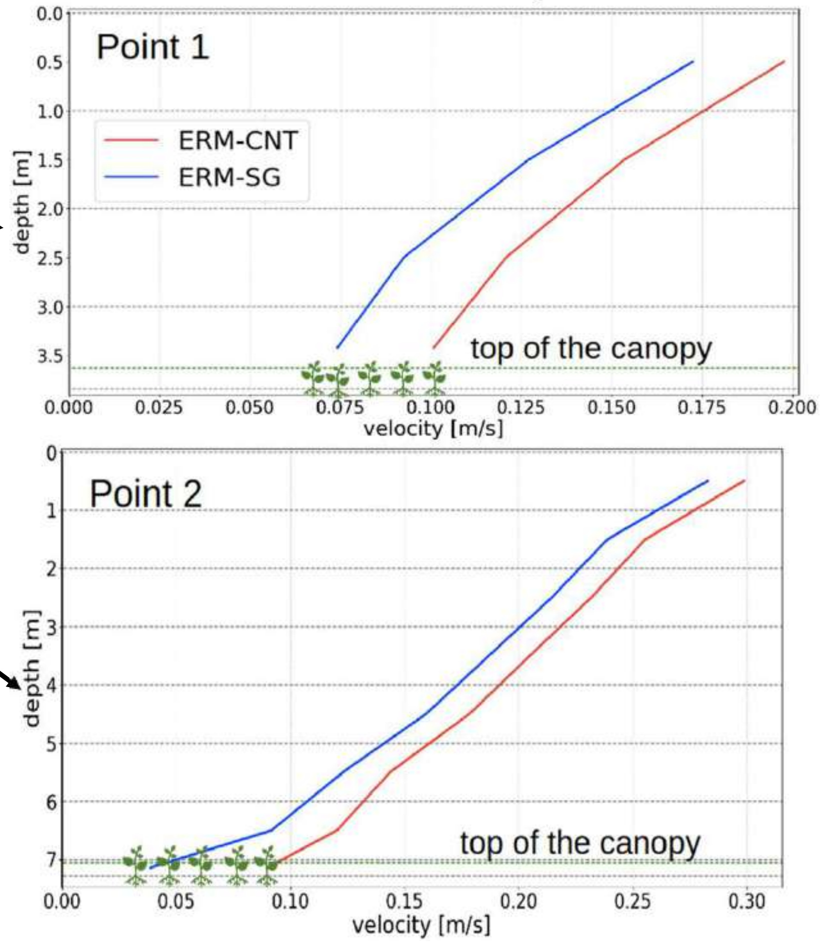
Sea level difference (Veg – NoVeg)



Bottom velocity difference (Veg – NoVeg)



Mean southward velocity on 2015-02-06



- ➢ Low impact of seagrass on sea level dependent from the water column depth.
- ➢ High impact of seagrass on bottom velocity.
- ➢ Possible effects on sediment transport.

SHYFEM System of HYdrodynamics Finite Element Modules

Umesh, P.A.P., Pinardi, N., Alessandri, J., et al., 2022. A digital twin modelling framework for the assessment of seagrass nature based solutions against storm surges. Sci. Total Environ. 847, 157603. https://doi.org/10.1016/j.scitotenv.2022.157603

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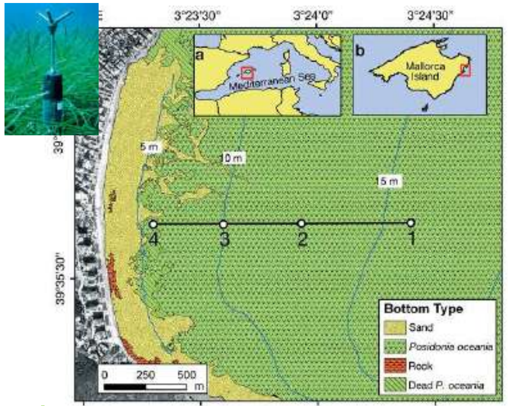
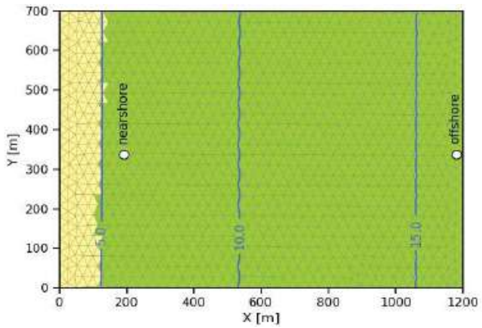
The role of Seagrass flexibility



Study area (Cala Millor, Mallorca, Spain)



- The flexibility of seagrass is tested reproducing the results of Infantes et al., 2012.
- The height of seagrass stem is replaced with an 'effective lenght' that account for seagrass flexibility.
- Overestimation of wave damping with rigid seagrass.

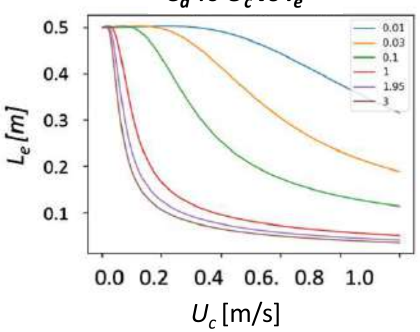
Luhar and Nepf (2011) and Beaudin et al. (2017)

$$l_e = l_v - \frac{\left(1-0.9Ca^{-1/3}\right)}{1+Ca^{-3/2}\left(8+B^{3/2}\right)} l_v$$

$$B = \frac{(\rho - \rho_v) g b_v t_v l_v^3}{EI}$$

$$Ca = 0.5 \frac{\rho C_D b_v U^2 l_v^3}{EI}$$

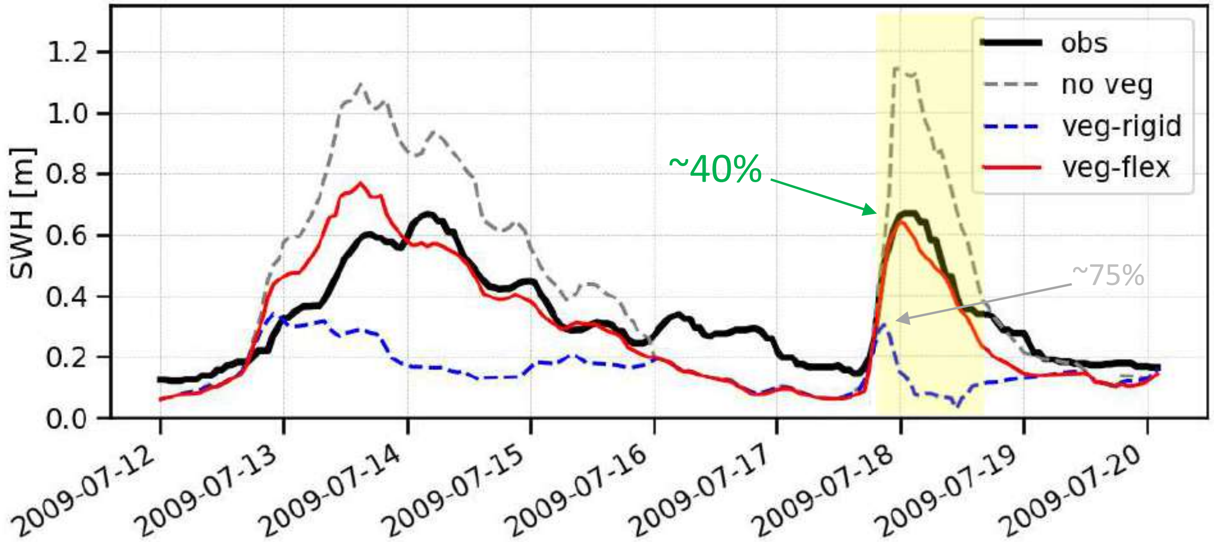
C_d vs U_c vs l_e



Instead using the vegetation length at rest l_v, we use an effective length l_e affected by the near-bottom water velocity (U_c)

Flow-dependent effective length l_e

Advancement with vegetation modelling including flexibility of seagrass plants



Infantes, E., Orfila, A., Simarro, G., Luhar, M., Terrados, J., Nepf, H., 2012. Effect of a seagrass (Posidonia oceanica) meadow on wave propagation. Mar. Ecol. Prog. Ser. 456, 63–72. https://doi.org/10.3354/meps09754

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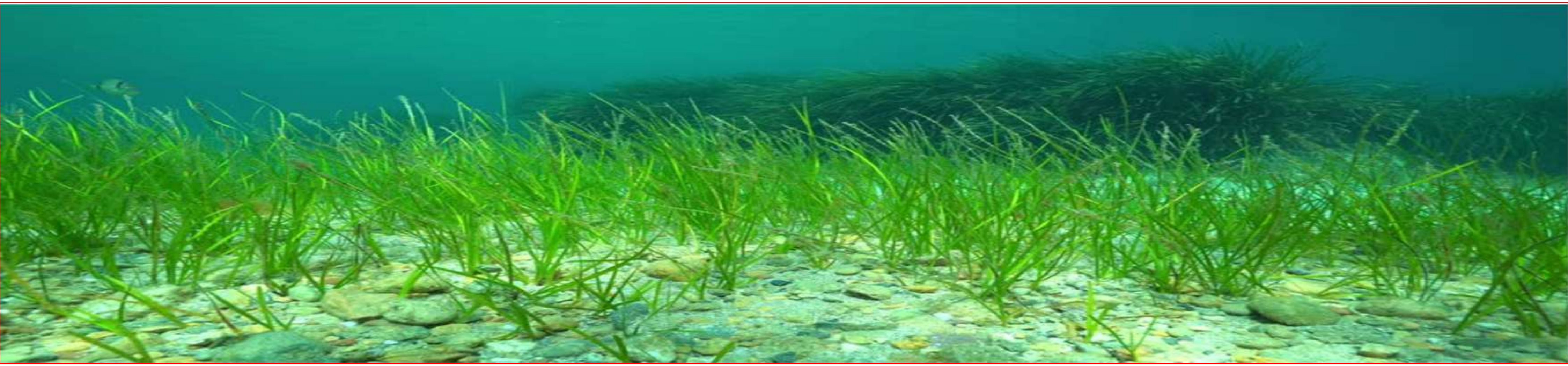
Conclusions

- Seagrass used as an NBS is effective in decreasing wave energy and bottom velocity
- In the framework of WP7, the **seagrass flexible parameterization** will be developed to evaluate impacts of NBSs on waves and currents.
- The next development will consider the usage of a ML algorithm on different NBS landscapes and then allow the user to compute the specific wave reduction along the EMR coastal area



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Thank you for your attention

ALMA MATER STUDIORUM UNIVERSITÀ DI BOLOGNA

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Ocean Prediction and Application (OPA)
Euro-Mdeiterranean Center for Climate Change (CMCC), Lecce, Italy

Jacopo Alessandri
Research fellow

Email: jacopo.alessandri2@unibo.it

USER SESSION 1 - Nature Based Solutions

2-DEMO

2-DEMO

- On-demand modelling for coastal hazards, esp. High resolu on, on-demand runs for storm surge cases, DMI (J She, V Freshfield) (20')

3-Discussion with users (20')

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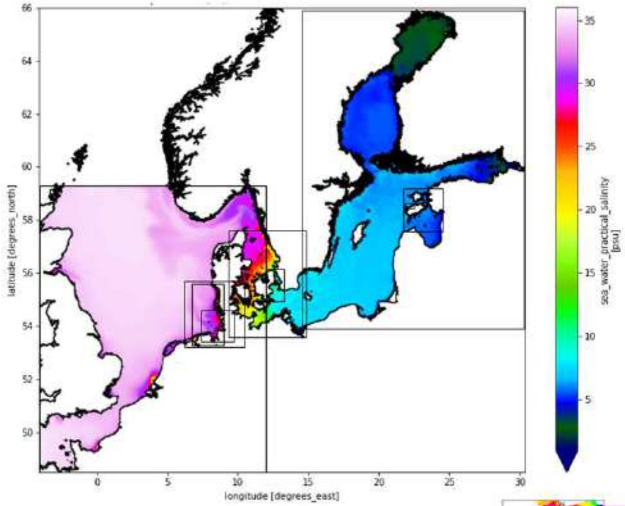
On-demand modelling for coastal hazard what-if scenarios

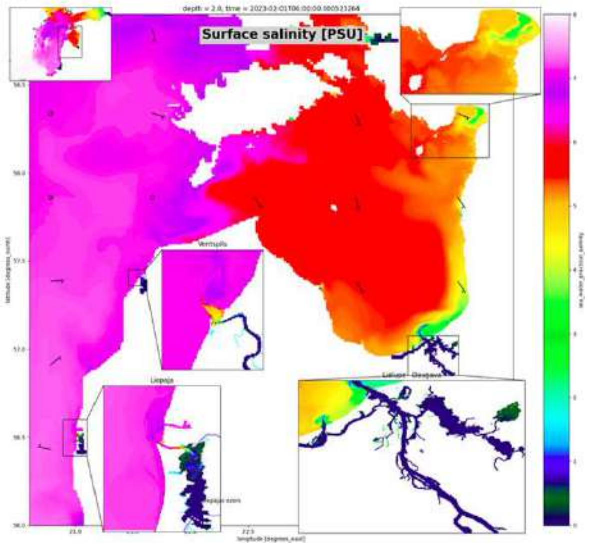
Jun She, Vilnis Frishfelds and Jens Murawski (DMI)

Two-way nested solution for on-demand modelling

- Open-source based software and input data
  - Operational model HBM code
  - Bathymetry (EMODnet, OpenStreetMap)
  - open source scripting-designing tools (Python, Fortran, QGIS, Ktinter)
  - Free weather/boundary forcing (DMI HARMONIE)
- Establish a background regional sea configuration (Baltic-North Sea) to reach operational quality
- Generate a “subModel-builder” allowing to automatically generate any sub-domain with HR up to 37m
- Stress tests to make “subModel-builder” mature
- Apply on-demand HBM for coastal hazard WiS
- Develop a GUI for on-demand usages
- Applications using containers and EuroHPC

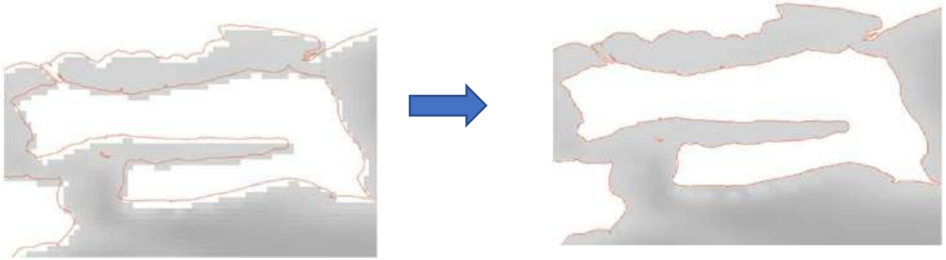


12 domain operational setup at UL: 3.5km – 1.76km – 0.88km – 293m – 73m – 37m (4 ports).

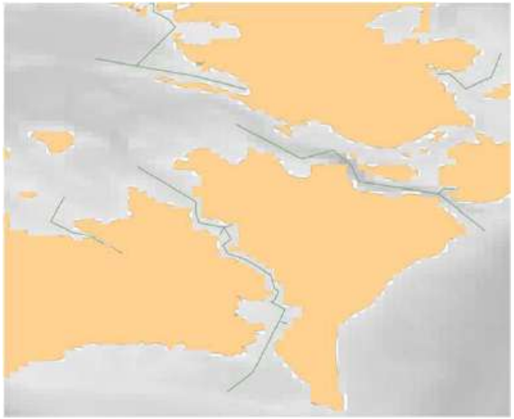


A bathymetry generator based on Q-GIS and python

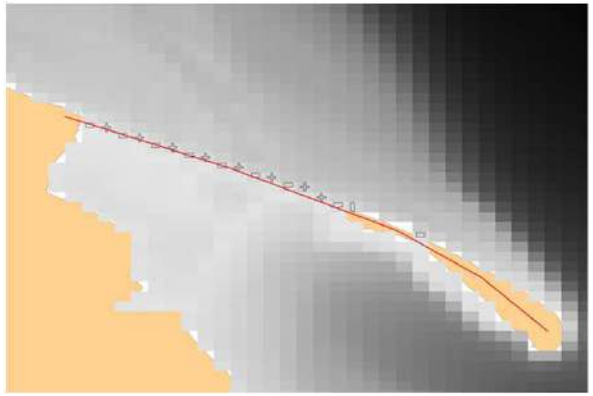
- Generate a 37 m (1/50 nm) bathymetry&land-sea mask using EMODnet+OpenStreetMap data
- Auto-match coastline and bathymetry:
  - set up wet/dry points,
  - ensure connections of water bodies using vector layer of waterways
  - Narrow land forms are ensured with a vector layer of dams
  - Remove disconnected features



Bathymetry-coastline matcher



Waterways to ensure connections



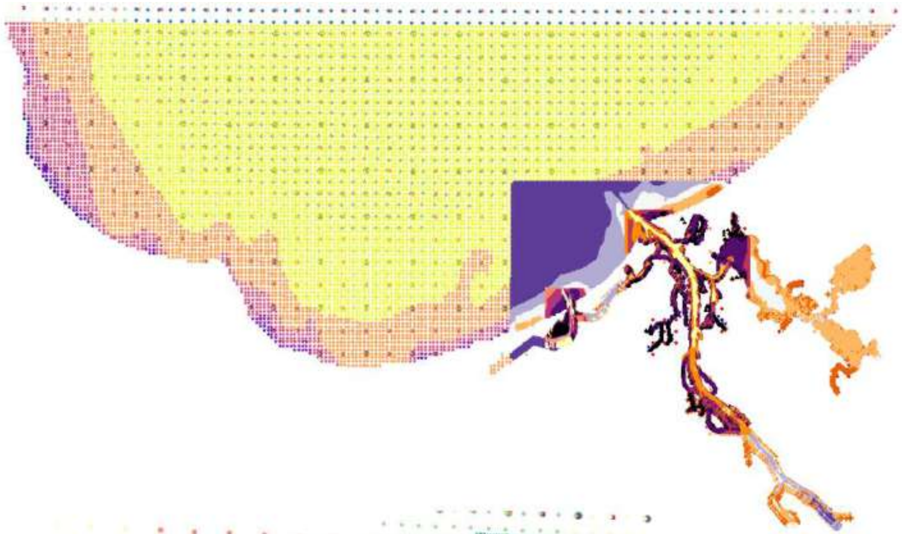
Narrow land forms (dams)

Adding user-defined bathymetry

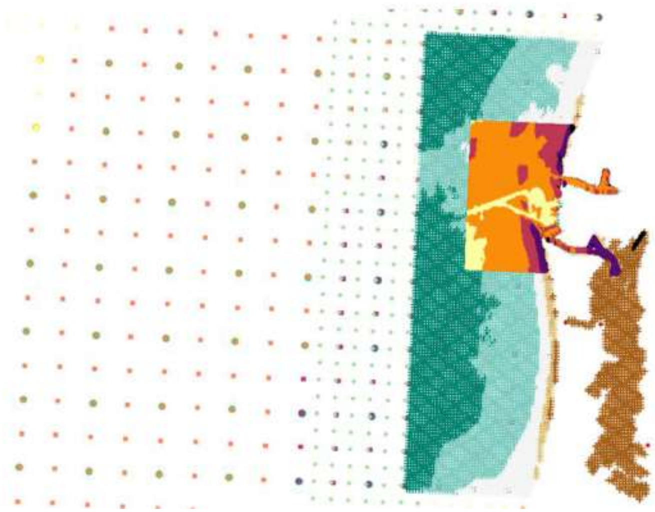
EmodNET bathymetry covers open sea but not necessary ports and lakes connected to the sea. Regional areas may have much better local bathymetry

Thus, we need to add local bathymetry, e.g., of a port.

This feature will be enabled in the later stages of EDITO project.

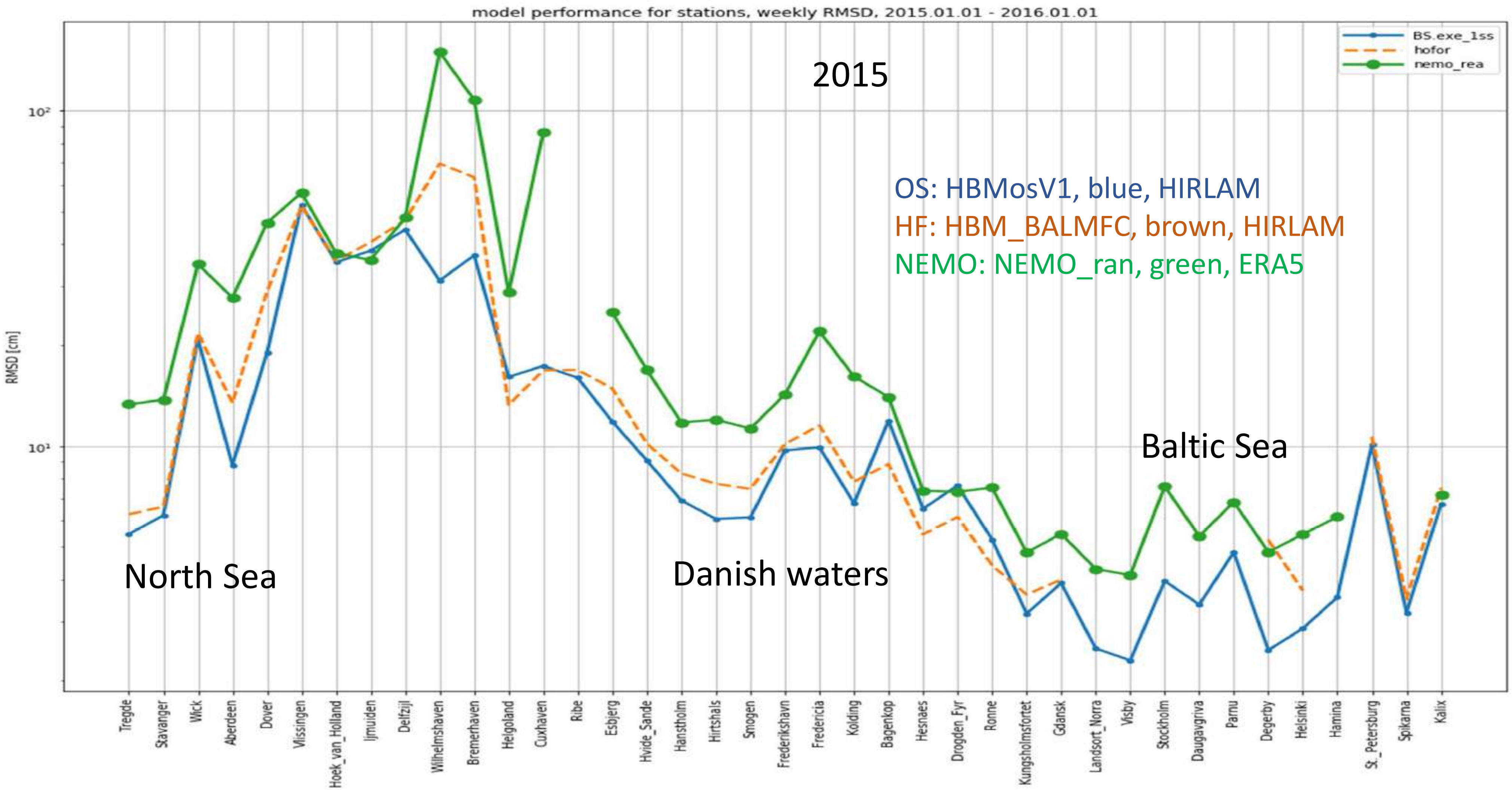


Riga and Jurmala ports with lakes



Liepaja port and lake

Quality of the background setup: intercomparison with operational models



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Experiences with high resolution coastal setups

- It is better to have nested open sea and coastal setup rather than keep the separate one-way nested setups. Better results both in open sea and at coast.
- Gradual nesting is beneficial using (5-6) nesting levels as compared to nesting with large ratios. Less stability problems, less artifacts, better results.
- Resolutions up to 1/50 nm are achievable, without major slow down of the computational performance in open seas.
- It is possible to include intense river sources in very fine grid domains. It may be necessary to redistribute river inflow to more than one grid point.

