The Story Behind the New Lagrangian Model

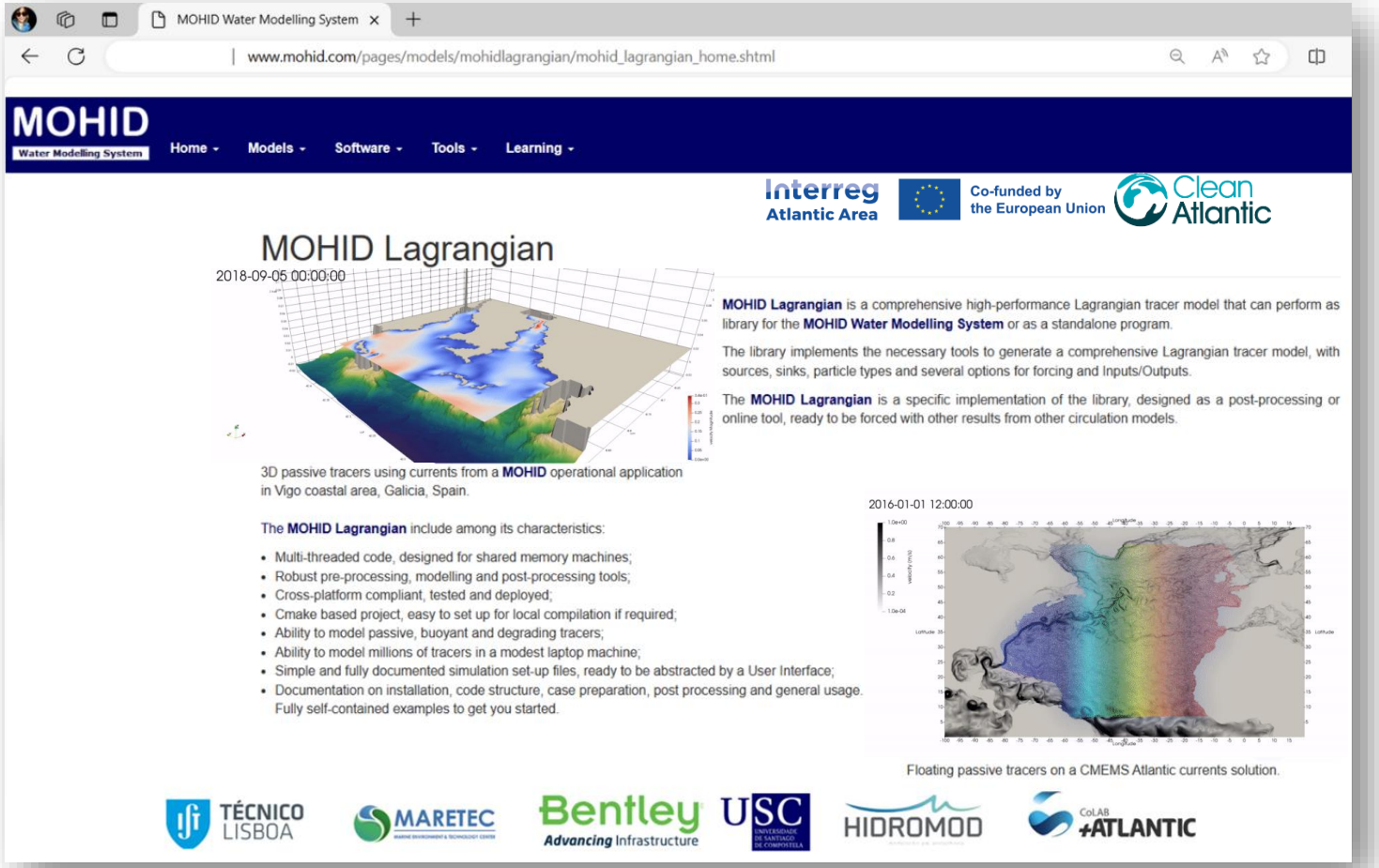
Set-up and achievements from the Lagrangian Model working group