Stress tests for on-demand HBM (different setups)

Variants/Domain	H. Resolution	Application
Straits-1/Øresund	0.02nm	Storm surge
High connectivity (HC)-1/Øresund	0.1nm	Variability in OWF (Kiegers Flak) and seaweed farm
HC-1.1/KiegersFlak W.	0.02nm	Submesoscale analysis, impact of Wind Turbines
HC-1.2/KiegersFlak E.	0.02nm	Submesoscale analysis, impact of wind turbines
HC-2/E. Germany Bight	0.1nm	Variability in OWF Helgoland and seaweed/mussel farms
HC-3/Estonian offshore	0.1nm	Variability in Seaweed/mussel/fish farms
HC-4/Limfjord	0.1nm	Oyster farming
Port-1/Latvia	0.02nm	Port management
Port-2/Latvia	0.02nm	Port management
Port-3/Latvia	0.02nm	Port management
Port-4/Latvia	0.02nm	Port management
Port-5/Latvia	0.02nm	Port management

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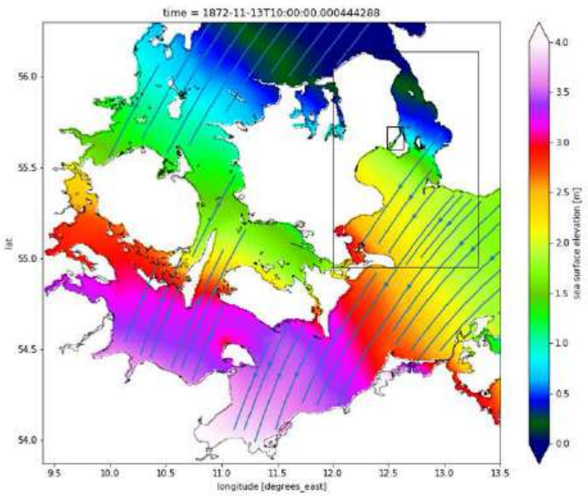
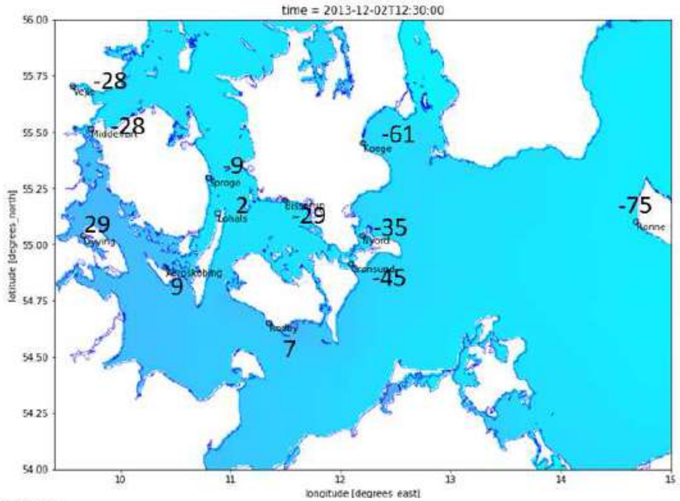
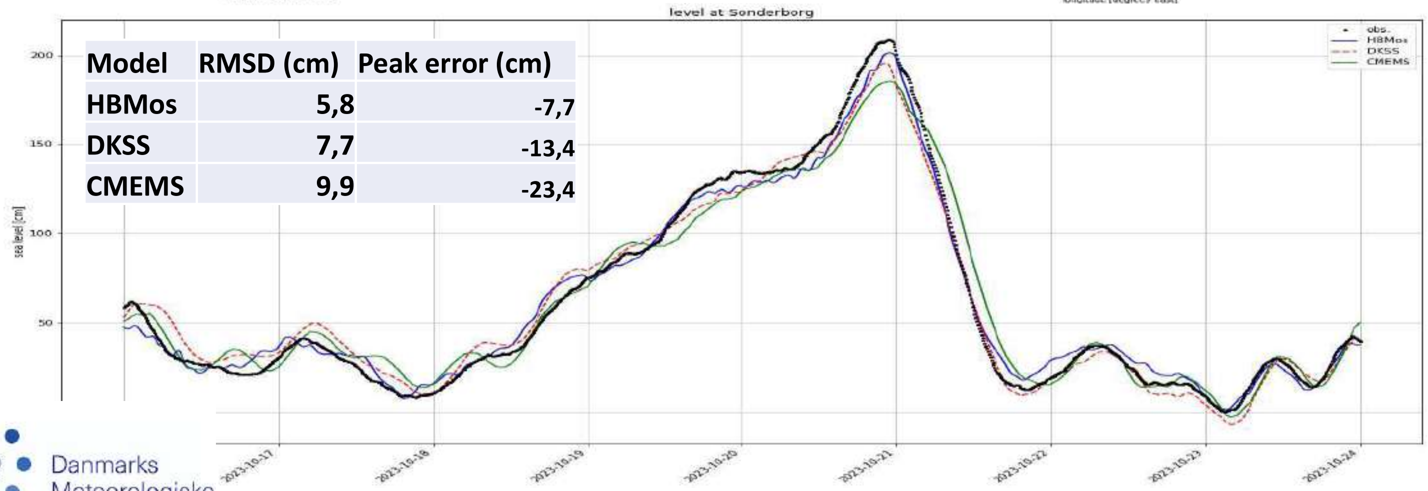
Stress tests for HBMos: relocatability, downscalability, stability, quality





1000y storm surge event: 13 Nov. 1872; 37-180m resolution

- Left: modelled sea level around peak time
- Right: sea level peak errors at DK stations (cm)



Model	RMSD (cm)	Peak error (cm)
HBMos	5,8	-7,7
DKSS	7,7	-13,4
CMEMS	9,9	-23,4

>200y storm surge event: 20 Oct. 2023 in W. Baltic Sea; 37-180m resolution

- Comparison of sea level forecasts from HBMos, DMI-DKSS, CMEMS BALMFC vs observations at Sonderborg station
- HR improves **block effects** in the Straits

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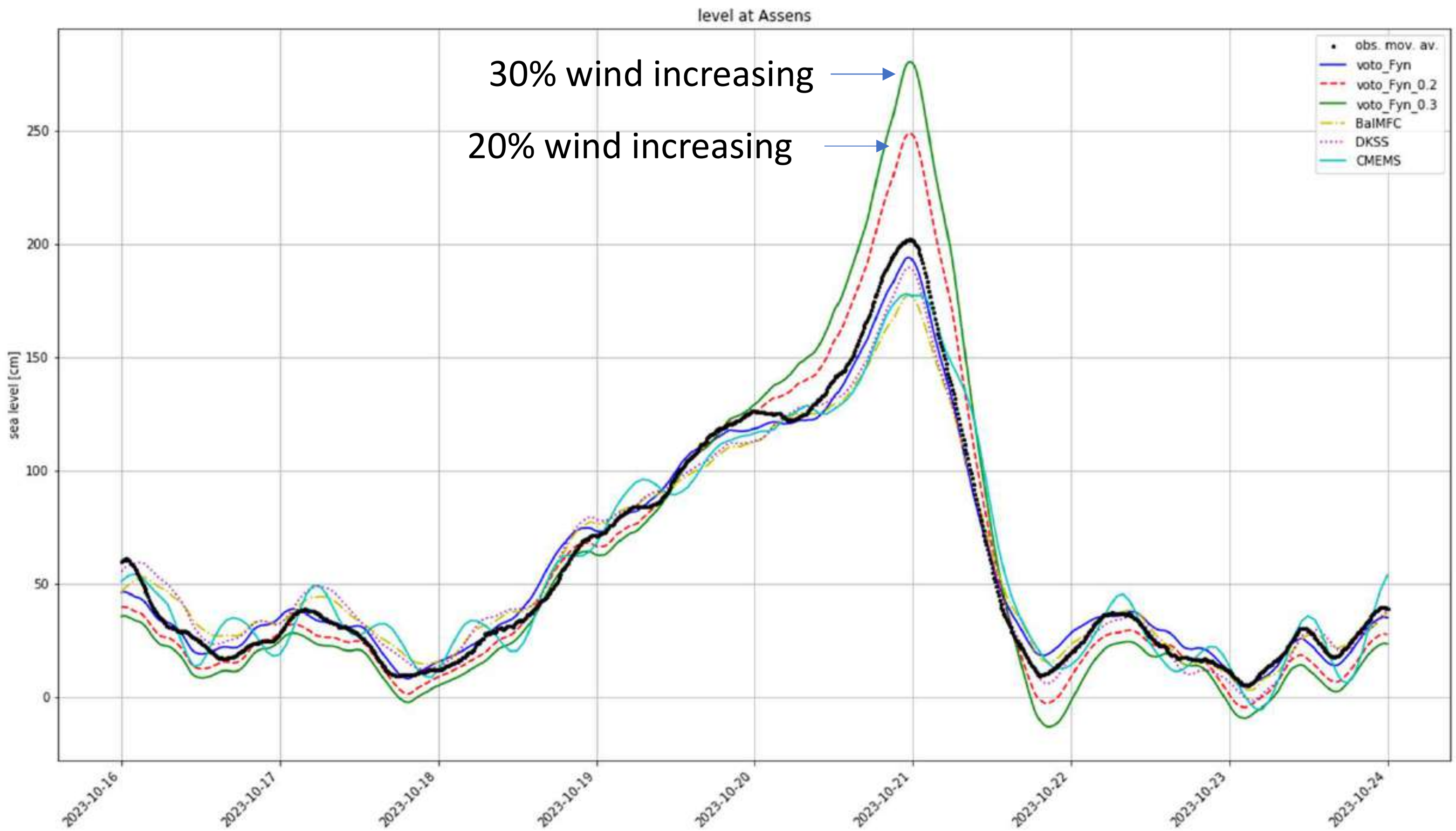
WiS examples for storm surge



Red and green lines: WiS for increased wind forcing by 20% & 30%. Sea level peaks are enhanced by 32% and 50%, respectively.

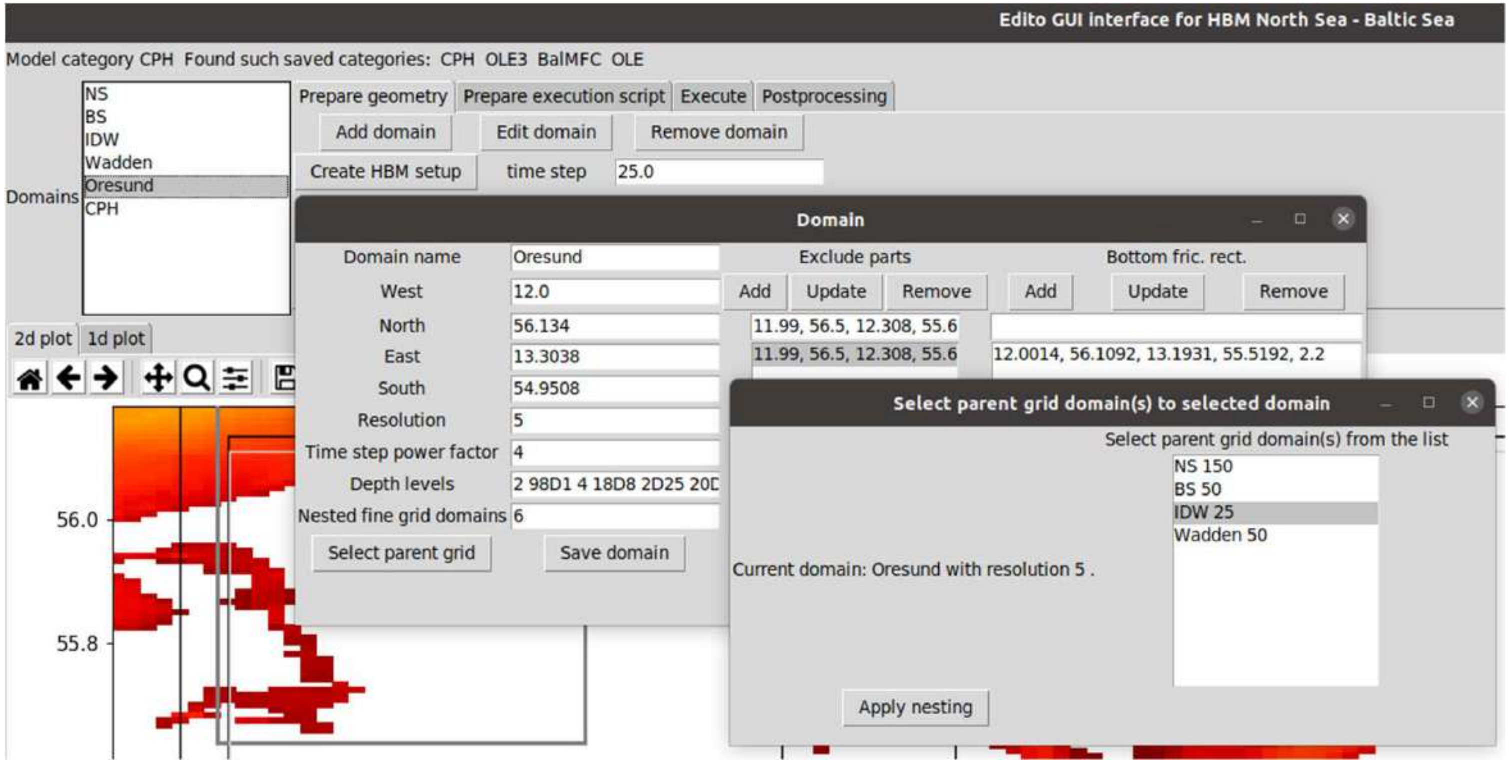
With on-demand model, many different WiS for storm surge can be made: e.g., for broken dikes, for future climate conditions with +SST and +SSH.

Introduction & demo of a subModel builder using a GUI

Design a GUI for on-demand modelling using HBM

- This GUI consists of **four modules**:
  - **Creating geometry** files for HBM with automatically nested lat-lon domains. User choses a template and makes desired modifications (e.g., adding/modifying subdomains)
  - **Creating script for execution** of HBM application for desired period of time. GUI will take care of metforcing, river runoff, boundary/initial conditions, etc.
  - **Executing** the HBM application using HPC resources and transferring the results to NetCDF format in parallel. Limited postprocessing will be available at execution stage to monitor the runs on the fly.
  - **Postprocessing** the results, i.e., viewing the results of NetCDF files and sea level files. The GUI will be designed for a quick display of main HBM results

GUI illustration: prepare geometry



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User defined setup

- Provide corner points of rectangular domains
- Provide discrete resolution for each domain as integer factor (1, 2, 3, …, 150) to the base 1/50 nm resolution
- Set layer depths for each domain
- Set which domains nests
- Set relative time step, bottom friction, etc.
- Exclude some areas from the domains (e.g. they are disconnected or accounted in finer grid)

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Thanks

BACK AT 11:10 AM

USER SESSION 2

WiS#2/FA#3 – Zero Pollution

Moderator: CMCC (G Coppini)

USER SESSION 2 – Zero Pollution

1-PRESENTATIONS

1-Presentation of Application

- FA#3 - Hazard mapping for oil spill pollution in the Mediterranean Sea - UniBO (N Pinardi) (10’)
- WiS#2 - Relocatable Oil Spill Simulations for Zero Pollution, CMCC (I Atake, G Coppini) (10’)
- WiS#2 - Marine microplastic modelling for zero pollution what-if scenarios, DMI (J Murawski) (10’)

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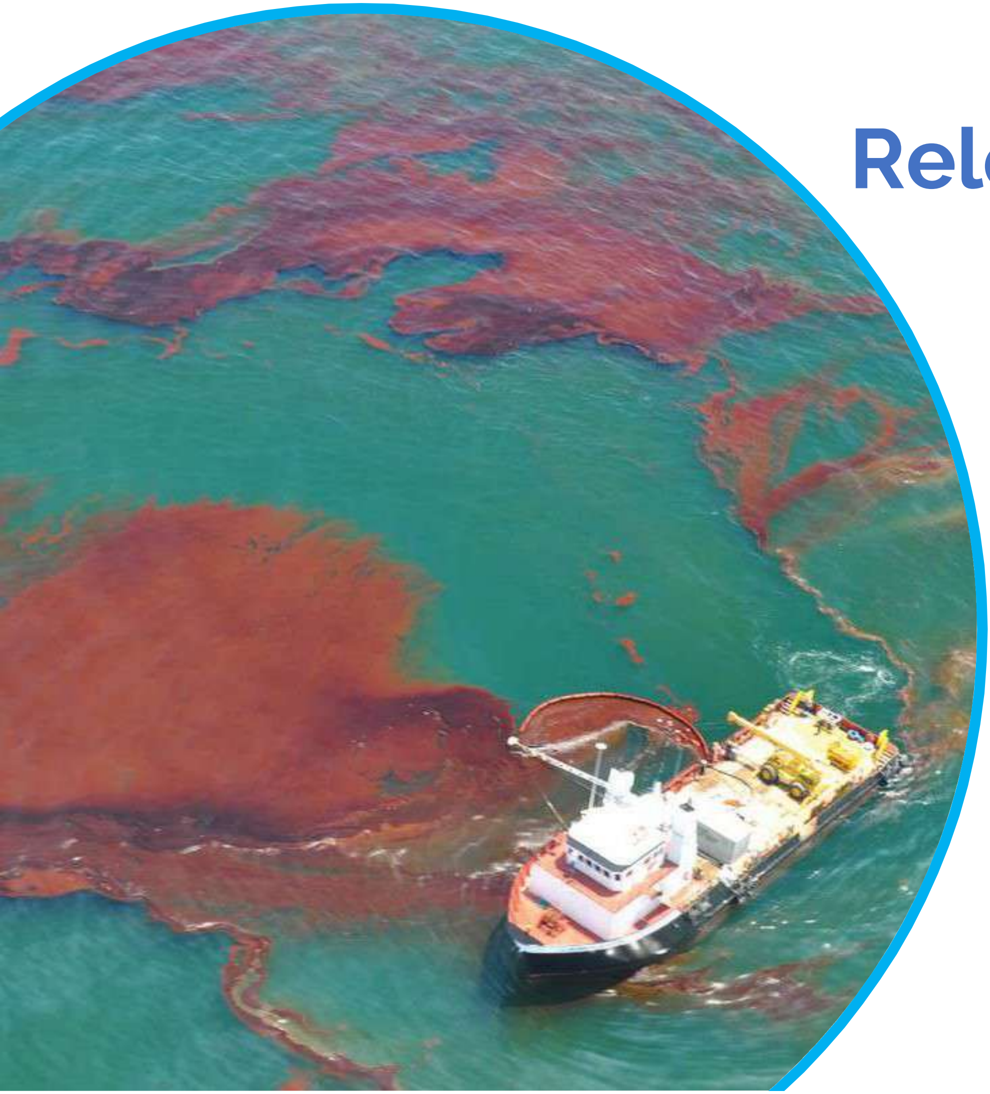
USER SESSION 2 – Zero Pollution

1-PRESENTATIONS

- FA#3 - Hazard mapping for oil spill pollution in the Mediterranean Sea - UniBO (N. Pinardi) (10’)

FA-3: Oil Spill for zero pollution



Relocatable Oil Spill forecasting

CMCC TEAM
Alessandro De Donno
Fabio Viola
Francesco Trotta
Giovanni Coppini
Igor Atake
Ivan Federico
Luca Giunti
Matteo Scuro
Megi Hoxhaj,

UNIBO TEAM
Francesco Benfenat
Marco Seracini
Nadia Pinardi

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Summary

Contextualization
Oil spill accidents

Objective
Why a relocatable approach

Proposed Methodology
How to achieve results within EDITO

FA-3: Oil Spill for zero pollution

Oil Spill incidents

Point sources (e.g. tankers, oil platform, refinery) in all seas and oceans

Data Sources

Official data provided by oil sourcing companies. Is it the whole ground truth?

Time is crucial

The faster an oil spill is identified, the faster a contingency plan could be applied

A global problem

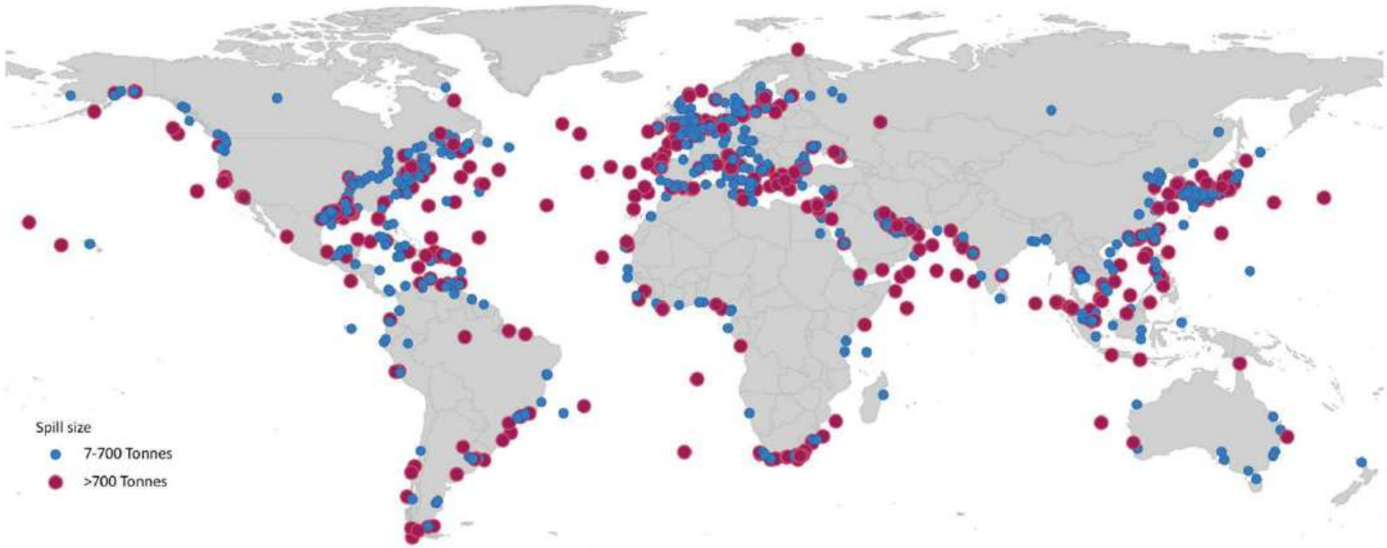

Figure 3: Location of spills >7 tonnes from 1970 to 2018 (All rights reserved © ITOPF)*

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FA-3: Oil Spill for zero pollution

Meteo-ocean Forcings

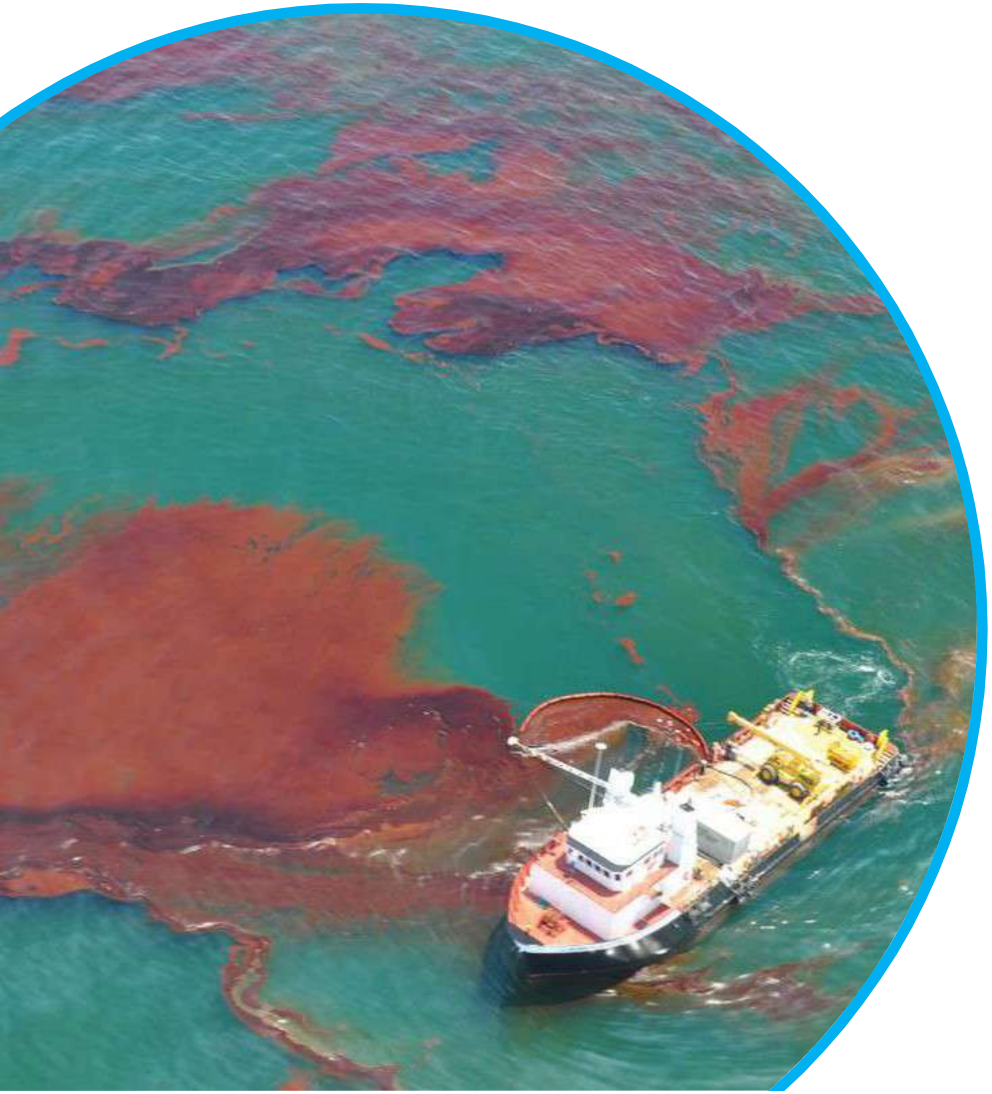
Not only oil spill data are needed, but as well as currents, temperature and wind

Resolution not always adequate

Specially for coastal incidents, some key aspects of the dispersion could not be reproduced due to the data resolution available

CMEMS Global and Mediterranean data

FA-3: Oil Spill for zero pollution



How to go from a global/regional scale to a local / coastal one?