Hilda de Pablo, Pedro Montero, Sara Cloux

MOHID

June 25, Lisbon


R(t)
v(t)
path1
ρ(t)
r(t)
T(t)
path2


MOHID Water Modelling System
www.mohid.com/pages/models/mohidlagrangian/mohid_lagrangian_home.shtml
MOHID
Water Modelling System
Home
Models
Software
Tools
Learning
Co-funded by the European Union
MOHID Lagrangian
2018-09-05 00:00:00
MOHID Lagrangian is a comprehensive high-performance Lagrangian tracer model that can perform as library for the MOHID Water Modelling System or as a standalone program.
The library implements the necessary tools to generate a comprehensive Lagrangian tracer model, with sources, sinks, particle types and several options for forcing and Inputs/Outputs.
The MOHID Lagrangian is a specific implementation of the library, designed as a post-processing or online tool, ready to be forced with other results from other circulation models.
3D passive tracers using currents from a MOHID operational application in Vigo coastal area, Galicia, Spain.
The MOHID Lagrangian include among its characteristics:
Multi-threaded code, designed for shared memory machines;
Robust pre-processing, modelling and post-processing tools;
Cross-platform compliant, tested and deployed;
Cmake based project, easy to set up for local compilation if required;
Ability to model passive, buoyant and degrading tracers;
Ability to model millions of tracers in a modest laptop machine;
Simple and fully documented simulation set-up files, ready to be abstracted by a User Interface;
Documentation on installation, code structure, case preparation, post processing and general usage. Fully self-contained examples to get you started.
2016-01-01 12:00:00
Floating passive tracers on a CMEMS Atlantic currents solution.
TÉCNICO LISBOA
MARETEC
Bentley Advancing Infrastructure
USC
HIDROMOD
CoLAB +ATLANTIC

implementation domains

Global Domain

- CMEMS ocean currents
- 2D and 3D
- 7 years simulations
- Simulations European rivers
- Hotpots