And then simulate an oil spill incident?

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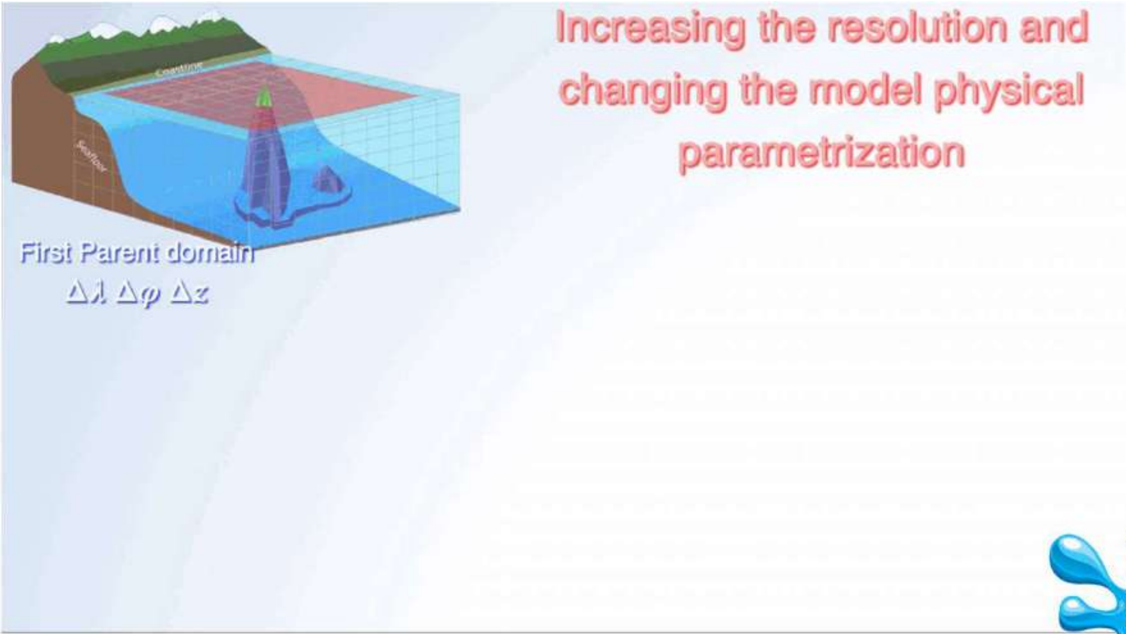
Relocatable Hydrodynamic Simulations (see WP5.3 and 5.4)

Downscaling Data

Obtaining data in the area of interest / oil spill simulation and then increasing resolution by additional modeling

SURF Framework

By coupling NEMO and SHYFEM, the SURF framework is possible to simulate high resolution hydrodynamical conditions in almost anywhere in the world with relative ease in a container solution



SURF

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Relocatable Oil Spill Forecast

Objective

Make it possible to run oil spill simulations anywhere in the world by using SURF relocatable model framework and MEDSLIK-II oil spill model

FA-3: Oil Spill for zero pollution

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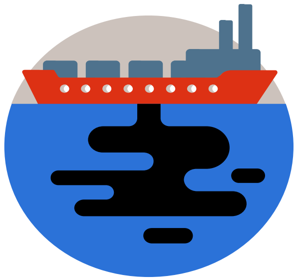
Relocatable Oil Spill Forecast

Ocean Simulation at High Resolution



Oil Spill Forecast

Forecast Results

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FA-3: Oil Spill for zero pollution

Relocatable Oil Spill Forecast

Ocean Simulation at High Resolution → **Oil Spill Forecast** → **Forecast Results**

Ocean Simulation at High Resolution

- Launch SURF in desired area of interest on the Edito-infra cloud
- Store output as netcdf in ERDDAP/data-lake

Oil Spill Forecast

- Through a new user interface, allows the user to choose how to lunch an oil spill simulation with Medslik-II
- Also storing output of the oil spill simulation as netcdf on the data lake/ERDAP

Forecast Results

- Collects ocean and atmospheric outputs used in the simulations along with desired oil spill simulation output and produce results such as: Oil Fate in the surface, Oil mass in the coast, Simulation Mass Balance
- Visualize the oil spill and meteo-oceanographic products

FA-3: Oil Spill for zero pollution

Relocatable Oil Spill Forecast

Proof of Concept at the Adriatic Sea

Interface using medfs currents and sea surface height

FA-3: Oil Spill for zero pollution

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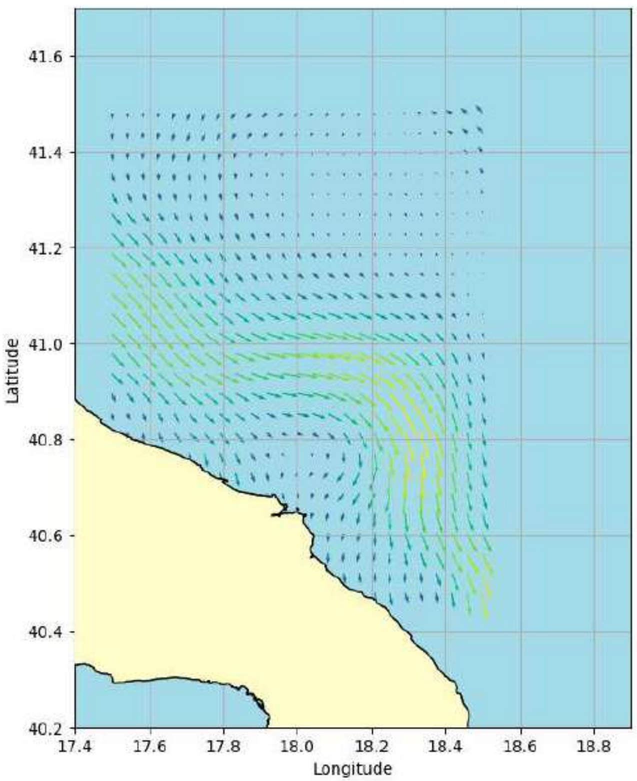
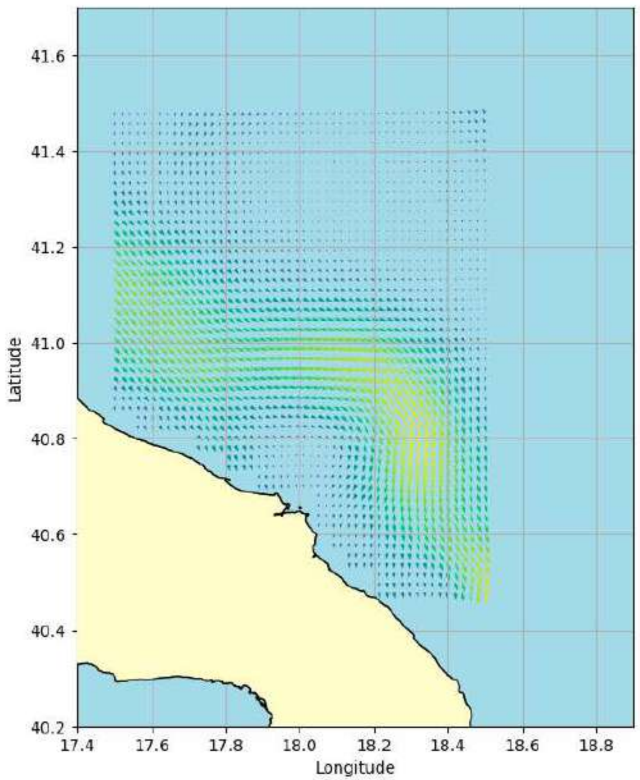
Relocatable Oil Spill Forecast

Ocean Simulation in High Resolution

Example at the Adriatic Sea



Refined grid
not produced by SURF



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FA-3: Oil Spill for zero pollution

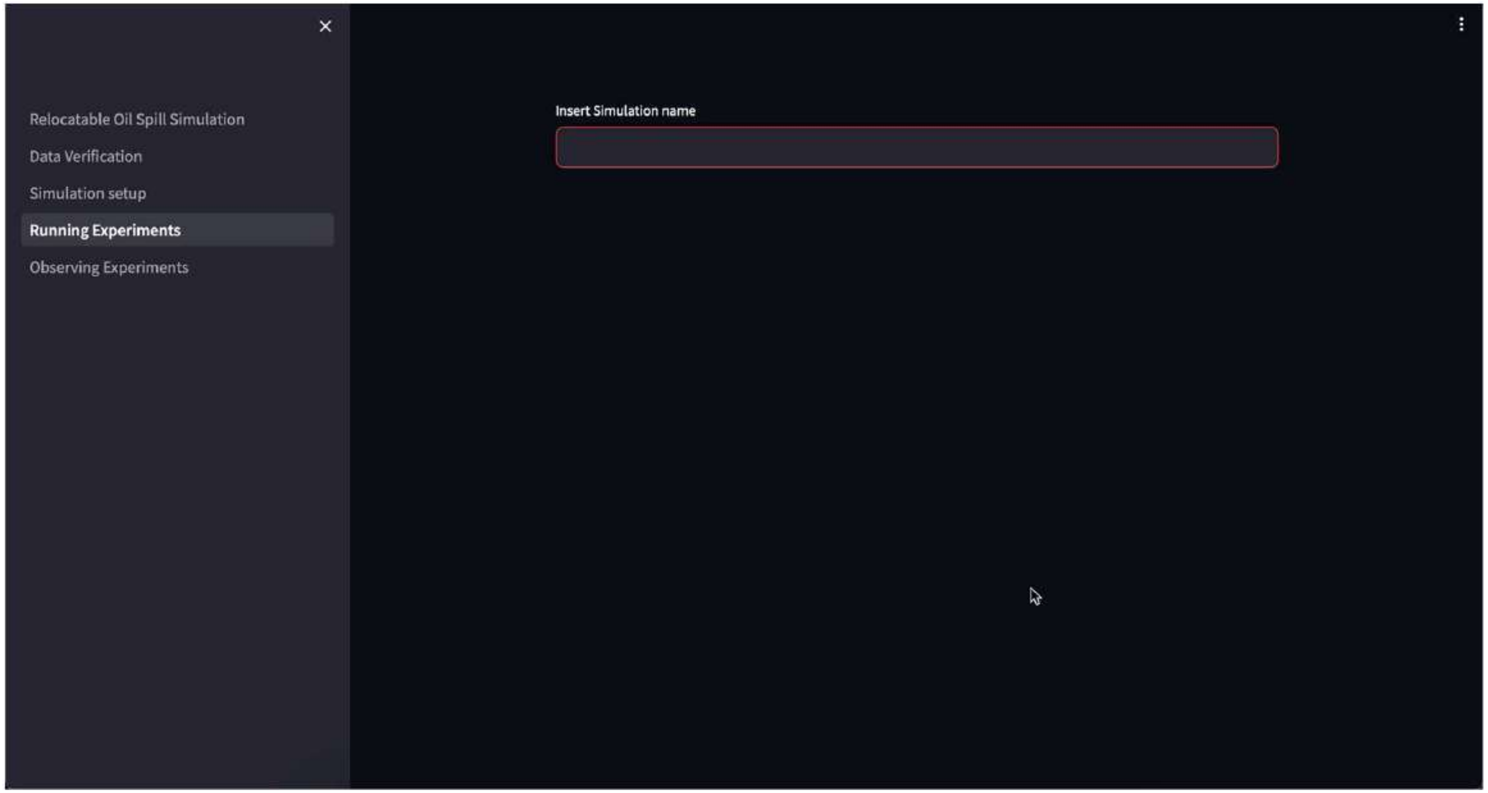
Relocatable Oil Spill Forecast

Oil Spill Forecast

FA-3: Oil Spill for zero pollution

Relocatable Oil Spill Forecast

Oil Spill Forecast



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FA-3: Oil Spill for zero pollution

Relocatable Oil Spill Forecast

Forecast Results

FA-3: Oil Spill for zero pollution

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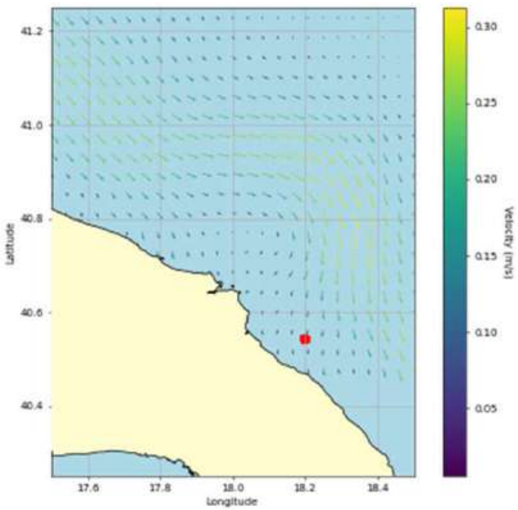
Relocatable Oil Spill Forecast

Forecast Results

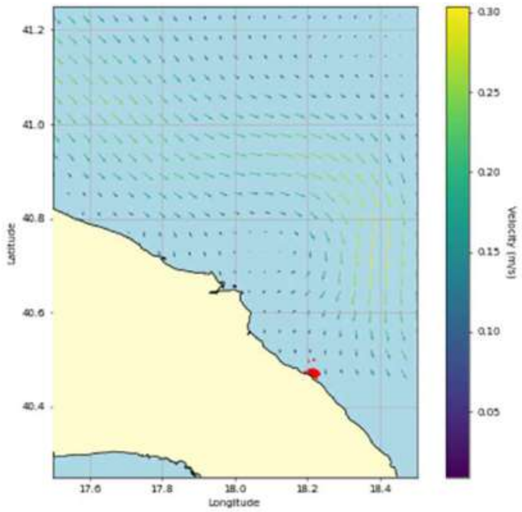
Oil Concentration on the surface

Kg/m2 of oil for each model grid cell



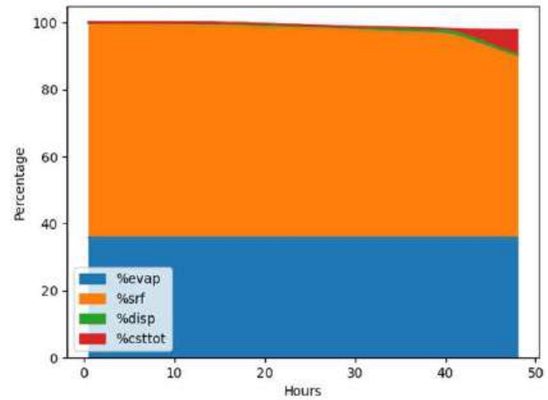
Oil Concentration on the coast

Kg/m2 for each coastal segment



Simulation Mass Balance

% of modeled oil status over output timesteps



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FA-3: Oil Spill for zero pollution

Relocatable Oil Spill Forecast

Forecast Results

Data manipulation of products at wms

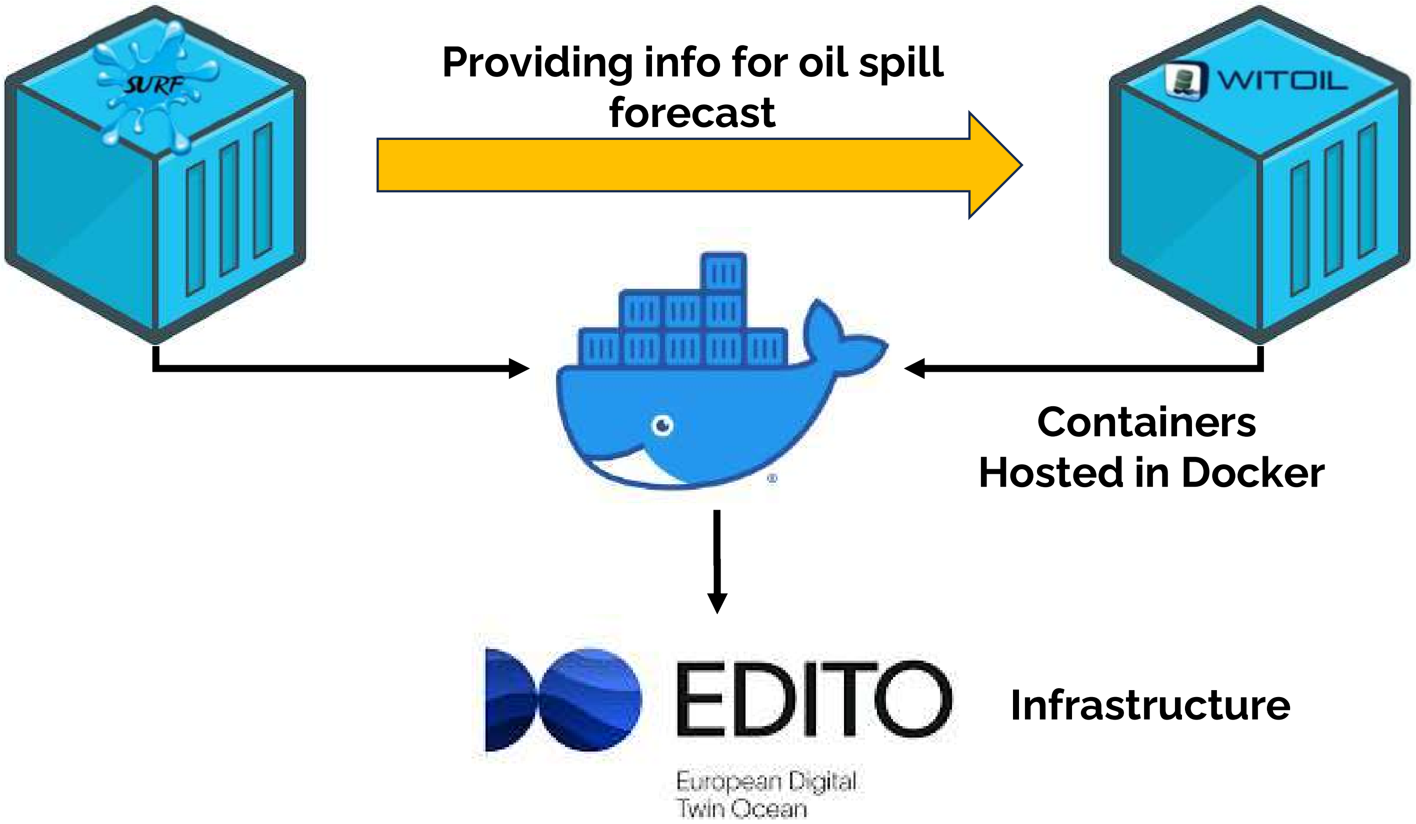
Overlaying of meteo-oceanographic fields

interoperability of results with users' GIS

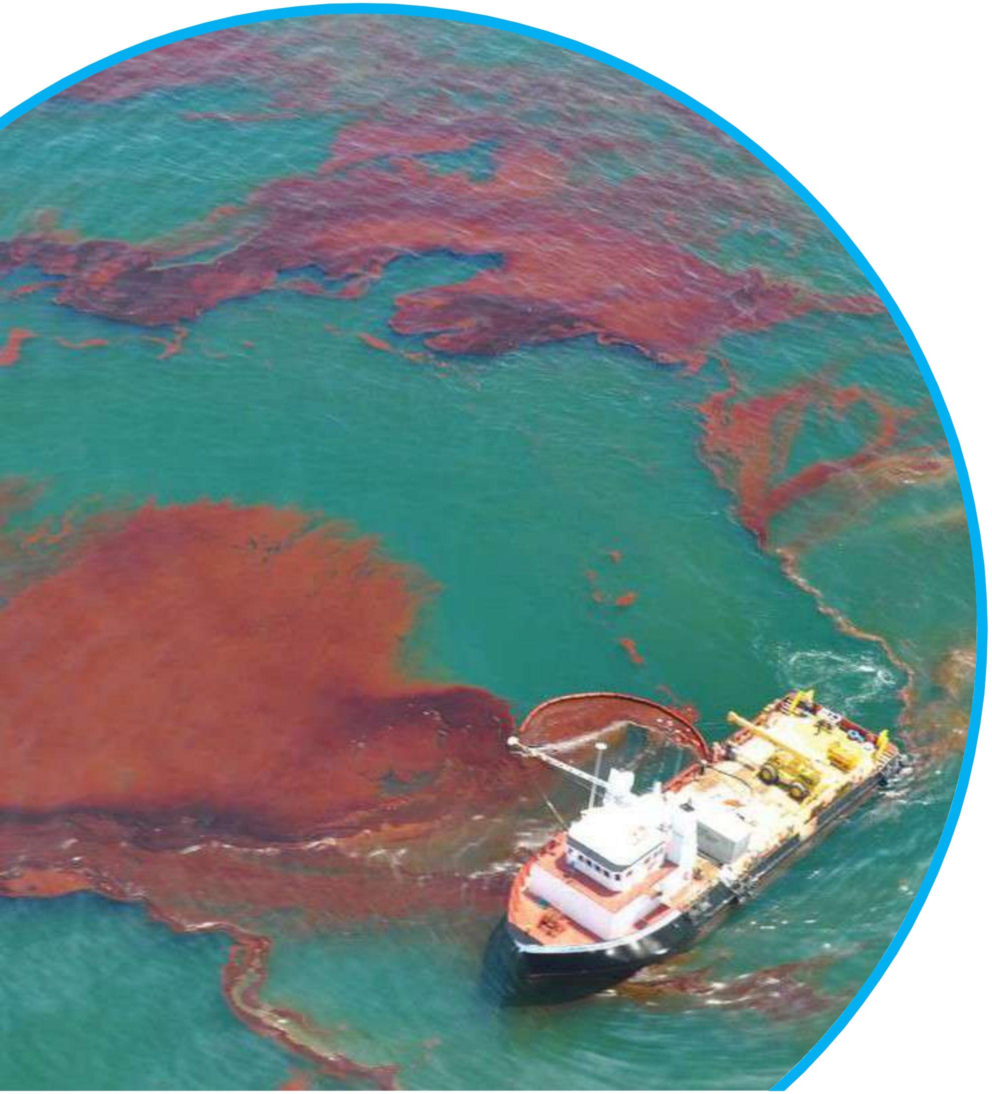
Relocatable Oil Spill Forecast: Architecture