Sources

Land-based

North Atlantic Gyre

Clean Atlantic

implementation domains

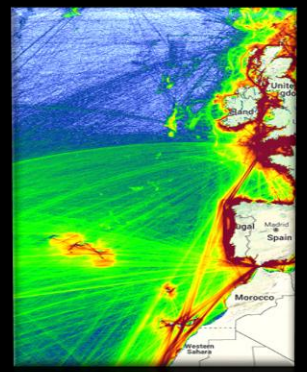
Regional Domains

Inter-boundary pollution
Regional currents
Regional wind

Sources

Land-based

Ocean-based



Clean Atlantic

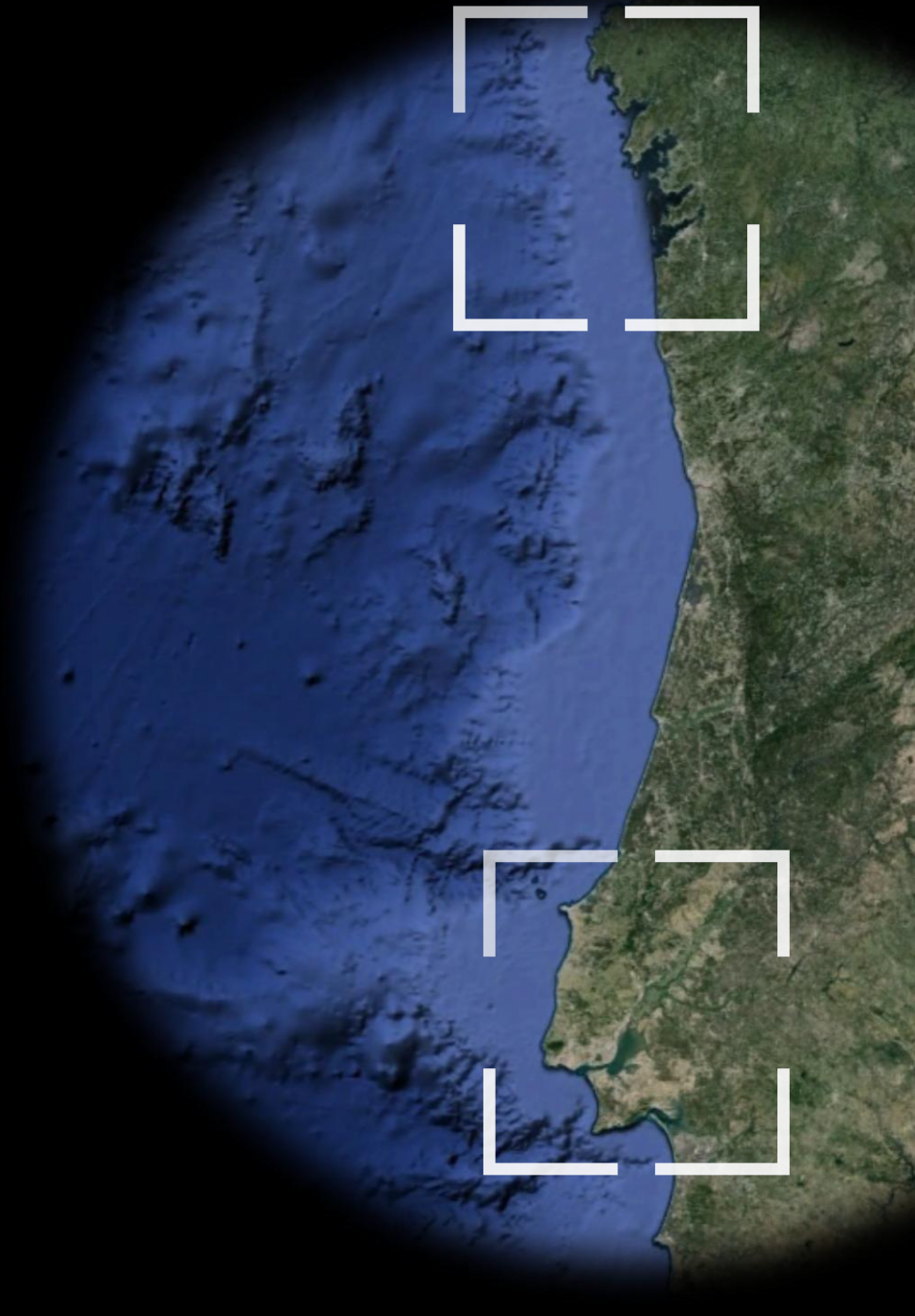
implementation domains

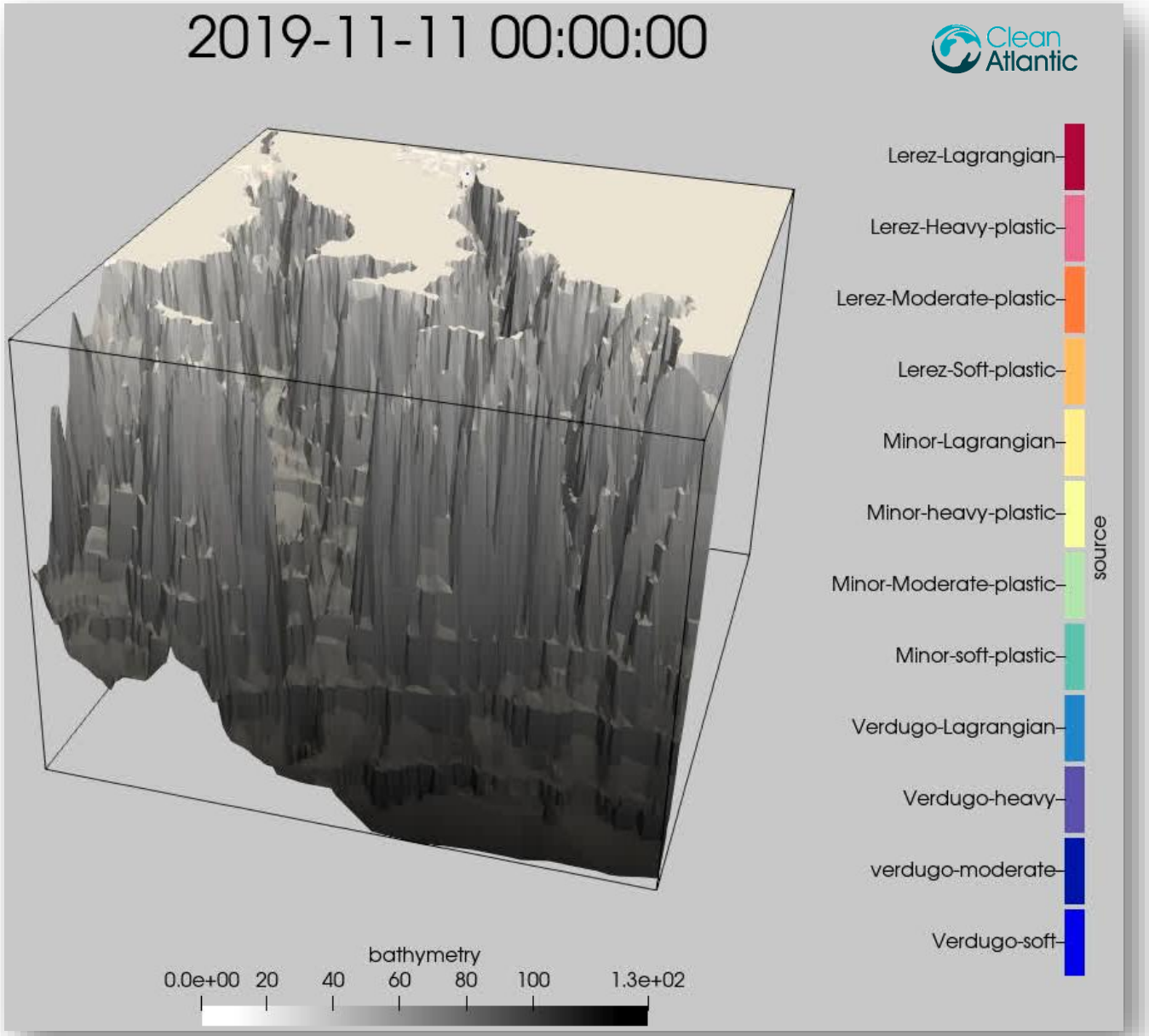
Local Domains

greater spatial and temporal resolution

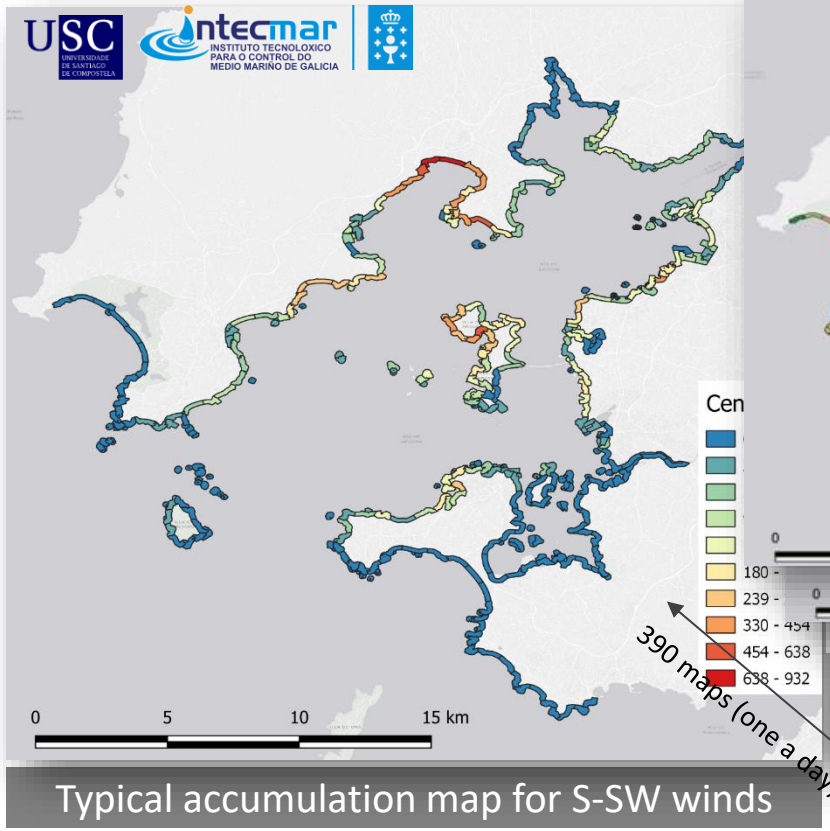
- **Bathymetry**
- **Currents**
- **Wind**