SURF Relocatable Hydrodynamic modeling

WITOIL Oil Spill Simulation



FA-3: Oil Spill for zero pollution



Thank You

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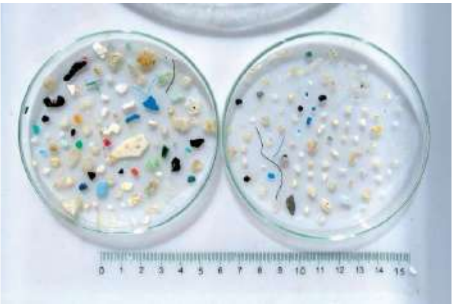
Marine microplastic modelling for zero pollution what-if scenarios

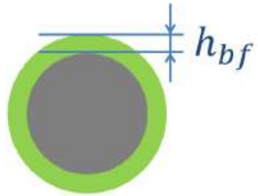
Jens Murawski, Jun She and Vilnis Frishfelds (DMI)

FA3 & WIS2: Zero Pollution, Microplastics in the Baltic Sea

Microplastic Pollution

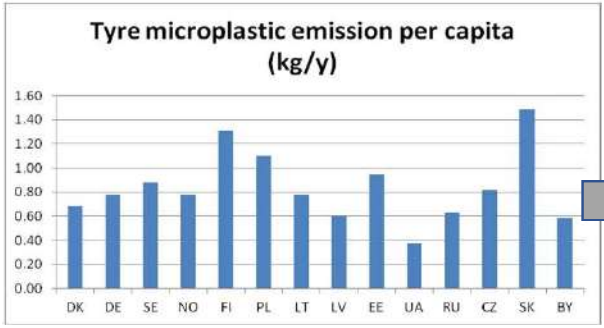


- ❑ Forced by currents and wave induced drift
- ❑ Modelled as spherical particles with a biofilm shell (h_{bf})
- ❑ No shape dependent parameterization (fibers)
- ❑ Sedimentation/resuspension, no beaching considered
- ❑ Size and density vary for different microplastic sources:
  - Tyre Wear MP1, (5 µm), *heavier than sea water*
  - Household MP2, average fraction (42 µm), *lighter than sea water*
  - Household MP3, large fraction (300 µm), *lighter than sea water*



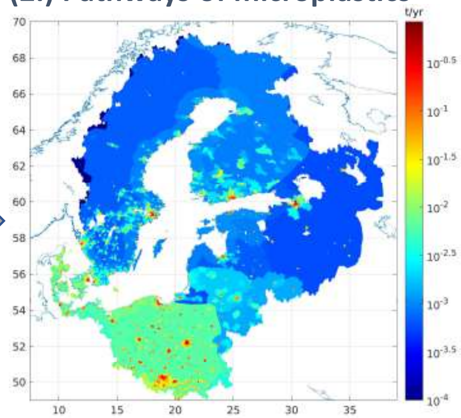
Source mapping for rivers and coastal catchments:

(1.) Emissions per country:

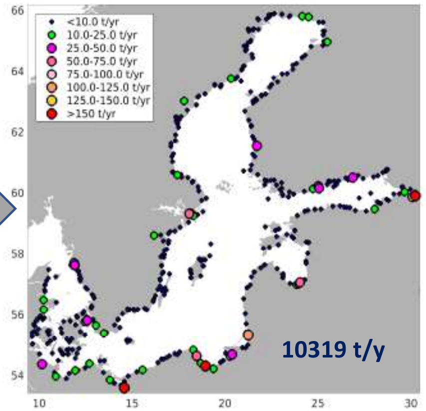


DK=Denmark, DE=Germany, SE=Sweden, NO=Norway, FI=Finland, PL=Poland, LT=Lithuania, LV=Latvia, EE= Estonia, UA=Ukraine, RU=Russia, CZ=Czech Rep., SK=Slovakia, BY Belorussia

(2.) Pathways of microplastics



(3.) Integrate over the catchment



Emissions are estimated using available statistics for each country.

Pathways: Estimate pathways of microplastics from road transpotation to soil, air, seawage water, WWTP[1], rivers and seas.

[1]WWTP stands for Waste Water Treatment Plants

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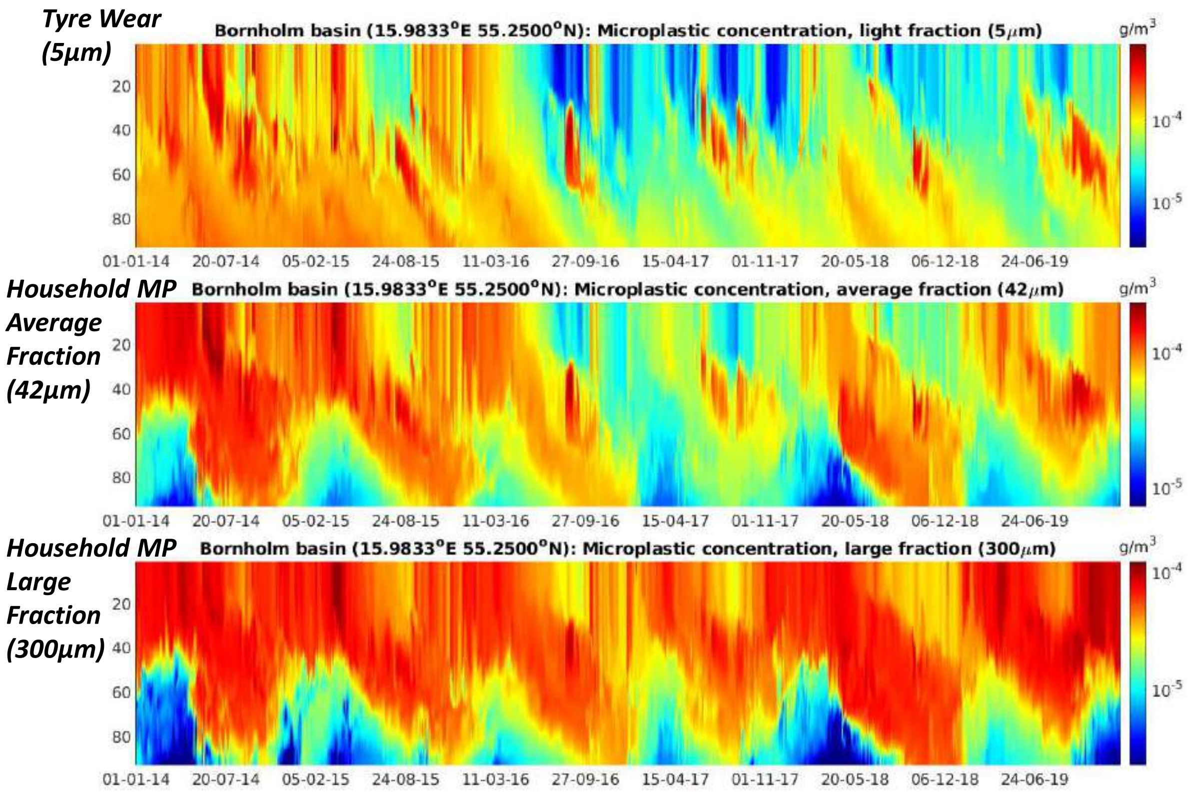
Microplastic drift modelling, an overview



Profile of microplastic concentration at station BMPK2, Bornholm Deep (July 2013 to Dec 2019). The development of a biofilm shell leads to sinking and sedimentation of microplastics during the growth season.

- Wave and current induced drift. (WAM and HBM model, setup in 0.5 nmi resolution)
- Mixing: Turbulent horizontal (Smagorinski) and vertical (k-ω) mixing (circulation model HBM).
- *Biofouling:* Empirical growth model for the biofilm thickness, using saturated growth functions. Seasonal dynamic through chl-a dependent activation of biofilm growth.
- *Vertical dynamic:* Stokes formulation for the sinking/raising velocity of spheres, dependent on the eddy viscosity of the model.

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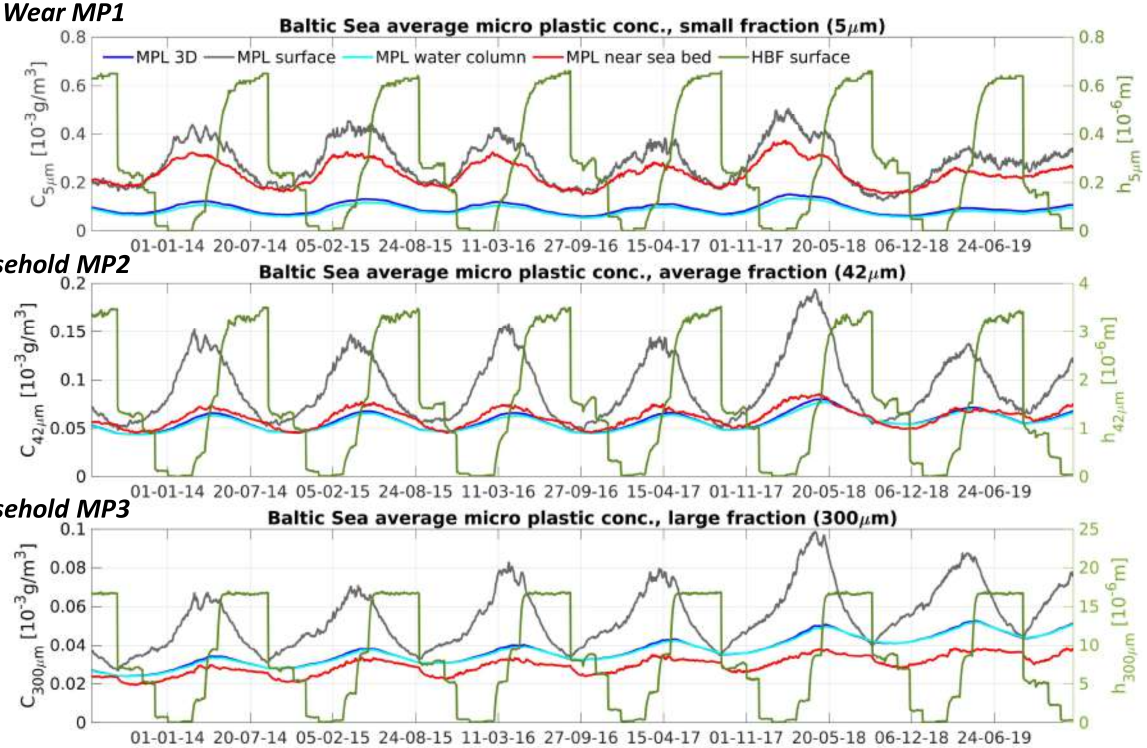
FA3: Seasonal dynamic of microplastic pollution

Tyre Wear MP1

Household MP2

Household MP3



Baltic Sea, average microplastic concentration (July 2013 to Dec 2019).

The model has been tuned to reproduce a stable seasonal cycle.

Time series can be provided for subdomains or location.

Concentrations at the **surface (grey), near the sea bed (red),** In the **water column (blue),** as well **as biofilm thickness (green).**

The Seasonal cycle, controlled by river runoff, biofilm growth. River concentrations are kept

Peak time controlled by biofilm growth:

- Tyre Wear MP1, first half of March.
- Household MP2, end of March to beginning of April
- Household MP3, end of April

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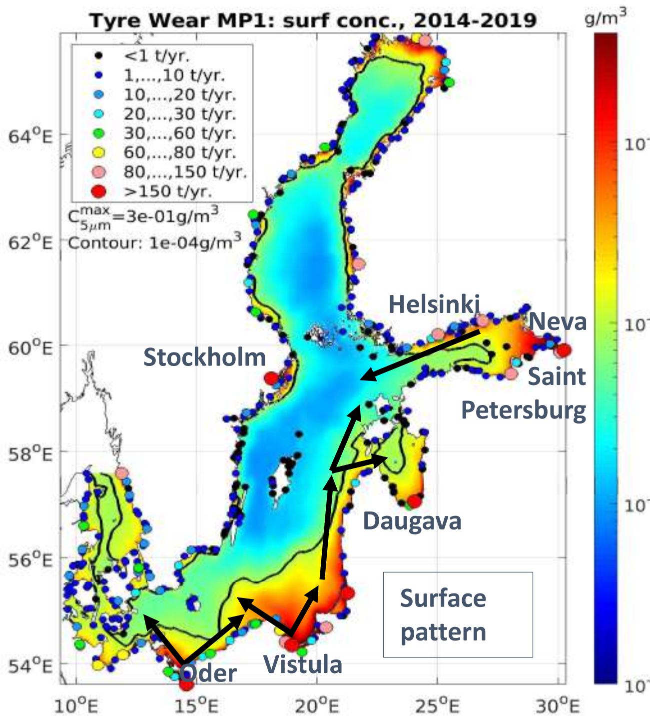
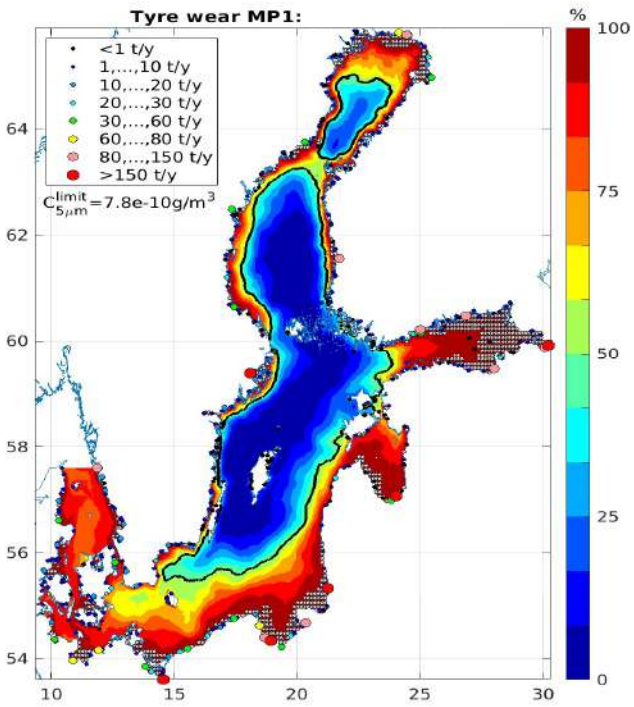
FA3: Spatial pattern of microplastic pollution



***Average microplastic concentration** and transport (Jan 2013 to Dec 2019).*



***Residence pattern:** Percentage of time with surface concentrations larger than 0.78 ng/m3. Contours at 50%, white dotted areas at 99% of the 6 year period 2014-2019.*

Surface pattern are persitent and located near major rivers and coastal outlets.

3D data sets (surface, near seabed, profiles) can be provided for subdomains or locations

The occurrence of microplastics can be studied using Residence pattern.

Data sets for tyre wear and household microplastics are available.

Marine surface transport with the mainly cyclonic circulation in the Baltic Proper leads to higher concentrations along the south-eastern coast of the Baltic Sea.

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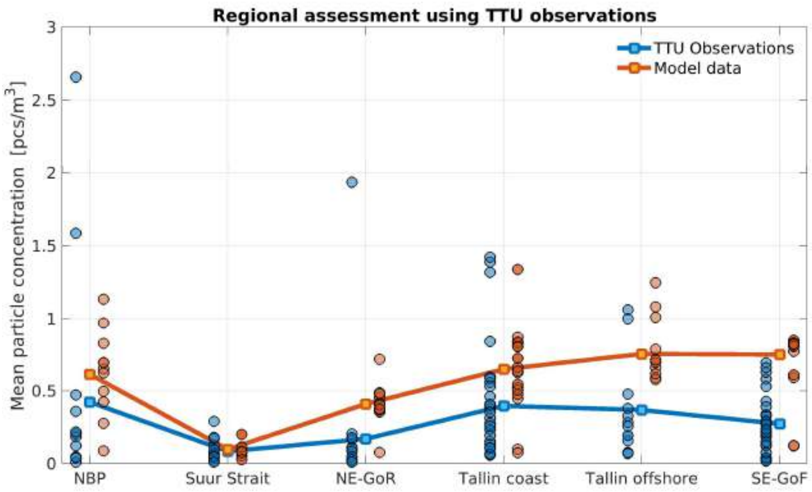
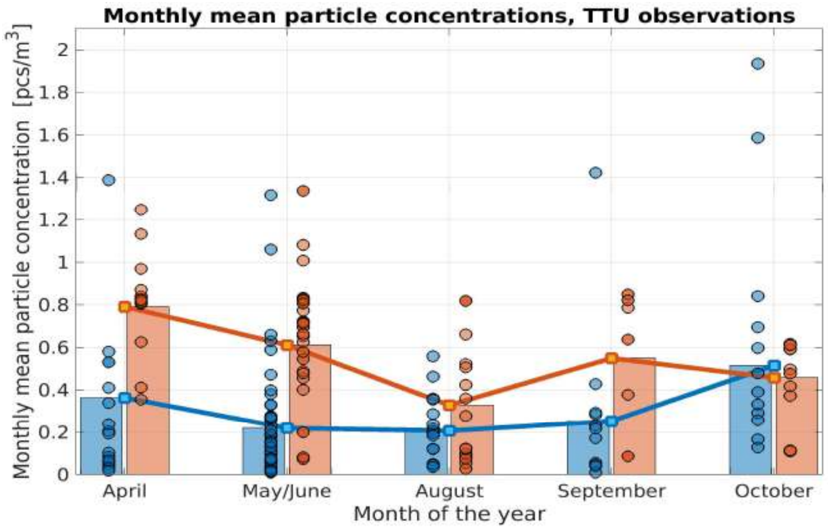
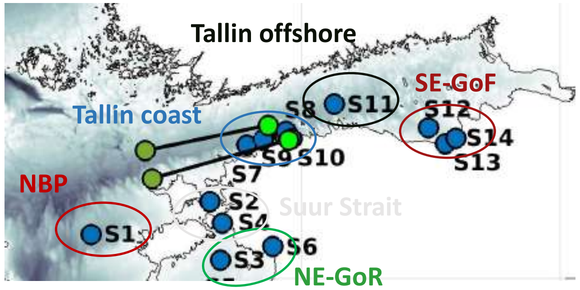
Assessment of spatial and temporal pattern of microplastic pollution using TTU data from regular monitoring cruises.







Comparisson of individual data points reveals that the variability in the observed data sets is larger, especially for the measured maximum values, which the model can not reproduce.

Spatial Pattern:

- ❑ The model is able to reproduce the average conditions in the sub-domains. (CC=0.81, P-Value=0.051)

Seasonal Pattern:

- ❑ *Spring and Summer:* The Seasonal variability of the averaged microplastic distributions is qualitatively reproduced.
- ❑ *Autumn:* The increase of measured (blue) concentrations after the summer is not captured by the model. The reason could be that the simplified biofilm model does not include biofilm removal processes, like grazing and that the biofilm concentrations are to high.

Dots represent model values (red) and obs. (blue), whereas bars and lines represent time averaged values

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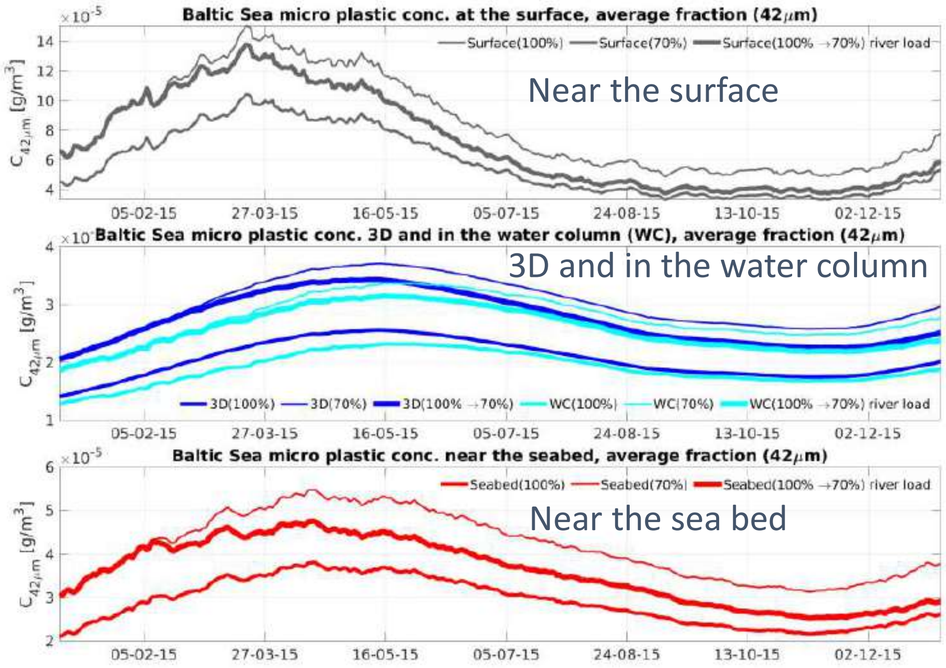
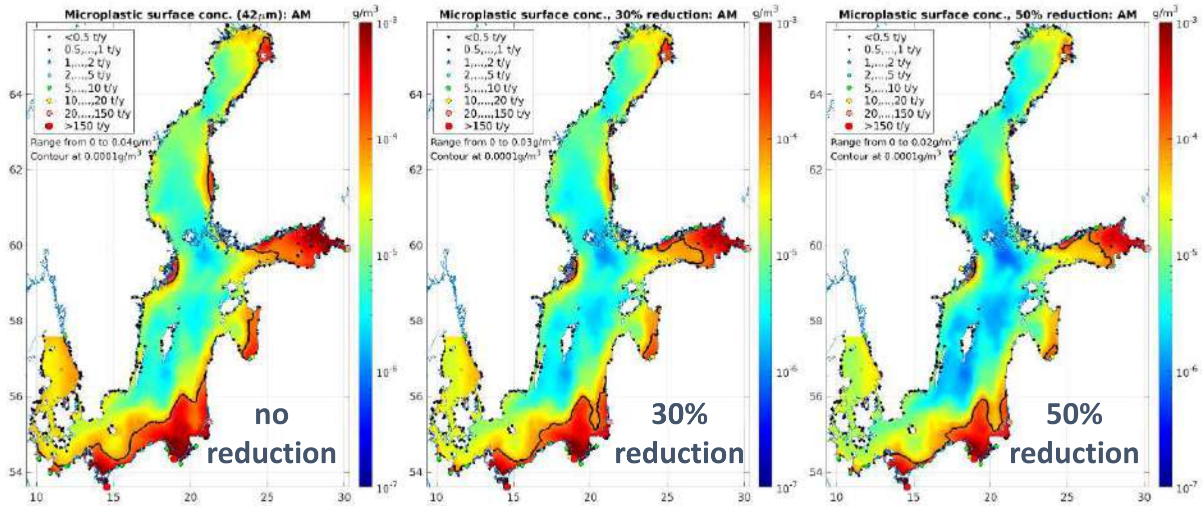
Effect of an overall reduction of all land based sources

Application of a 30% reduction of all microplastic sources in the Baltic Sea



30% source reduction, applied at the 1th of February 2015



Microplastic concentrations in the ocean adapt relatively fast to changing pollution levels in the rivers, due to the action of removal processes, i.e. biofilm growth, sinking and sedimentation. Microplastic concentrations in the sediment are expected to adapt at a much slower pace.