Local sources

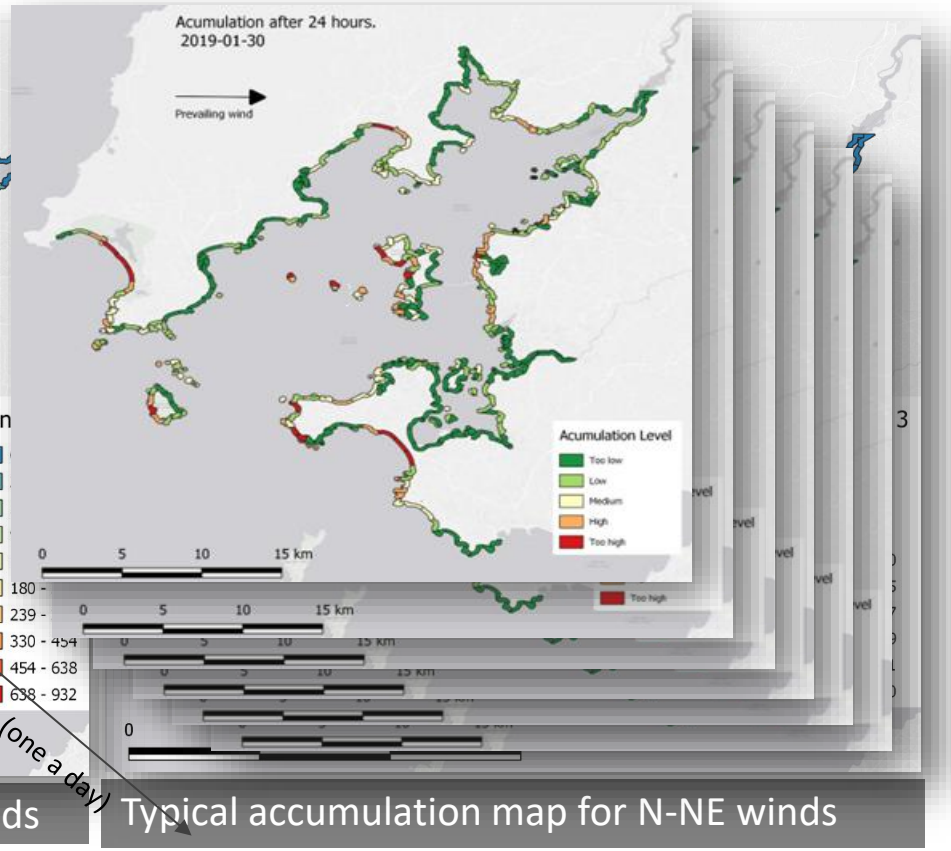



2019-11-11 00:00:00
Clean Atlantic
Lerez-Lagrangian
Lerez-Heavy-plastic
Lerez-Moderate-plastic
Lerez-Soft-plastic
Minor-Lagrangian
Minor-heavy-plastic
Minor-Moderate-plastic
Minor-soft-plastic
Verdugo-Lagrangian
Verdugo-heavy
verdugo-moderate
Verdugo-soft
source
bathymetry
0.0e+00 20 40 60 80 100 1.3e+02