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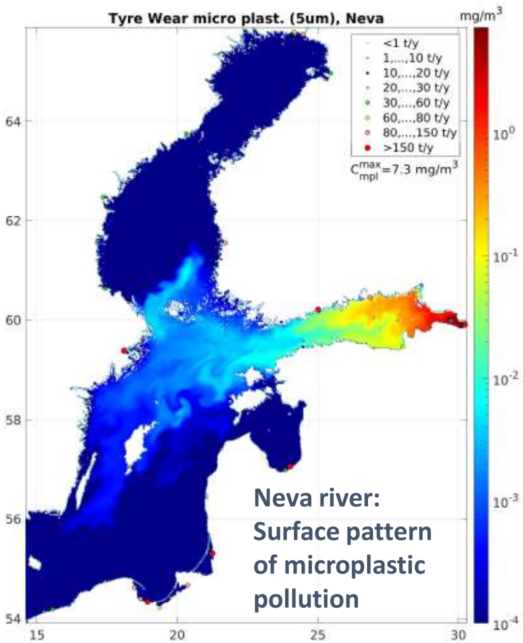
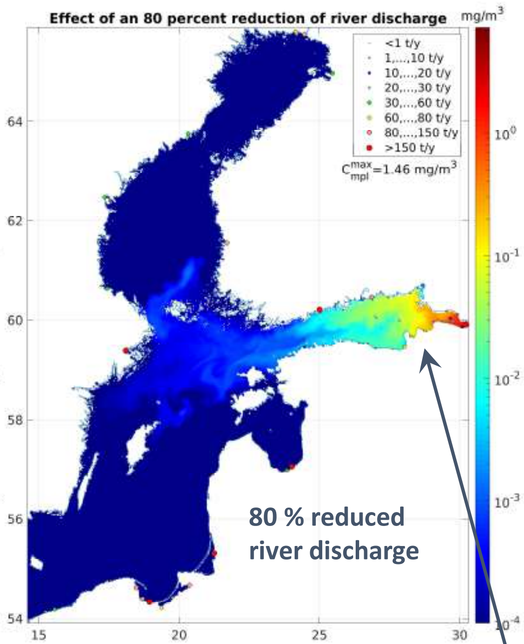
WIS2: Study of the contribution of individual sources

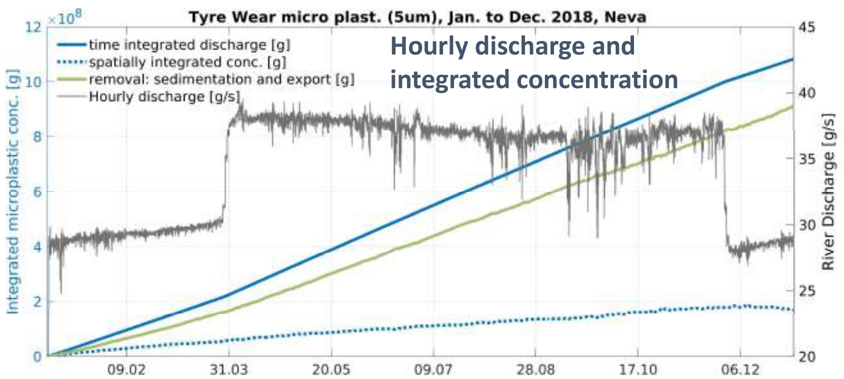


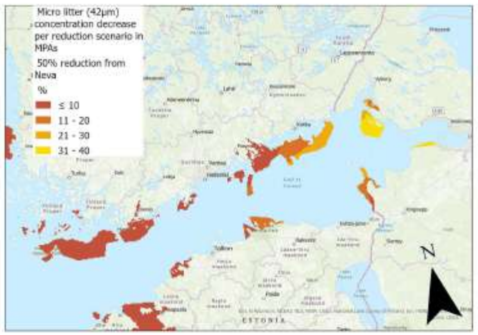


The study of individual sources using scalable pollution pattern (Greens Functions) allows the assessment of cleaning impacts.

Cleaning strategies can be developed and tested, in terms of coverage and impact.

13 major sources in terms of runoff have been investigated: Neva, Oder, Vistula, Nemunas, Daugava, Kemijoki, Indalsälven, Ume, Tornio, Gavleån





Neva, Impact of a source reduction of 50%: Simulated changes in concentrations of middle-size micro plastics (42 µm) in the HELCOM MPAs in the Gulf of Finland (impact assessment by MSI)

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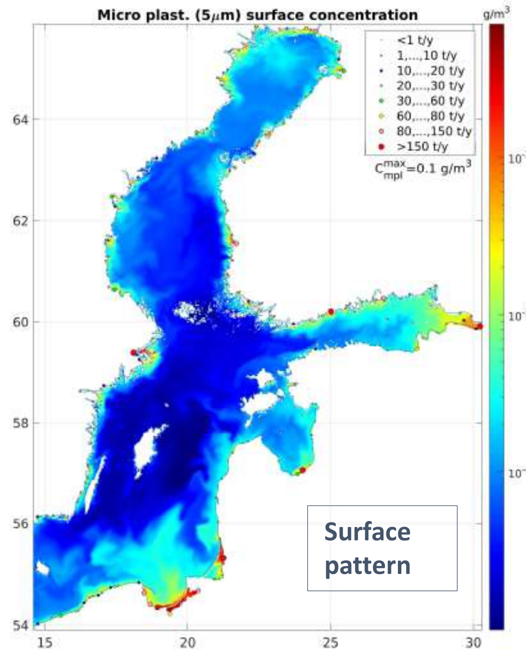
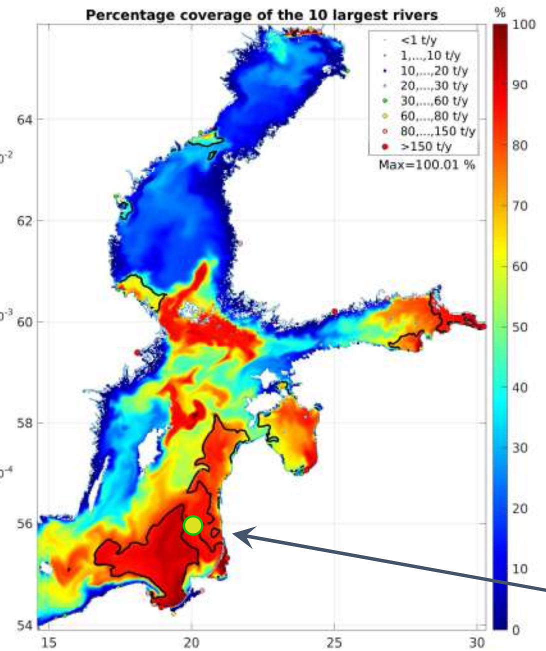
WIS2: Attribution of microplastic offshore concentrations



***Microplastic concentration** at the December 31, 2018, after 1 year of simulation.*



***Attribution of microplastic pollution** using the contribution of 10 major Rivers: Neva, Vistula, Nemunas, Daugava, Kemijoki, Indalsälven, Ume, Tornio, Gavleån*

The contribution of each river to the microplastic concentration at offshore locations can be estimated using the drift pattern of individual sources.

13 major sources in terms of runoff have been investigated. That is 13/455 ≈ 3% of the total number of Rivers in the Baltic Sea.

River	Percentage	River	Percentage
Neva	0.05 %	Narva	0.16 %
Vistula	**46.17 %**	Indalsälven	0.07 %
Nemunas	**38.94 %**	Ume	0.06 %
Daugava	0.7 %	Tornio	0.0 %
Kemijoki	0.0 %	Gavleån	0.07 %
		Total	**86.24 %**

Table: Attribution for offshore location 56°N 20°E

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European Digital Twin Ocean

cmcc Centro Euro-Mediterraneo sui Cambiamenti Climatici

Danmarks Meteorologiske Institut

MERCATOR OCEAN INTERNATIONAL

ALMA MATER STUDIORUM UNIVERSITÀ DI BOLOGNA

Helmholtz-Zentrum hereon

BSC

SOCIB

Deltares

CINECA

Thanks

USER SESSION 2 – Zero Pollution

2-DEMO

2-DEMO

- Marine Platic for Zero Pollution, MOi (S Van Gennip) (20’)

3-Discussion with users (20’)

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European Digital Twin Ocean

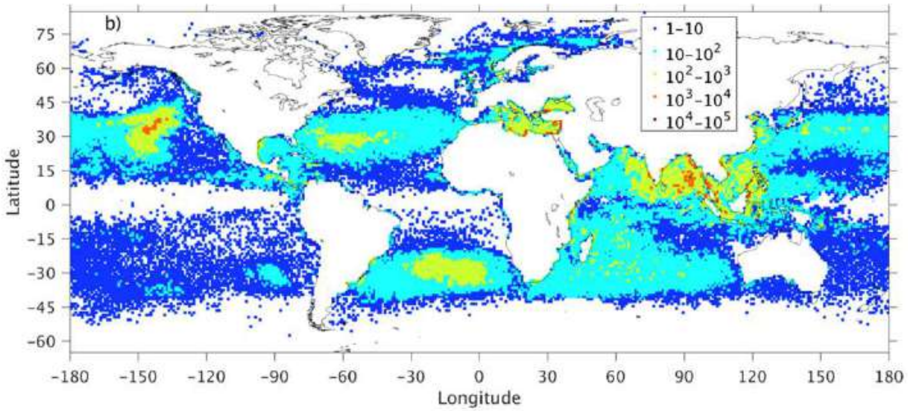
Danmarks Meteorologiske Institut

Marine microplastic modelling for zero pollution what-if scenarios

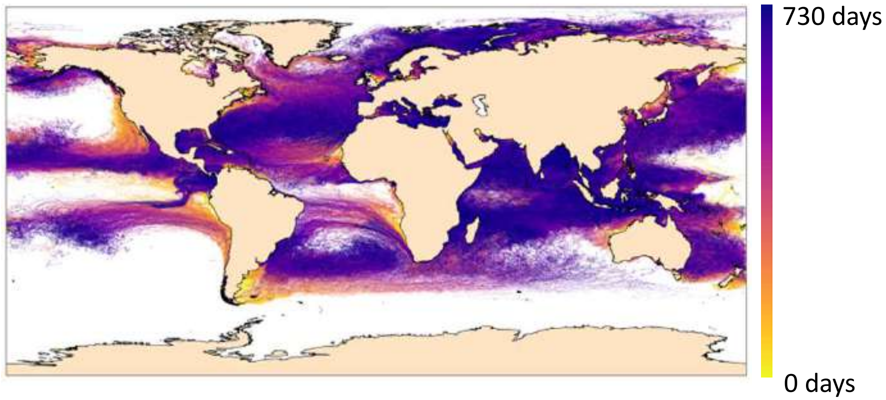
Simon van Gennip
(Mercator Ocean)

Context

Modelled Plastic distribution



2 year drift from coastal positions



- Plastic pollution is a global problem
- Coastal connectivity is function of ocean circulation (far away doesn't mean not connected!)
- A coastal area's exposure to plastic is not a local problem

- Need to develop user relevant tools to inform on the impact of potential action plans

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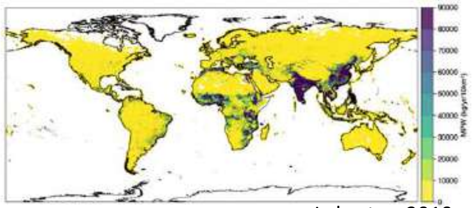
Step 1: Monitoring plastic waste

What are the impacts of river and continental inputs of plastics, at what spatial and temporal scales?

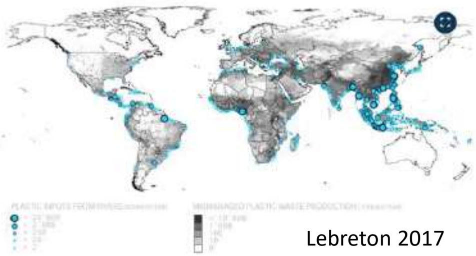
1. Plastic waste input

Continental waste



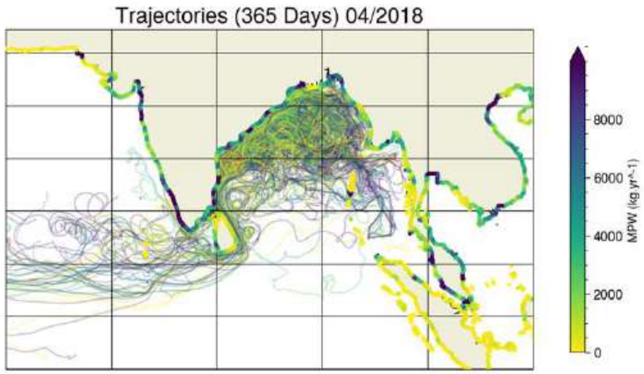
Lebreton 2019

Riverine waste

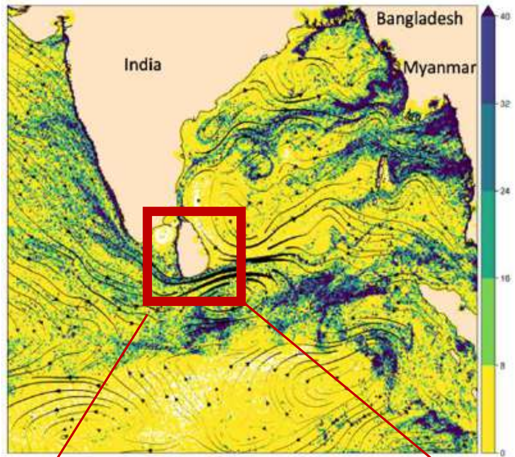


Lebreton 2017

2. Transport in the ocean
Lagrangian modeling



3. Monitoring plastic, and quantifying exposure



WiS: Identify region of interest
Use history of particles to determine sources and associated timescale

4. What if Scenario :
What's the impact of potential plastic removal action plans on local exposure e.g. focus on coastal vs riverine?

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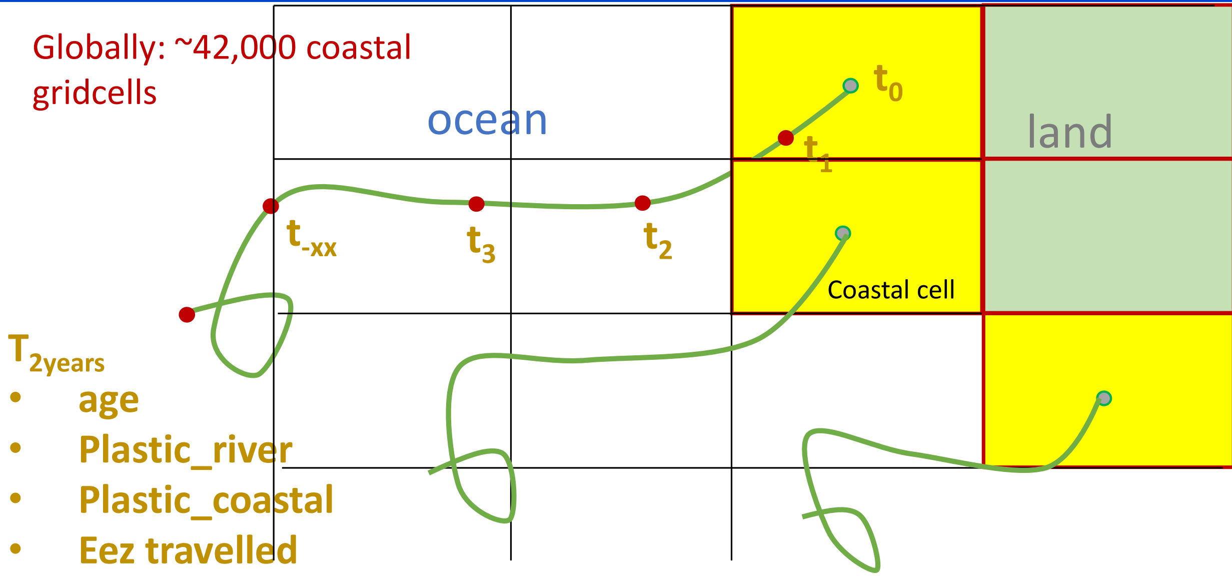
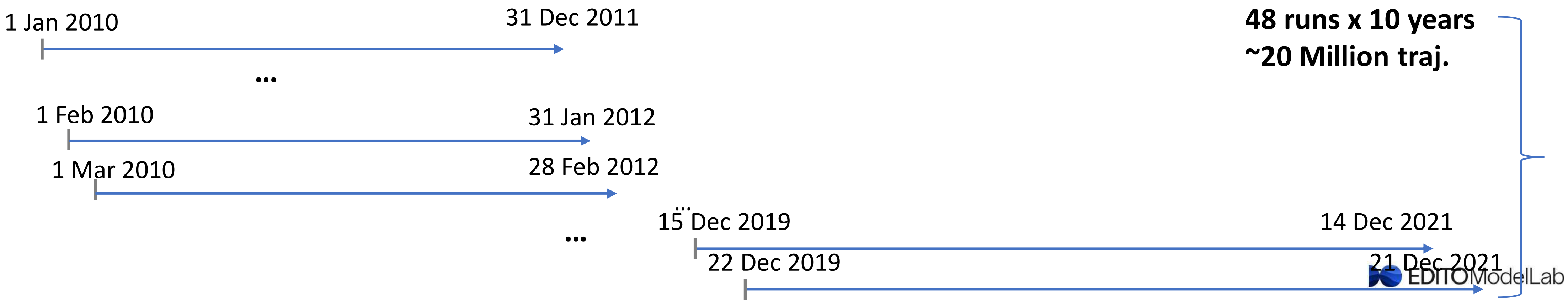
Simulating Lagrangian particle drift

Ocean Model: SMOC
- 6 hour average surface u,v field
- 1/12 horiz. degree resolution
- Ocean currents + Stokes drift

Simulation:
- Passive, surface 2D
- 4 releases per month
- 2 year drifting time
- From 2010 to 2019





Step 1: Monitoring plastic waste

Access to MDS for visualizing current streamlines

Pre-calculated trajectories

Series of NetCDF files of lagrangian simulations (uploaded on shared S3 space)

Preprocess_data.py

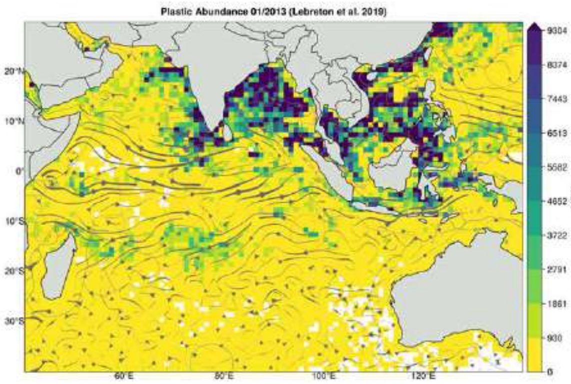
Generation of one NetCDF files containing:

- *particle positions for given period of interest*
- *+ origin and time of release*

(computation time ~ 15min)

Density_FMD.py

Visualize Abundance (output Netcdf, png)



2 years x 48 runs x 42,000 particles = 4M particles in the ocean
Age between 1 day and 2 years

December 2011

1 Jan 2010 — 31 Dec 2011

...

1 Feb 2010 — 31 Jan 2012

1 Mar 2010 — 28 Feb 2012

...

15 Dec 2019 — 14 Dec 2021

22 Dec 2019 — 21 Dec 2021

48 runs x 10 years
~20 Million traj.

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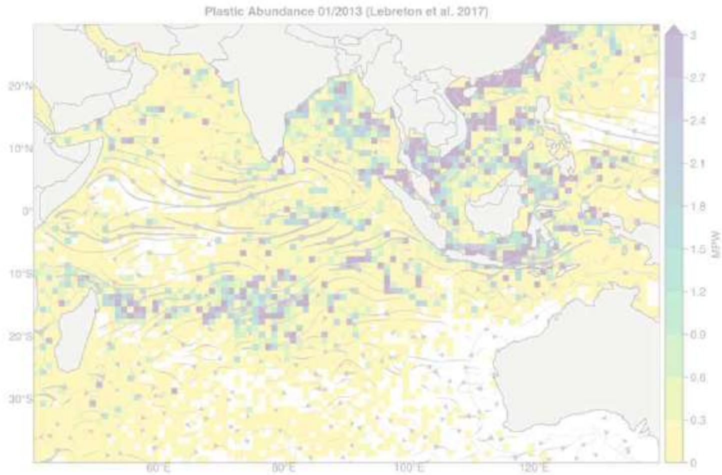
Exposure to floating plastic and sources

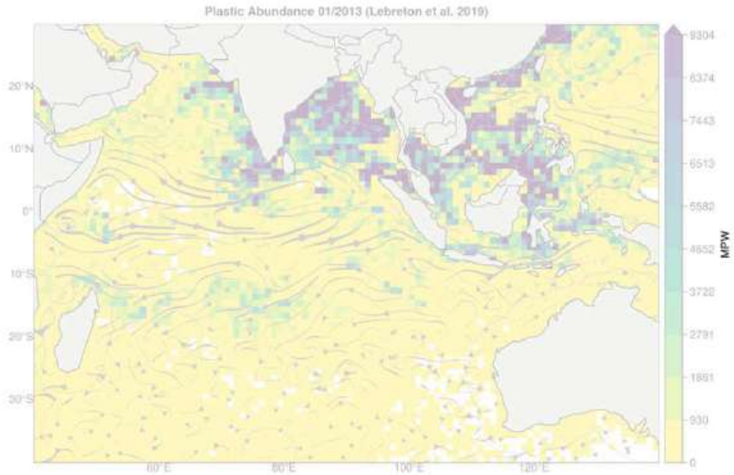
Access to MDS for visualizing current streamlines

↓

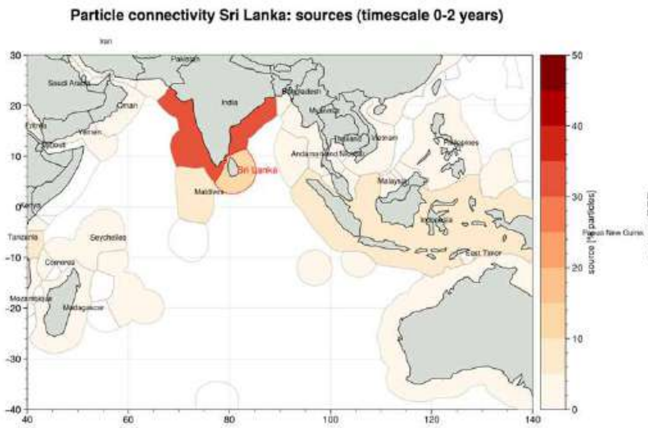
Density_FMD.py

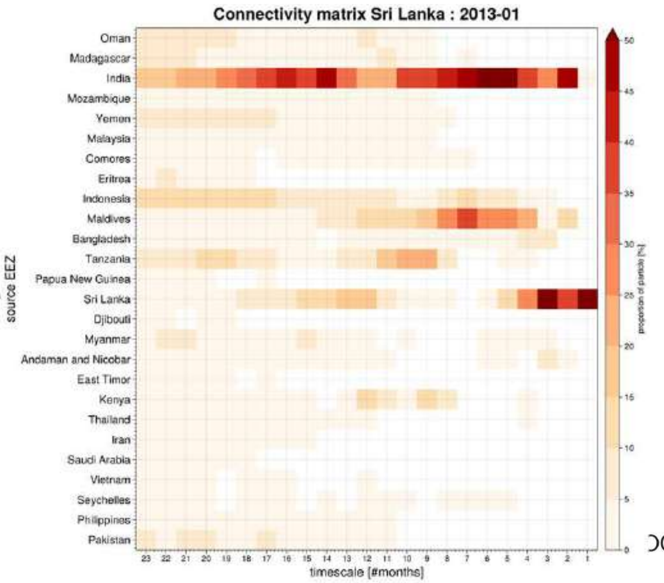
Visualize Abundance (output Netcdf, png)

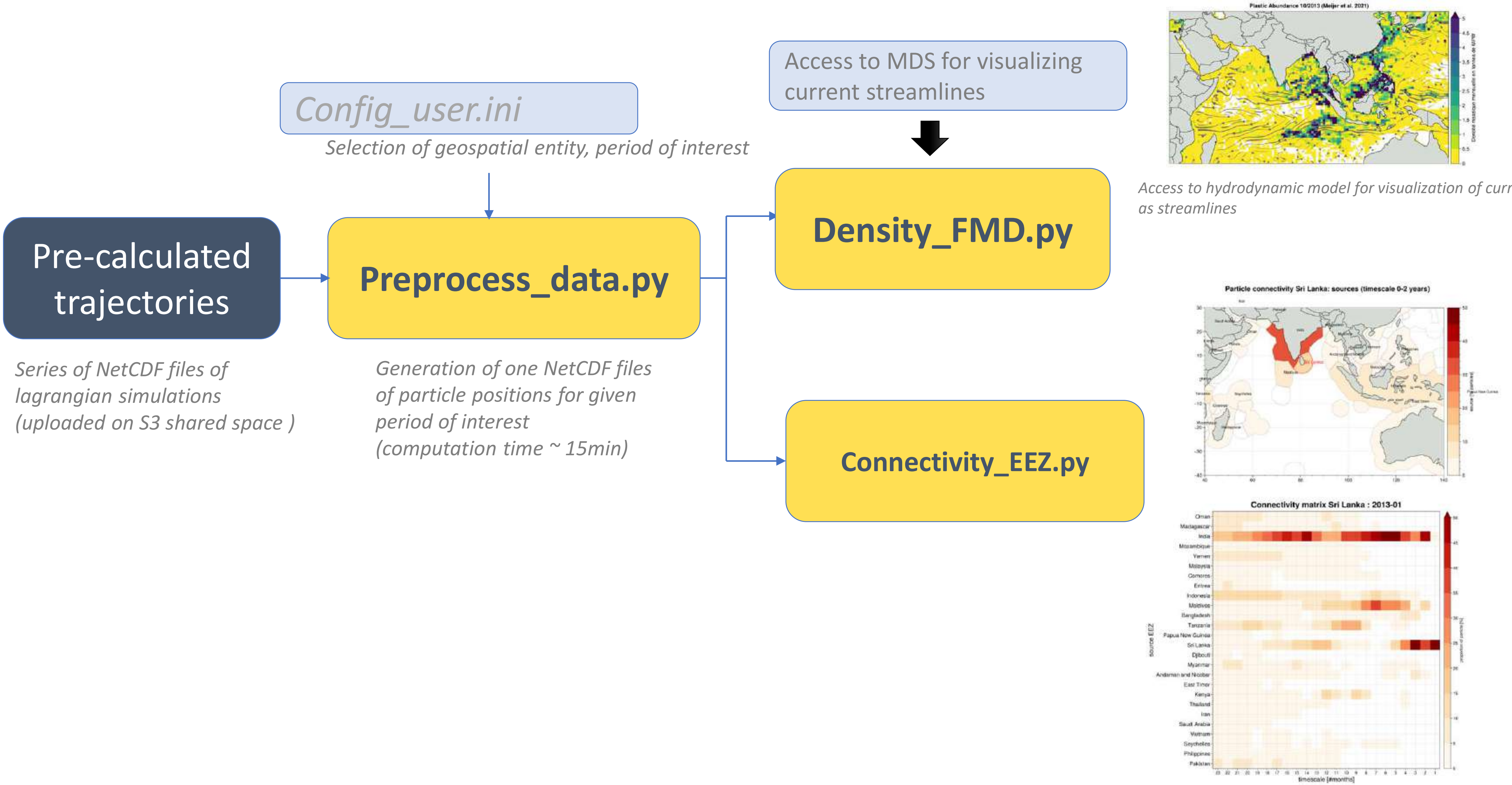




Connectivity_EEZ.py







Config_user.ini
Selection of geospatial entity, period of interest
Pre-calculated trajectories
Series of NetCDF files of lagrangian simulations (uploaded on S3 shared space)
Preprocess_data.py
Generation of one NetCDF files of particle positions for given period of interest (computation time ~ 15min)
Access to MDS for visualizing current streamlines
Density_FMD.py
Connectivity_EEZ.py
Plastic Abundance 10/2013 (Meijer et al. 2021)
Access to hydrodynamic model for visualization of curr
as streamlines
Particle connectivity Sri Lanka: sources (timescale 0-2 years)
Connectivity matrix Sri Lanka : 2013-01
Oman
Madagascar
India
Mozambique
Yemen
Malaysia
Comoros
Eritrea
Indonesia
Maldives
Bangladesh
Tanzania
Papua New Guinea
Sri Lanka
Djibouti
Myanmar
Andaman and Nicobar
East Timor
Kenya
Thailand
Iran
Saudi Arabia
Vietnam
Seychelles
Philippines
Pakistan
Source EEZ
timescale [#months]

Assess exposure and connectivity: user experience

Work year1

Config.ini

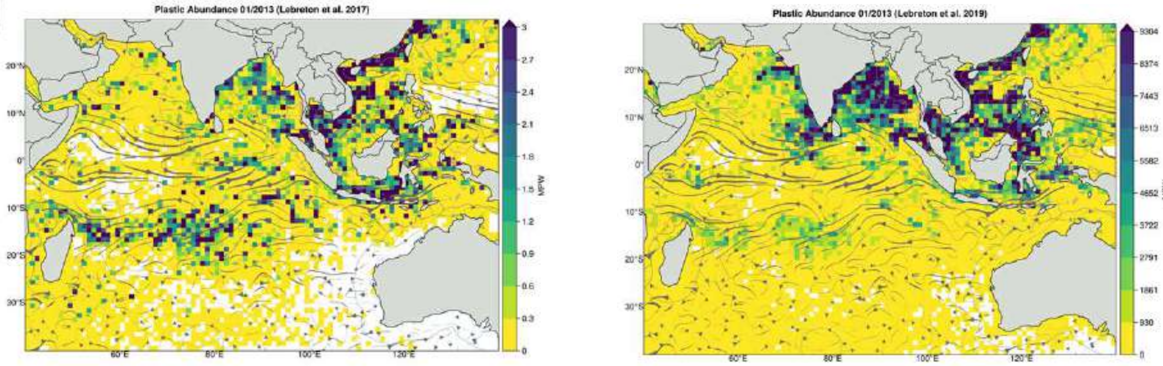
```
Launcher | Config_Madagascar_2013-1 | List_EEZ.txt
[PLASTIC_INFO]
YEAR = 2013
MONTH = 10
#choose plastic dataset: PARTICLE, RIVER, COAST, ALL
PLASTIC_INPUT = ALL
TARGET_EEZ= Madagascar
```

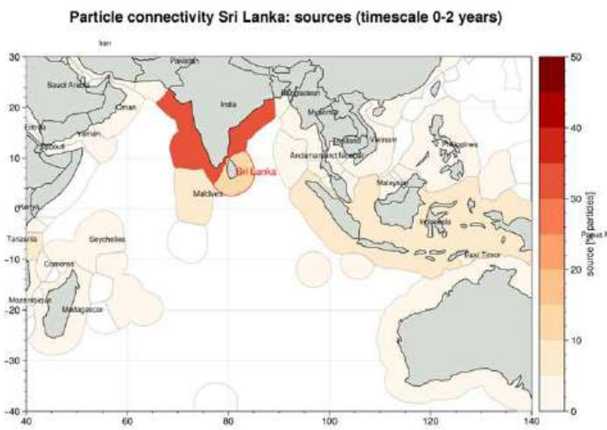
User input:

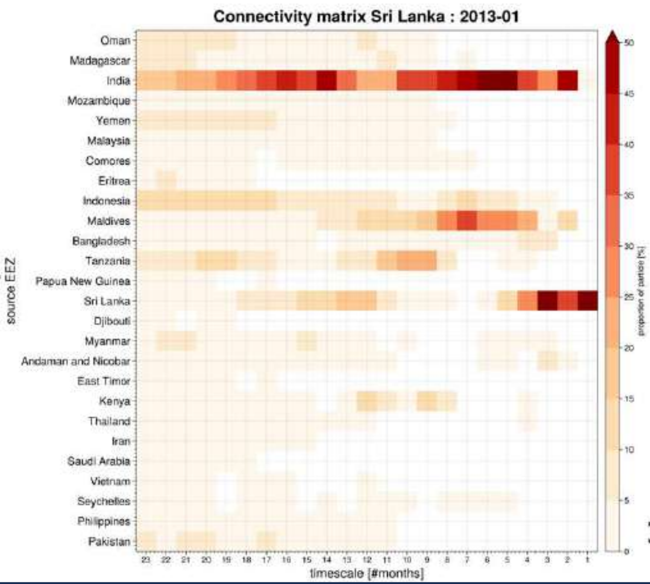
- Source of plastic: riverine, coastal, all
- Zone of interest (e.g. EEZ)
- Max. age of plastic

List_EEZ

```
Estonia
Mayotte
Overlapping claim Qatar / Saudi Arabia / Unite...
Cameroon
Finland
Bassas da India
Faeroe
Gilbert Islands
Overlapping claim: Venezuela / Colombia / Domi...
Nigeria
Pakistan
Syria
Overlapping claim: Kenya / Somalia
Philippines
Bahrain
British Virgin Islands
Cuba
Johnston Atoll
Guyana
Seychelles
Phoenix Group
Overlapping claim South China Sea
Equatorial Guinea
Vietnam
Matthew and Hunter Islands
```







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Simulate action plan

Work year2

User input:

Source of plastic: riverine, coastal, all

Zone of interest (e.g. EEZ)

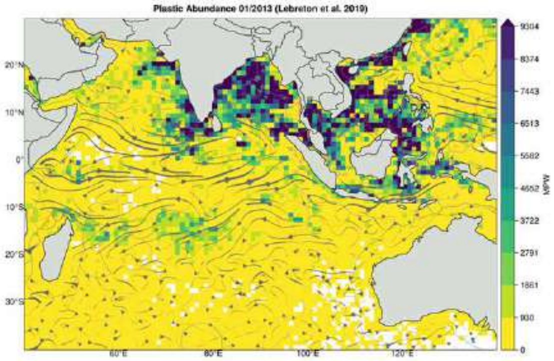
Max. age of plastic

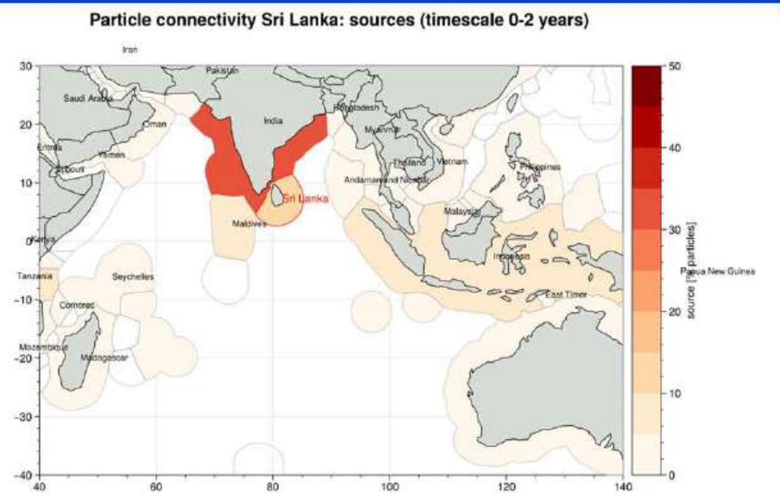
Scenario:

River cut: 20%

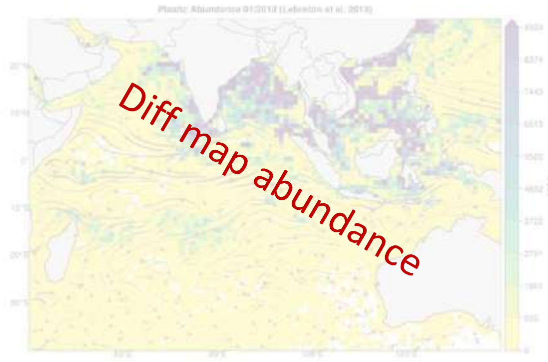
Source EEZ: India

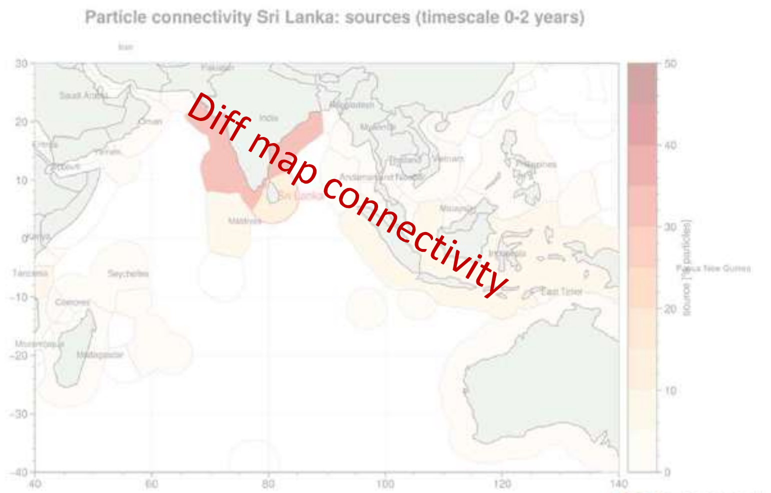
Coastal cut : 0%





Before





After

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User Session 2 - Zero Pollution I Presentation

Overview:

- Creation of application for assessing exposure
- Optimization of R&D code (computation and volumetry)
- Implementation on Edito platform (ongoing)
- Design user-relevant metrics that enable actions (codesign with regional conventions)
- Set up What if Scenario and evaluate impact

Further work:

- Enable user to upload own spatial area (e.g. new MPA), change origin (LMEs, catchment areas)
- Generate longer trajectories, long enough (~5years) to fill the gyres (accumulation zones)
- apply a plastic decay factor on the mass, so to reach total mass in the accumulation zones in agreement with observations
- Implement updates so to resolve transport as close to near real time
- Implement other types of plastic (neutrally buoyant, sinking particles)

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3 levels of interaction: **Explore**

Explore

USE THE DIGITAL TWIN OCEAN PLATFORM

A user will be able to <u>explore & visualize</u>:

- Model configuration*: streamline of ocean currents to understand impact of currents (and variablility) on exposure and visualise* plastic input data emissions
- *Assess Plastic pollution of spatial entity (currently: EEZ, future: user uploaded shapefile e.g. new MPA) and evaluate potential reductions scenarios*
  - *proportion from coastal sources*
  - *proportion from river discharges*

Contribute

ADD DATA & SERVICES TO THE DIGITAL TWIN OCEAN PLATFORM

A user will be able to contribute by:

- *Providing an update plastic emission dataset for a given region (Improve initialisation)*
- Simulating own lagrangian trajectory datasets (different ocean models, parameterisation, types of plastic)

Create

BUILD YOUR EXTERNAL THIRD-PARTY SERVICES

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USER SESSION 3

FA#1 – Marine Protected Areas for Biodiversity
Moderator: CMCC (G Coppini)

USER SESSION 3 – Biodiversity in Marine Protected Areas

1-Presentation and demonstration

- Habitat Suitability Mapping in the Wadden Sea (F Dols) (20’)

2-Discussion with users (20’)

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European Digital Twin Ocean

Focus Application 1 demonstration

Development team Deltares:
Felix Dols, Ghada El Serafy, Lőrinc Mészáros, Jelmer Veenstra, Hidde Elzinga, Mostafa Farrag, Lauriane Vilmin & Jimena Medina Rubio

Support team Mercator Ocean: Renaud Dussurget, Chloe Delpont-Ramat, John Brouillet & Mathis Bertin

17-1-2024, Deltares

Deltares

Focus Application 1 - Habitat Suitability Mapping in the Wadden Sea

Habitat species can offer food for birds (e.g. shellfish) **and shelter for fish** (e.g. seagrasses).

Healthy, clean and undisturbed **habitats are essential for local and global ecosystems** and can be used as **indicator for biodiversity** *(Kirsten et al., 2023).*

Understanding the **response of habitat species to physical conditions** can be used to **map the spatial distribution of suitability**.

Which support planning of protective & restorative measures.

Photograph by Shane Gross (Canada): Juvenile "Atlantic cod" hiding in eelgrass (Zostera marina).

Photograph by Ian Kirke (UK): An "Oystercatcher" with a cockle.

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Geographical application – **Dutch Wadden Sea**

Marine Protected Area & World Heritage

Intertidal mud- and sandflats offer **habitat** for higher trophic animals, like threatened ground-nesting birds.

Source: Stichting Visit Wadden

Source CWSS: Area of the World Heritage site.
In red highlighted the Dutch Wadden Sea.

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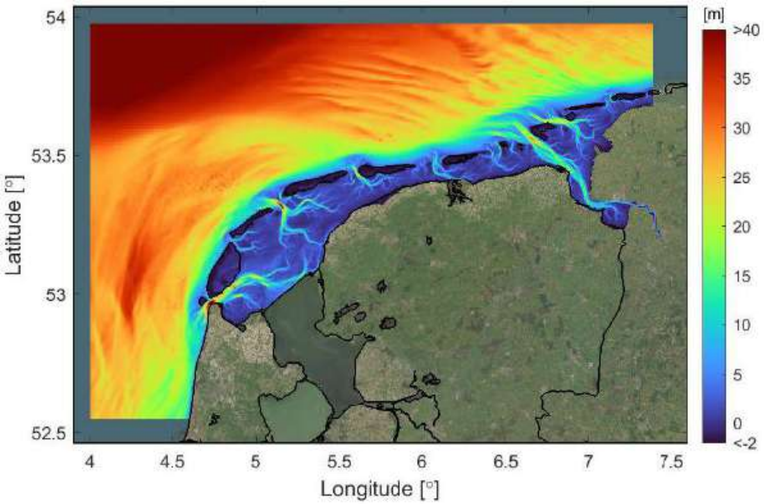
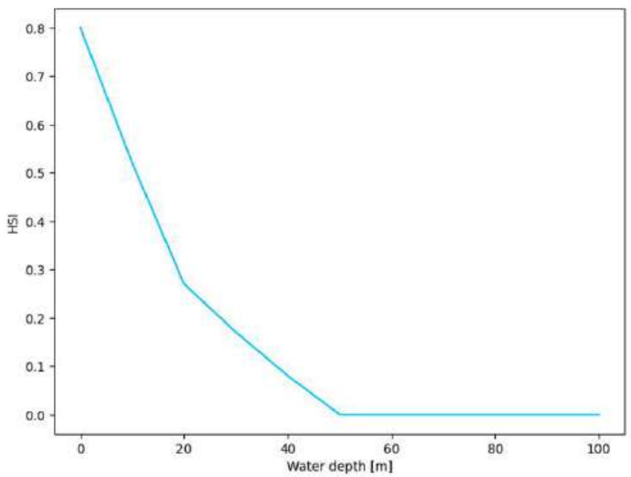
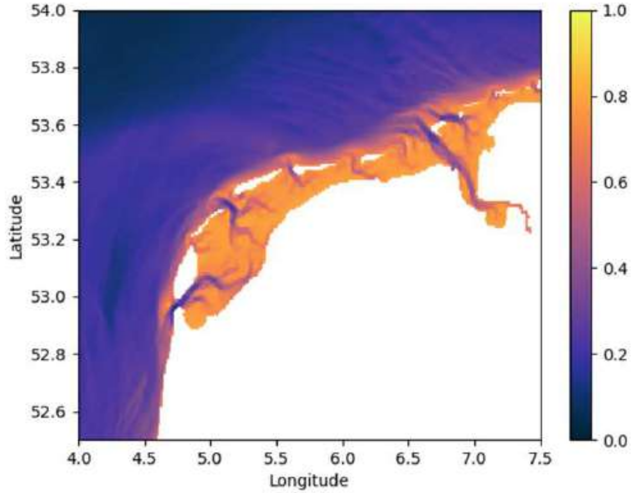
How to compute Habitat Suitability Maps?