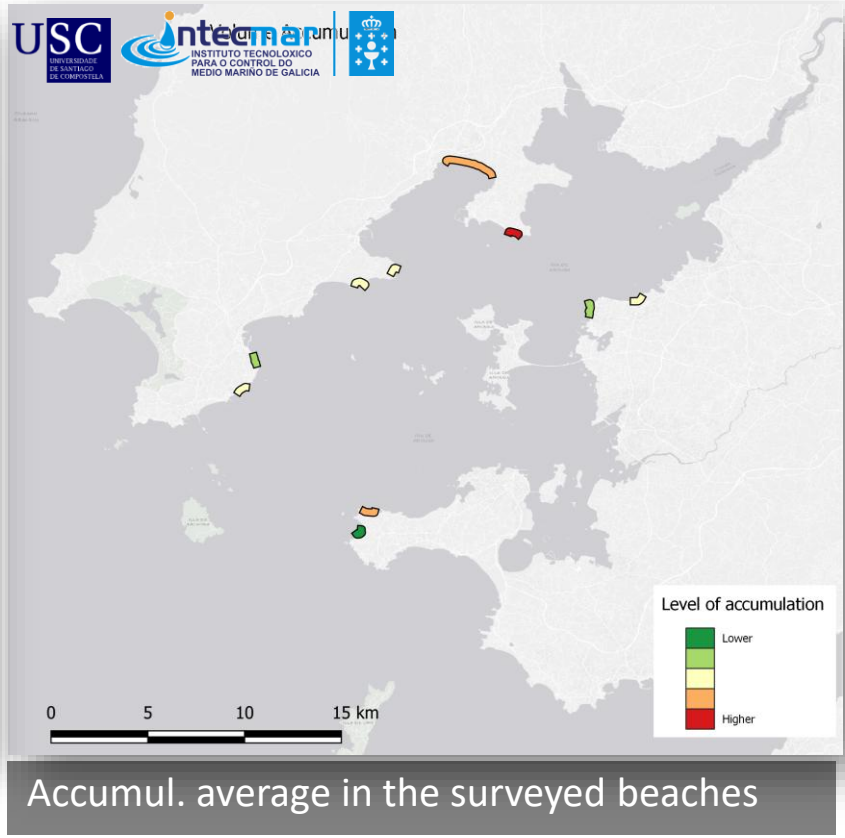
Model validation – local domain



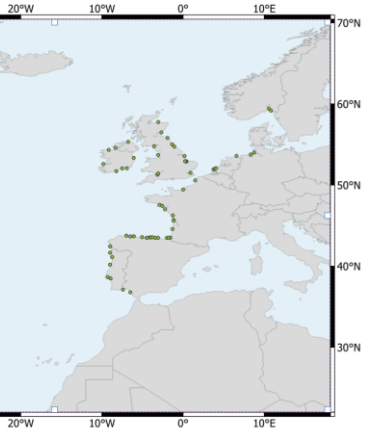
Typical accumulation map for S-SW winds



Typical accumulation map for N-NE winds



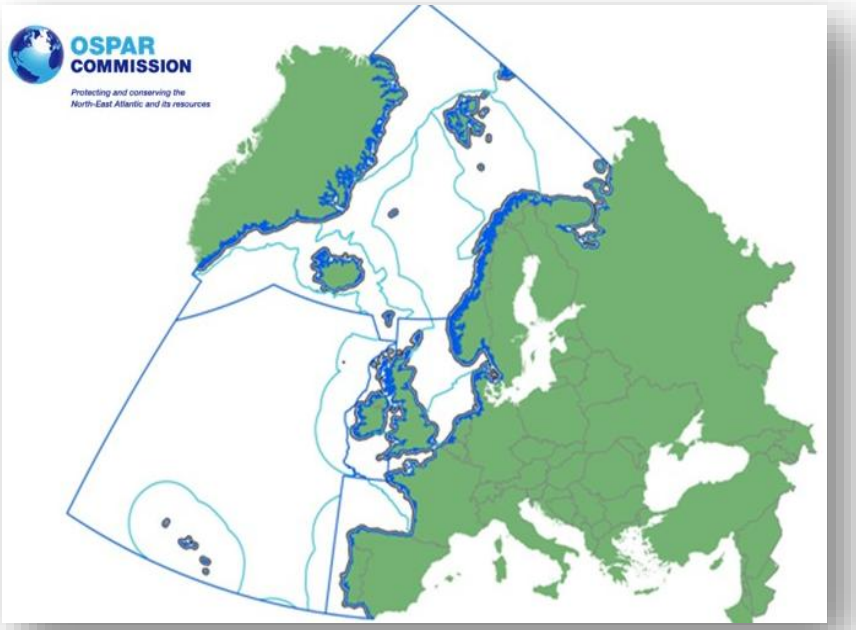
Accumul. average in the surveyed beaches

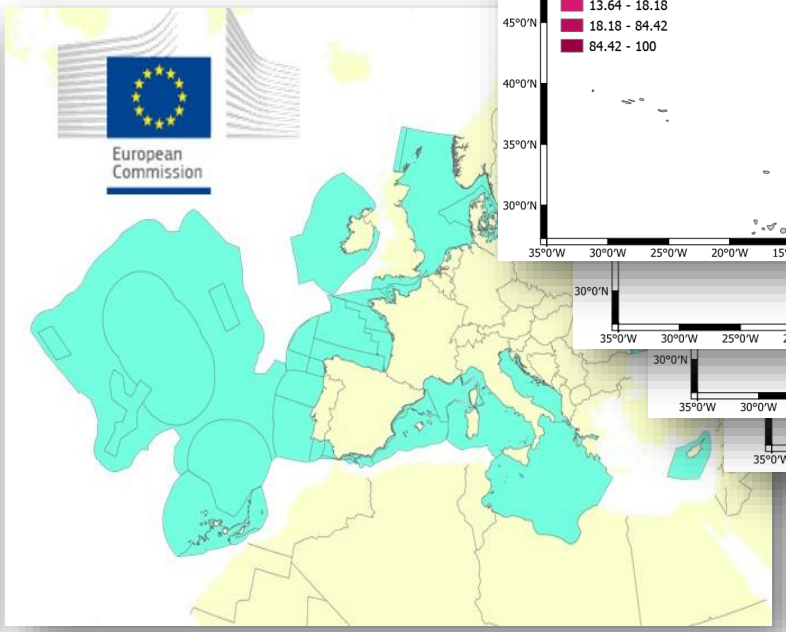


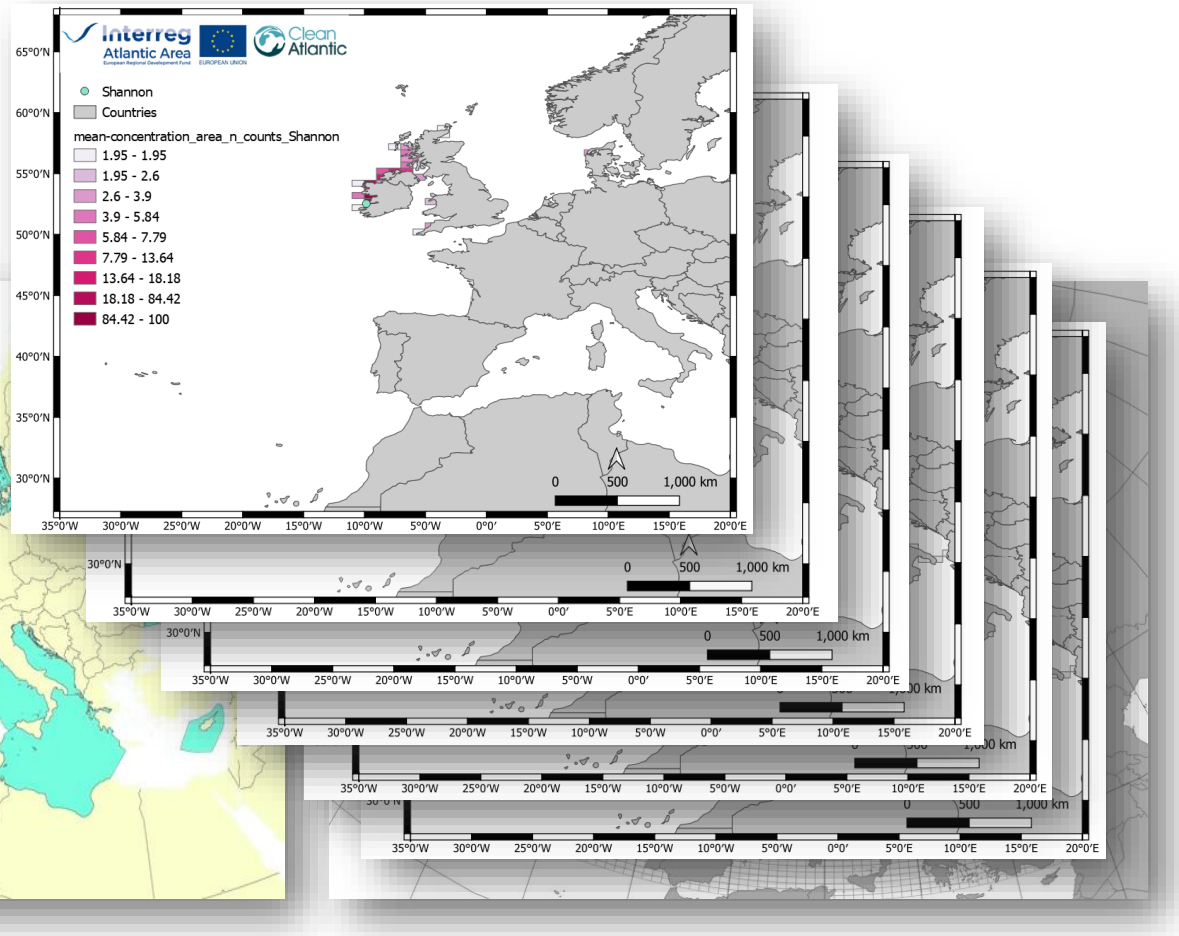
68 EUROPEAN RIVER

Simulation: 3 years

Emission rate: **constant**
(all rivers emit the same number of particles)
Emission rate: **variable**
(rivers emit particles depending on their daily flow)
mean particle concentration (part / km^2) in each polygon