We combine:
- **Spatial environmental data**
- **Ecological knowledge rules** (habitat response to physical parameters)
- **Ecological Impact assessment tool**

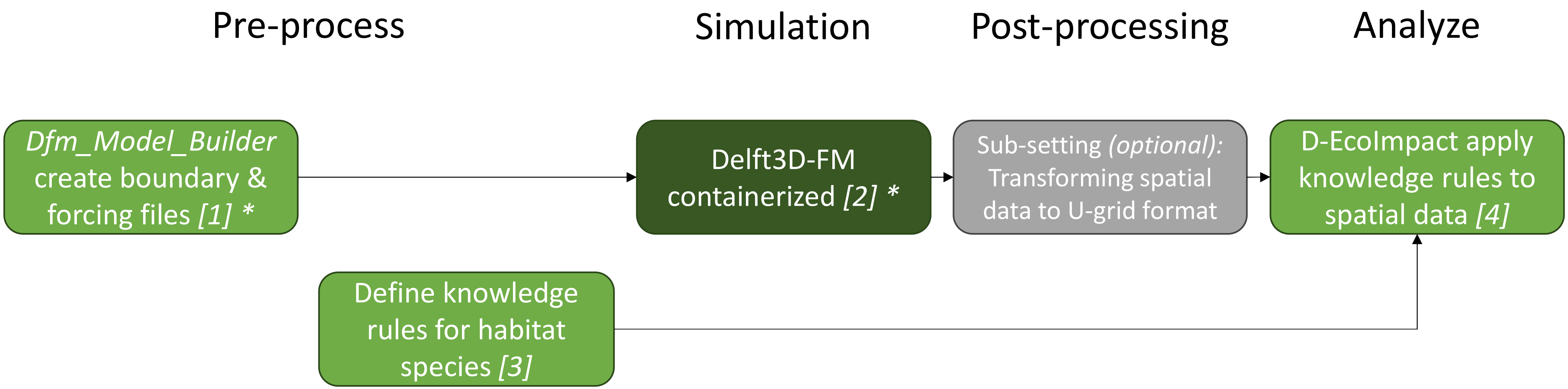
e.g. Year averaged water depth (m) **+** **HSI of Pacific Oyster to water depth** **=** **Habitat Suitability Map of 1 parameter**







End-to-end technical workflow for Habitat Suitability Mapping



*Only applicable for on-demand modelling

Component published on EDITO platform in the service catalogue

Component deployed on EDITO platform

Component temporarily necessary for external simulation software

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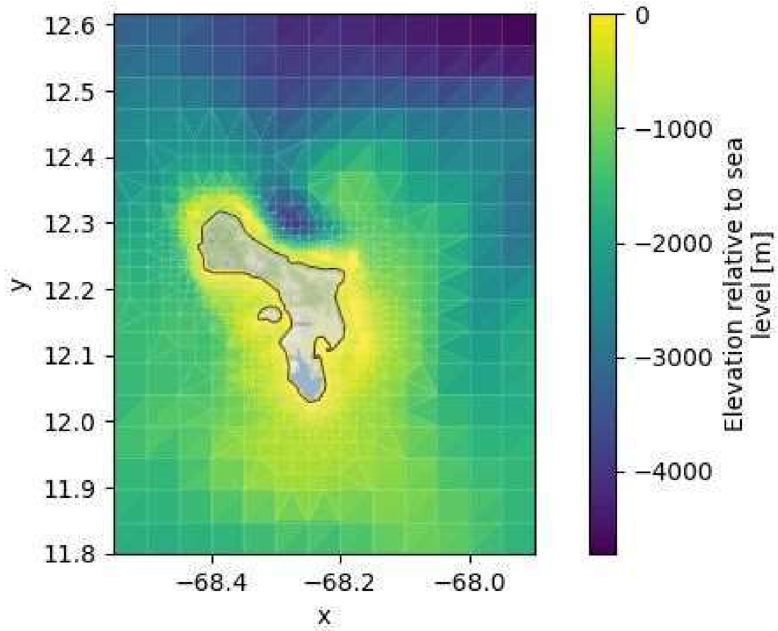
[1] Pre-process with *dfm_Model_Builder*

- User defined spatiotemporal domain and –resolution.
- Automatic download of atmospheric- and marine data
- Automatic model generation (*grid, boundaries, config files, etc.)*

Snapshot of Digital Twin Ocean Viewer
https://digitaltwinocean.edito.eu/map



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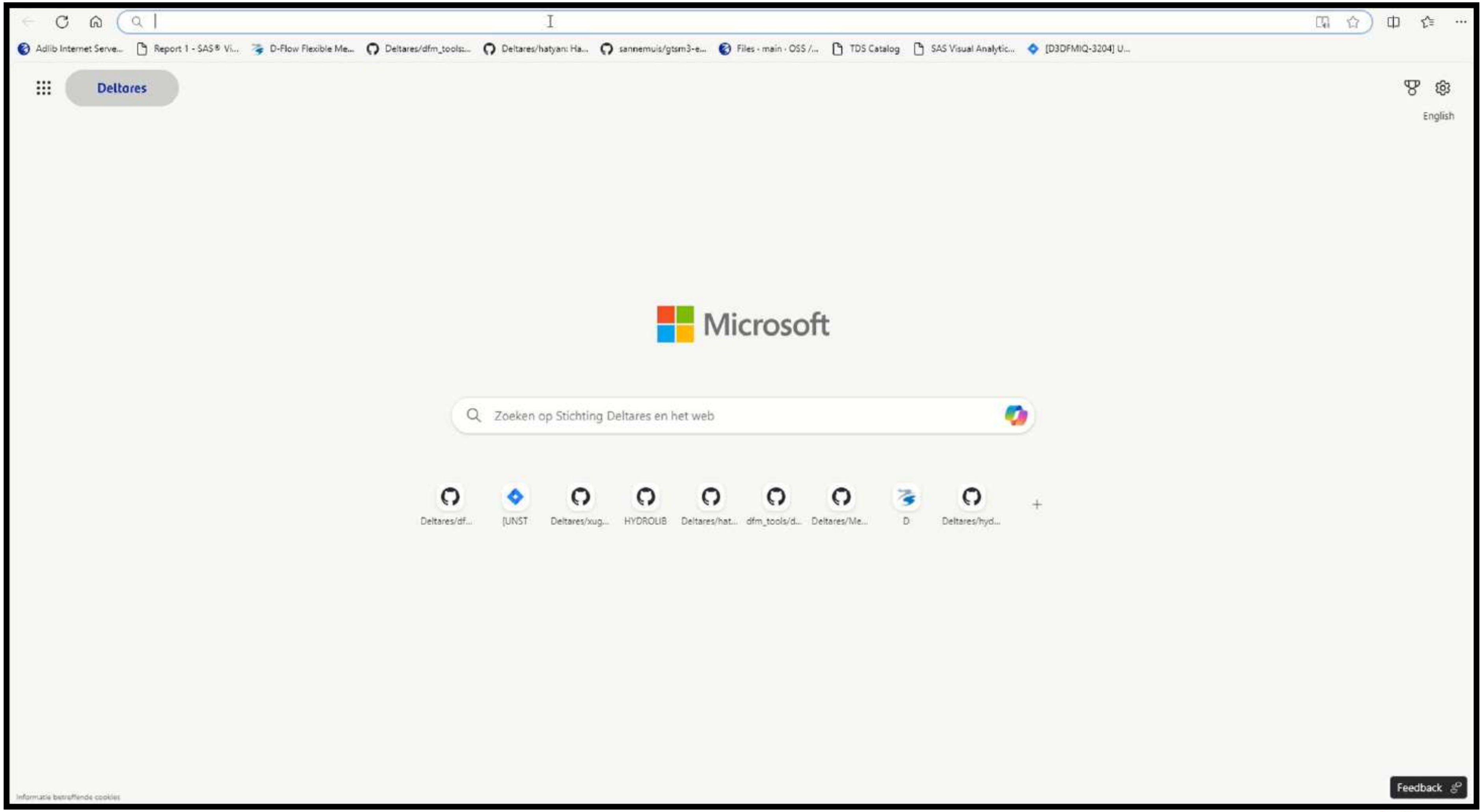
[1] Pre-process with *dfm_Model_Builder on EDITO*



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[2] Simulate with Hydrodynamic-, Biogeochemical- & Wave models

Data from previous simulations is made FAIR (Findable, Accessible, Interoperable, Reusable)
So only run models when required parameters are not available for the scenario of interest.

Delft3D-FM: Hydrodynamics & Water Quality simulates e.g.: temperature, salinity, inundation time, SPM, flow velocity, water depth, concentrations of Dissolved Oxygen & Chlorophyll-a.

2D SWAN: Waves simulates e.g. orbital velocity & wave height

Continental Shelf Model, to 800m res.

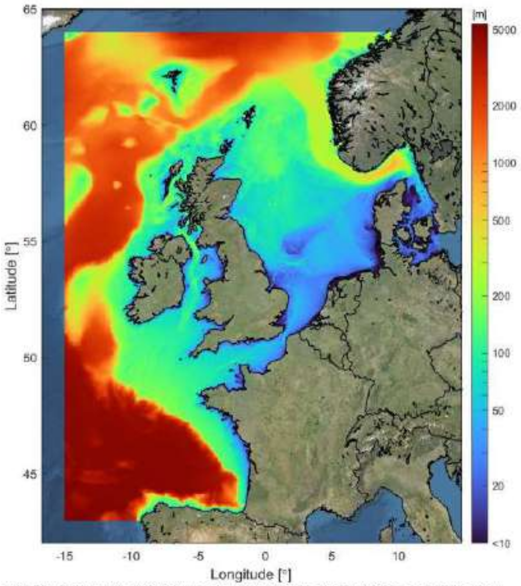


Figure 2.5 Overview of the DCSM-FM model bathymetry (depths relative to NAP, on a logarithmic scale).

Dutch Wadden Sea Model, to 100m res.

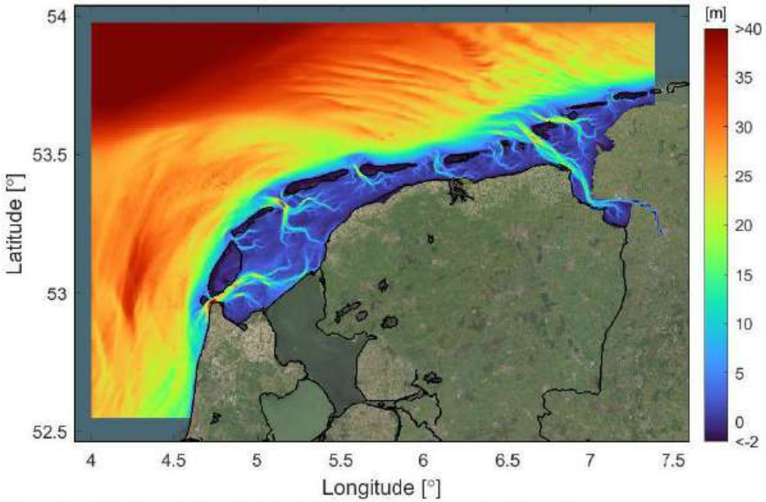
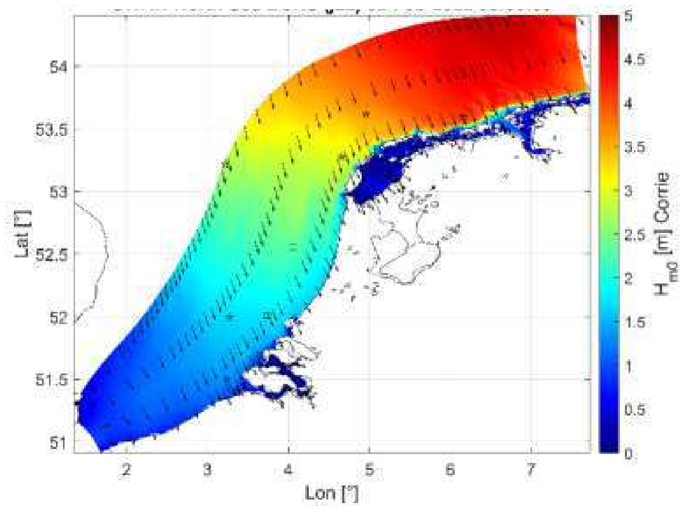


Figure 2.2 Overview of the DWSM model bathymetry (entire model domain).

Dutch Shoreline Model



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[2] Simulate with Delft3D-FM on EDITO

containerized

run in the cloud or on high performance computing, no installation required

Delft3D-FM:

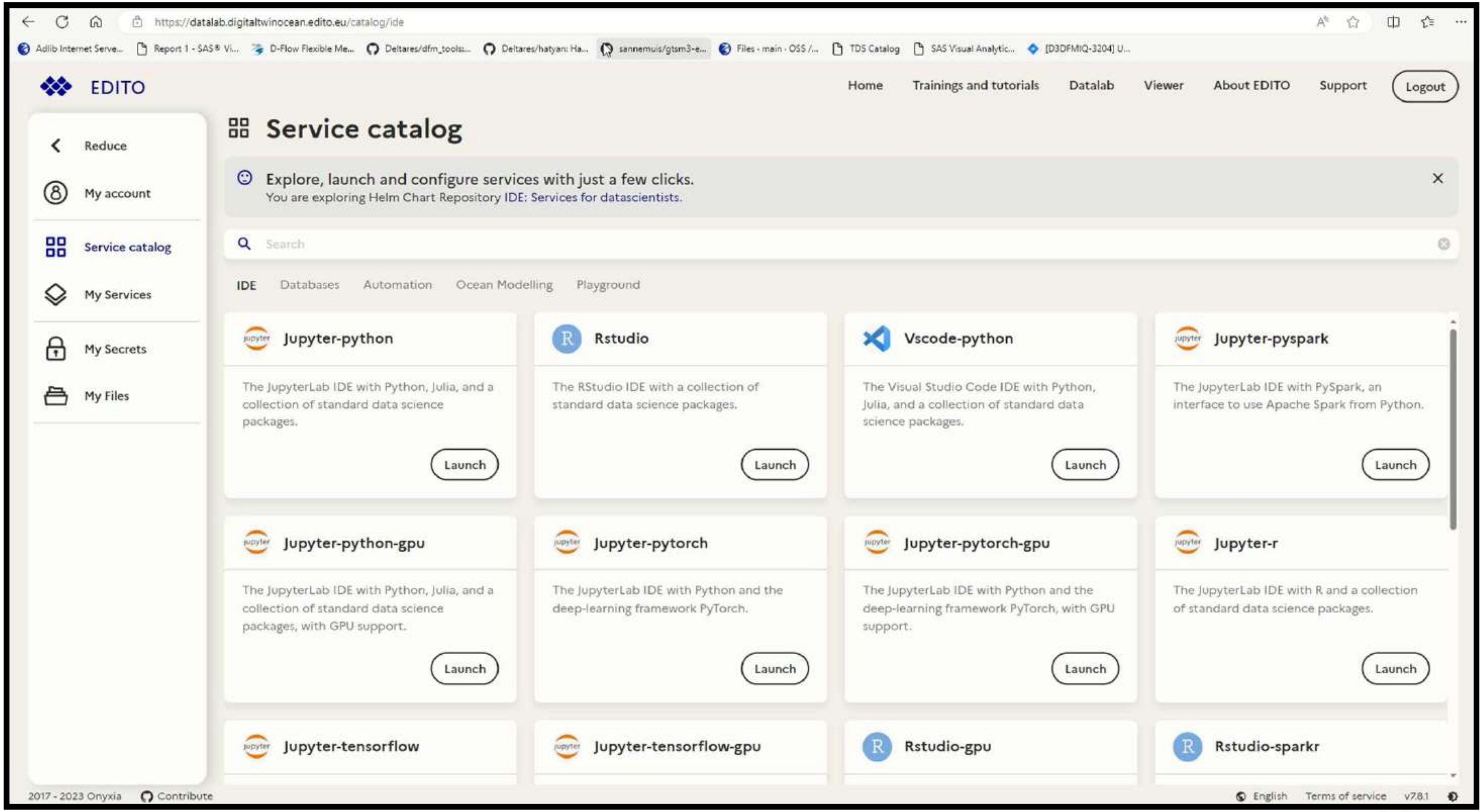
Software suite for simulating 1D/2D/3D flow, sediment transport, morphology, waves, water quality and ecology

docker

apptainer.org

EDITO platform

[2] Simulate with Delft3D-FM on EDITO



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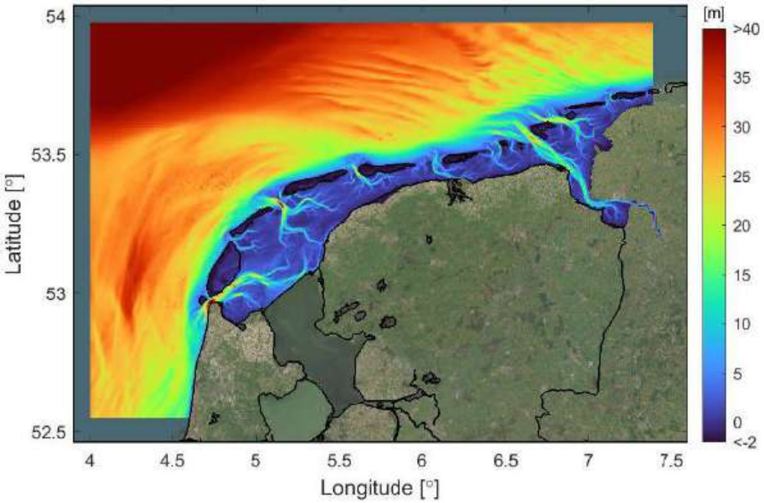
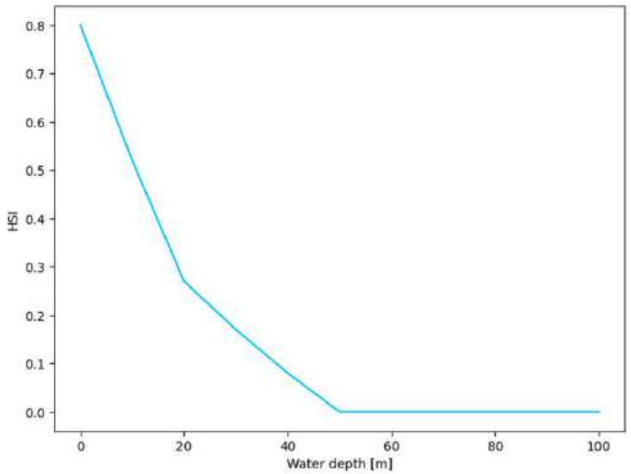
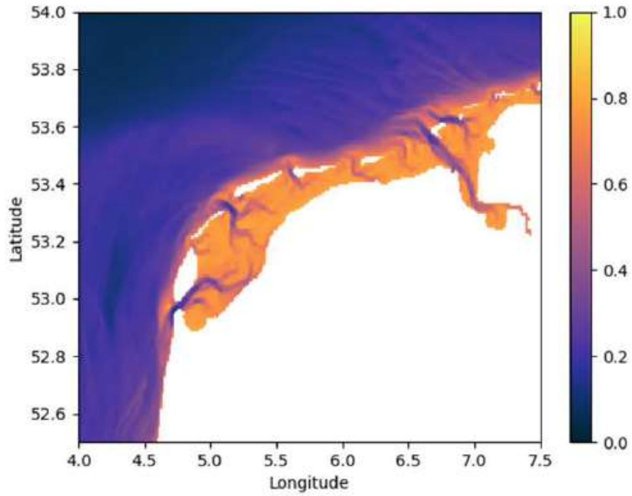
[3] Use or create ecological knowledge rules

e.g. Year averaged water depth (m) + HSI of Pacific Oyster to water depth = Habitat Suitability Map of 1 parameter







Create a configuration file (.yaml), **using knowledge rules from [HABITAT repository] or create new rules**

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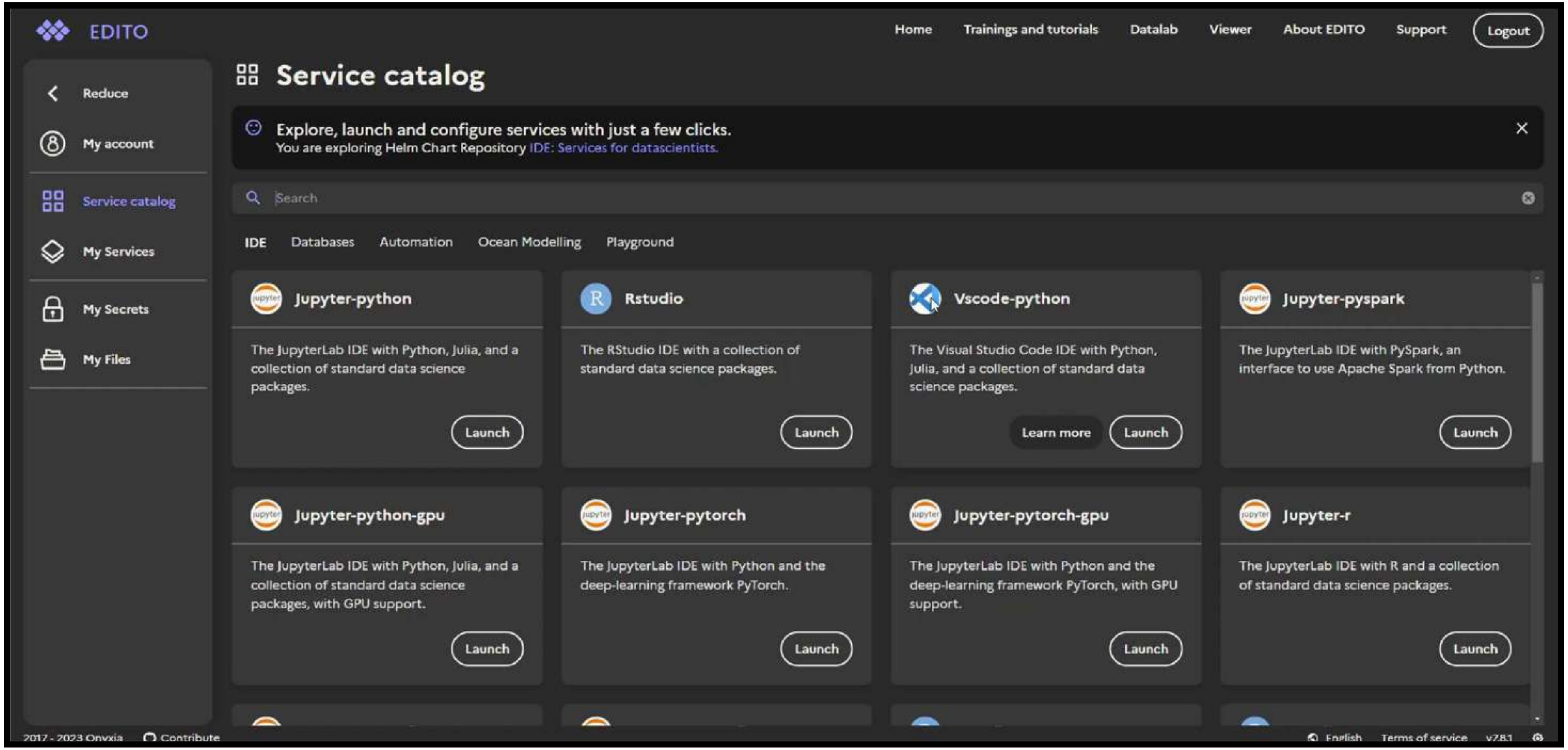
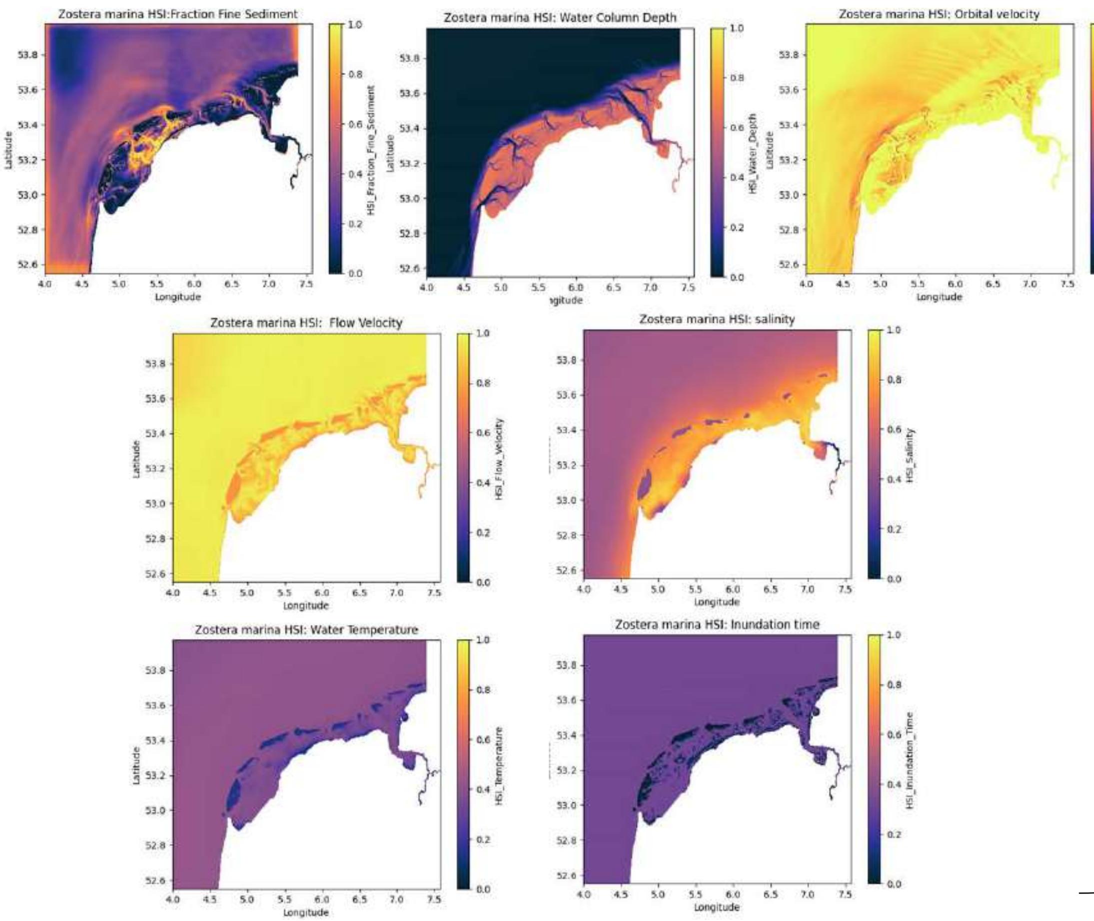
[3] Create knowledge rules on EDITO

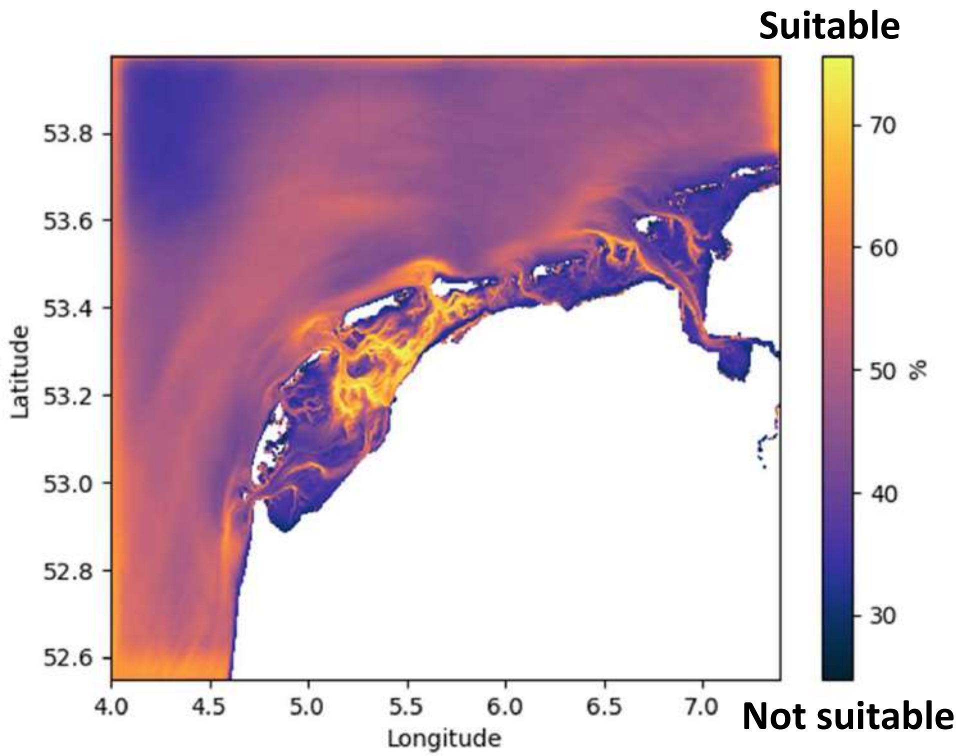


[4] Produce habitat suitability maps with *D-EcoImpact*

- **We aim to produce maps like these**



Weighted Habitat Suitability of Zostera Marina



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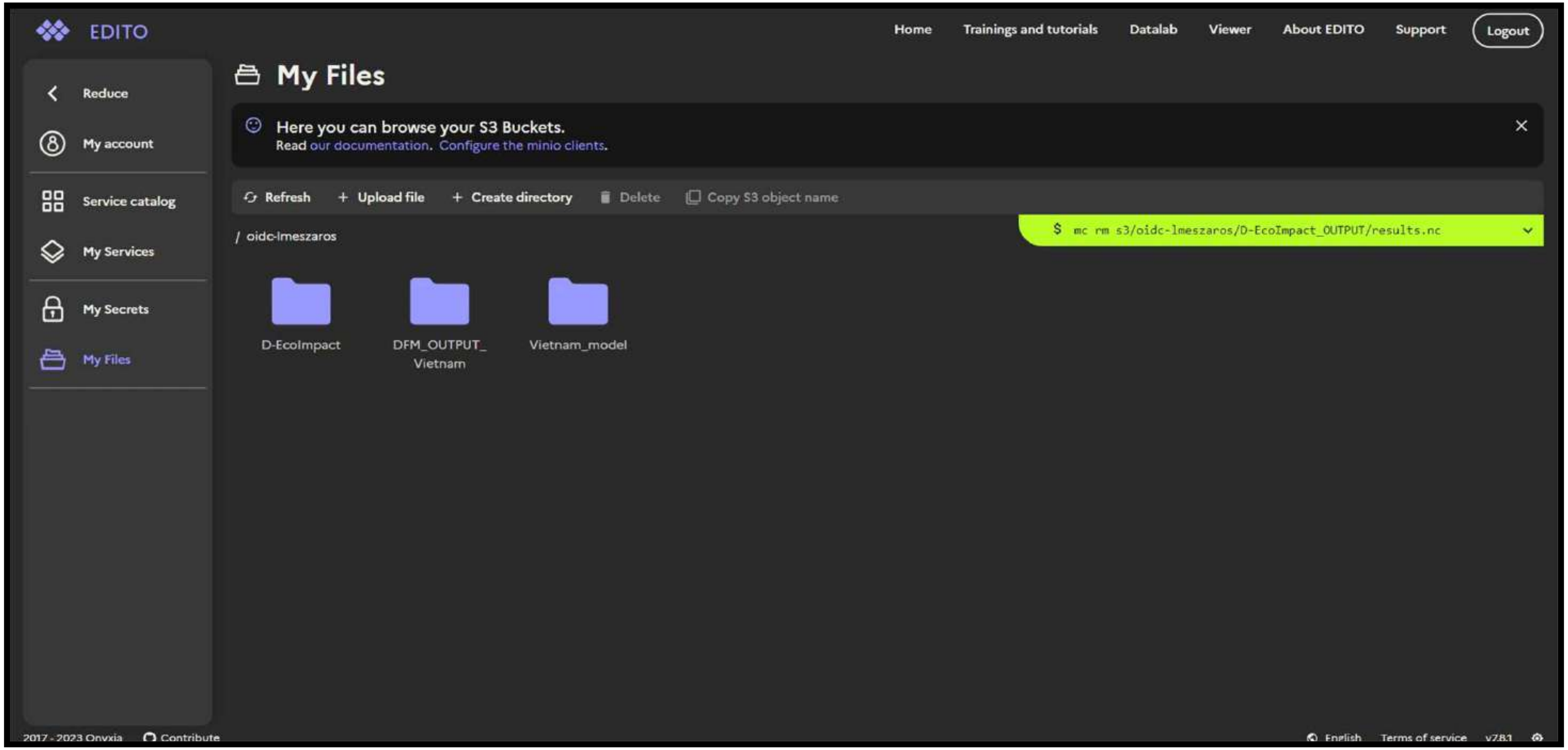
[4] Run *D-EcoImpact* on EDITO platform



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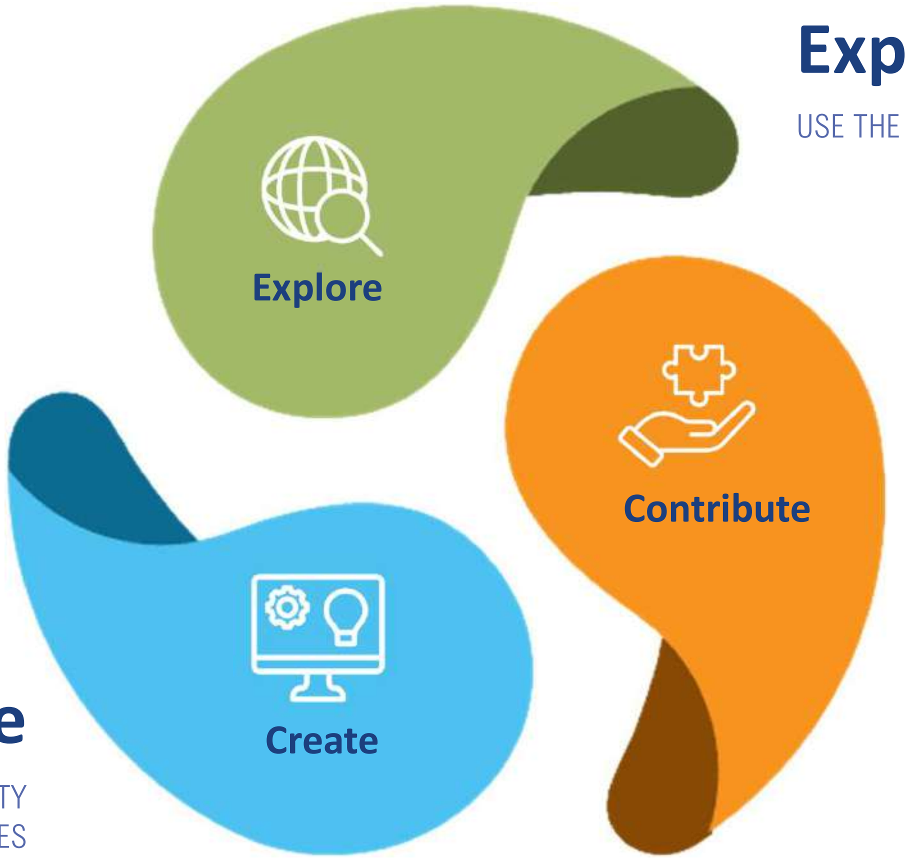
3 levels of interaction



Explore

USE THE DIGITAL TWTN OCEAN PLATFORM

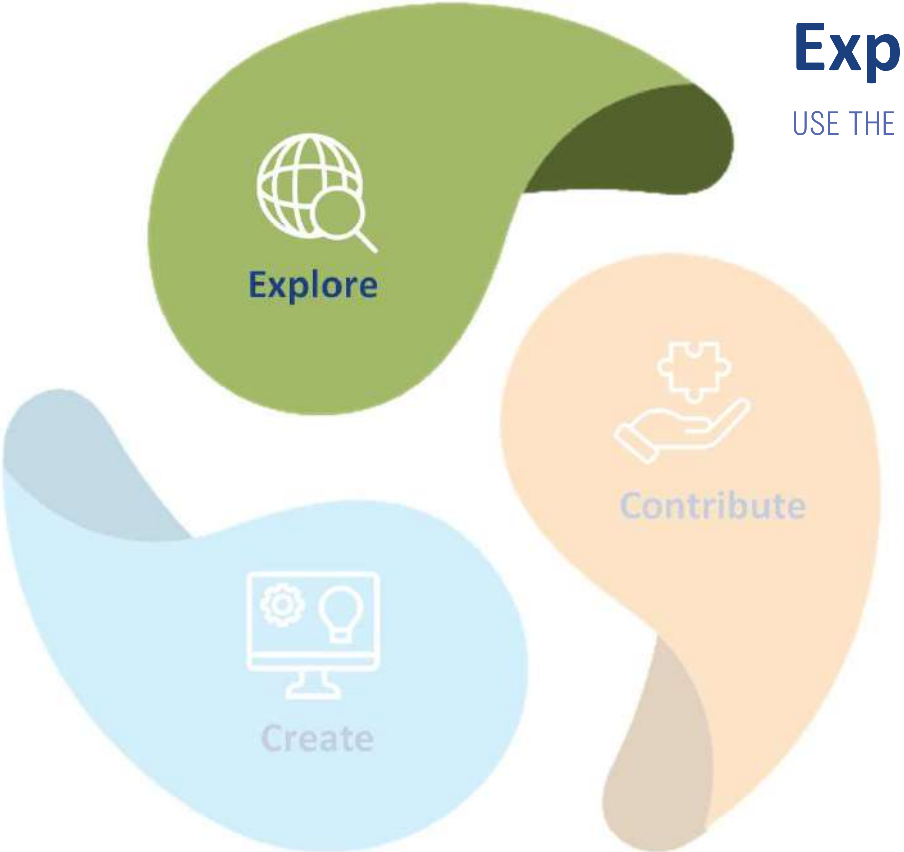
Contribute

ADD DATA & SERVICES TO THE DIGITAL TWIN OCEAN PLATFORM

Create

BUILD YOUR EXTERNAL THIRD-PARTY SERVICES

3 levels of interaction: **Explore**



Explore

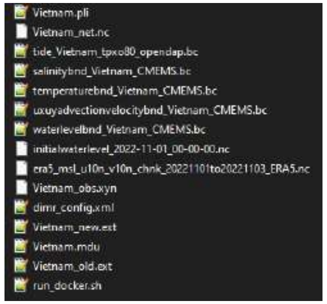
USE THE DIGITAL TWTN OCEAN PLATFORM

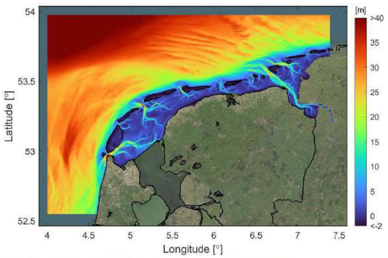
EDITOModelLab

3 levels of interaction: **Explore**

A user will be able to **explore & visualize** data:

- **Model configurations** *[1]*
- **Spatial environmental data** *[2]*
- **Repository of knowledge rules** *[3]*
- **Habitat Suitability maps** *[4]*





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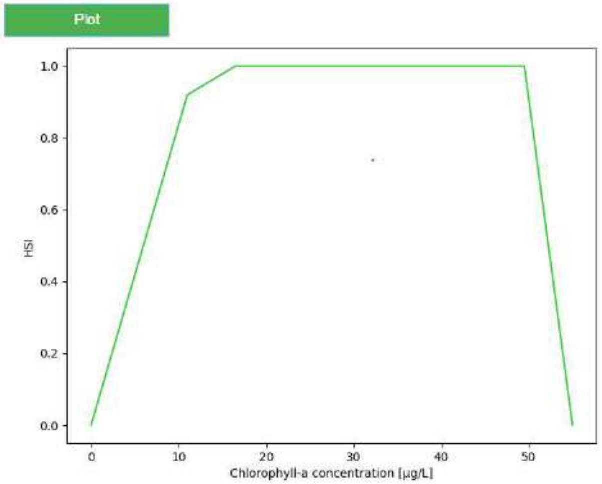

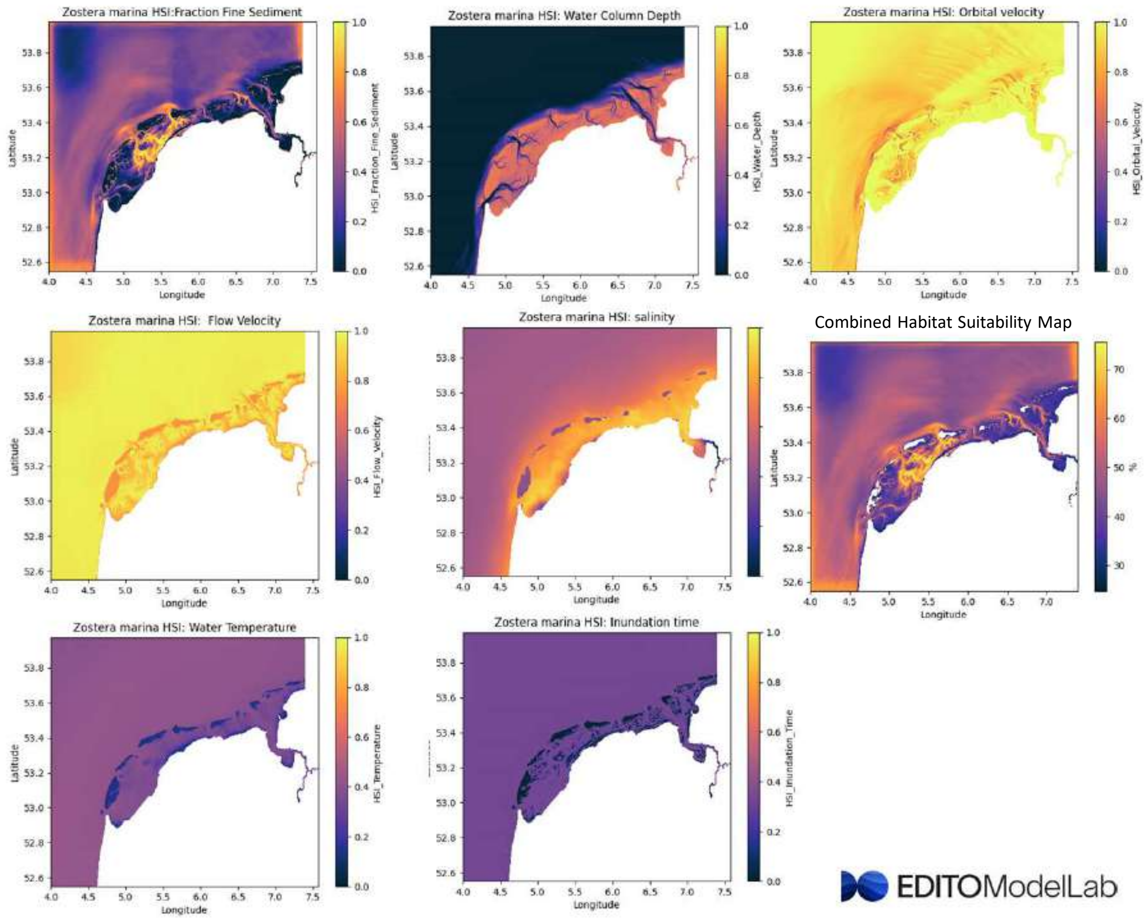

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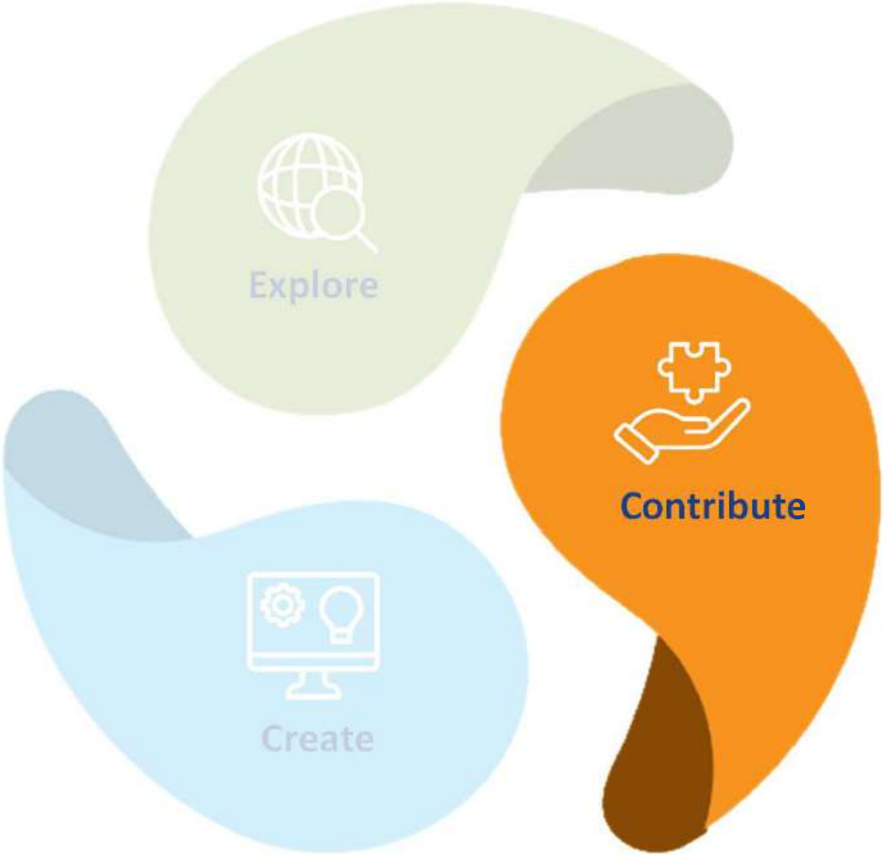
3 levels of interaction: **Contribute**



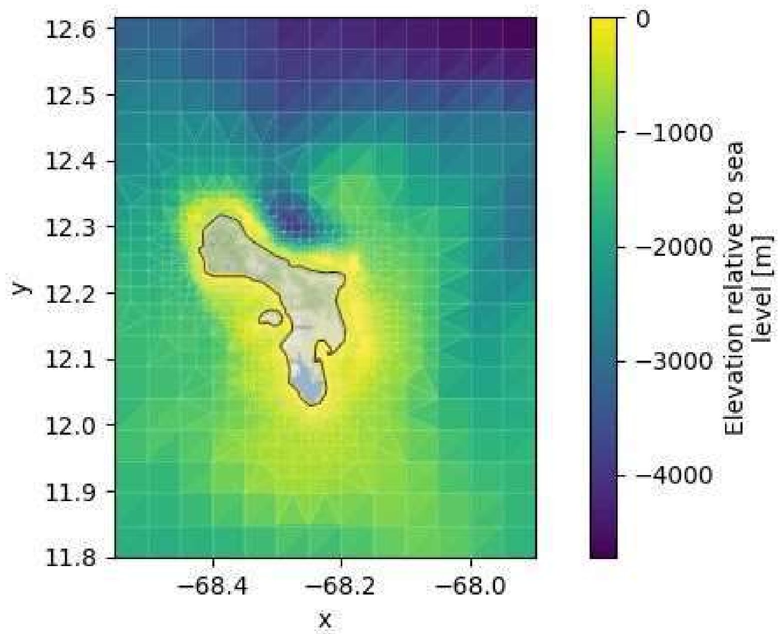
Contribute

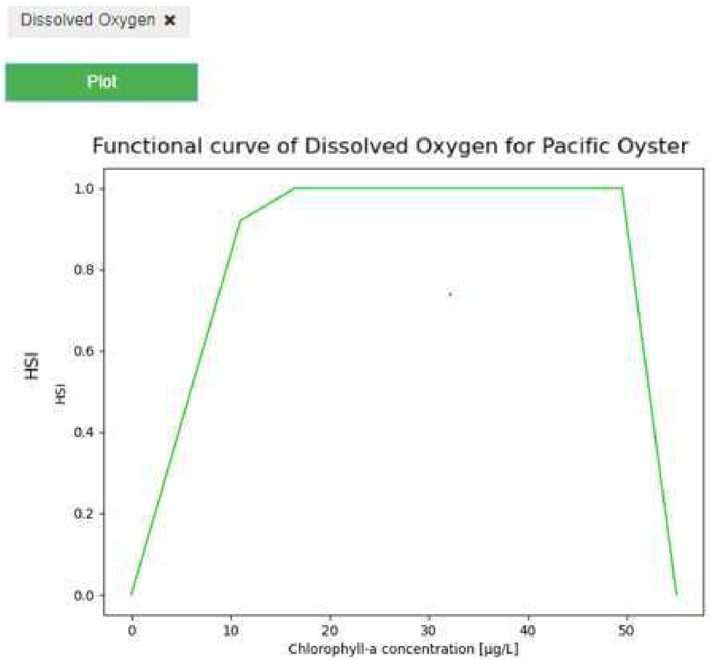
ADD DATA & SERVICES TO THE DIGITAL TWIN OCEAN PLATFORM

3 levels of interaction: **Contribute**

A user will be able to **contribute** by:

- **Relocation: <u>create a new model</u> configuration from scratch** *[1]*
- **Producing spatial environmental data: run models <u>on-demand</u>** *[2]*
- **Ecological knowledge rules: <u>creating response curves</u>** *[3]*
- **Habitat suitability data: <u>run D-EcoImpact for other species</u>** *[4]*





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3 levels of interaction: **Create**

Create

BUILD YOUR EXTERNAL THIRD-PARTY SERVICES

3 levels of interaction: **Create**

Intermediate users *will be** able to execute this workflow with (their own) **third-party models and data** and are enabled to **use the components to create services for end-users**.

**To be developed during the EDITO Model Lab project:*

User discussion

What did you like?
Where to improve?
How to make it more applicable for you?
Are you interested in shaping the evolution?

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Grazzi
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grazie
Paldies
Danke
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thank
dank je
Благодаря ти
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tak skal du have
σας ευχαριστώ
Kiitos
Merci
köszönöm
go raibh maith agat