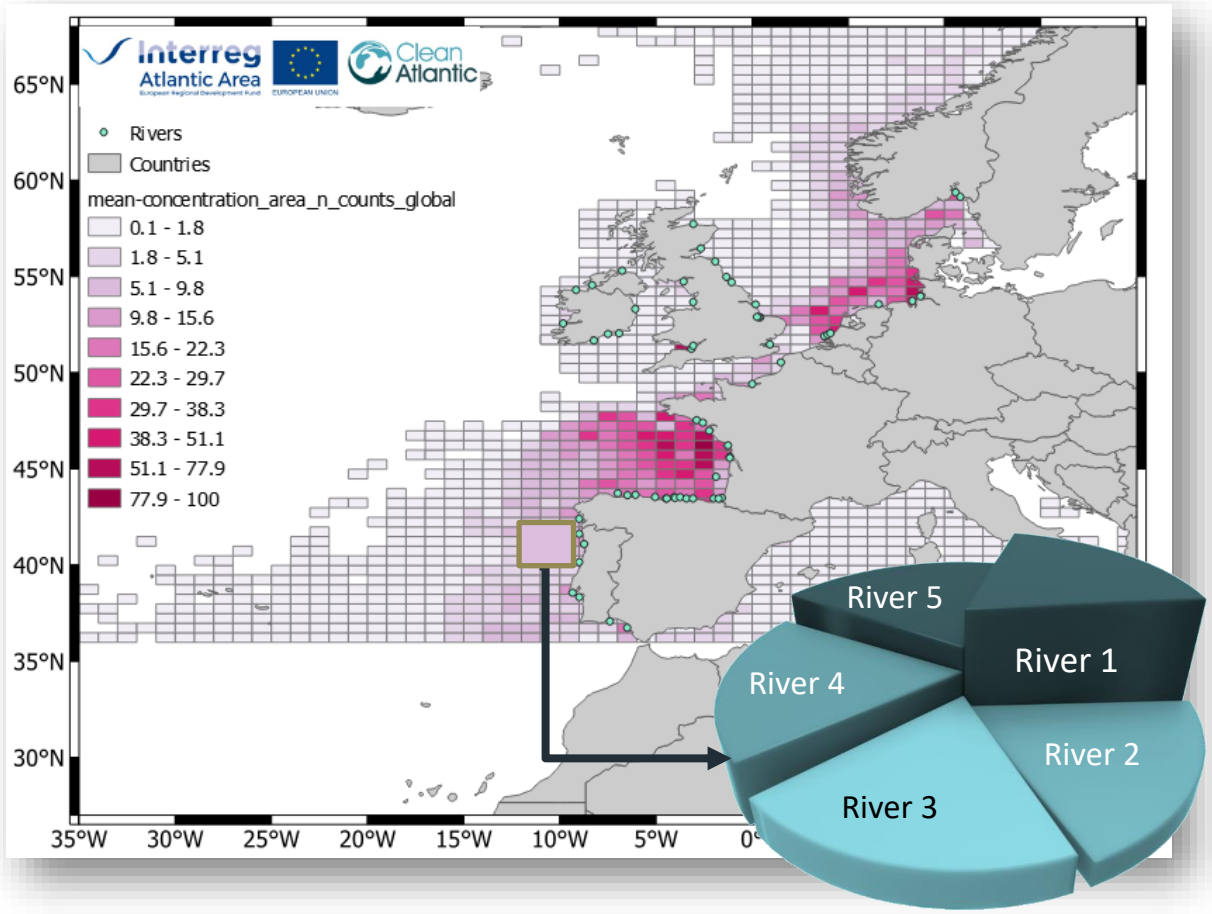


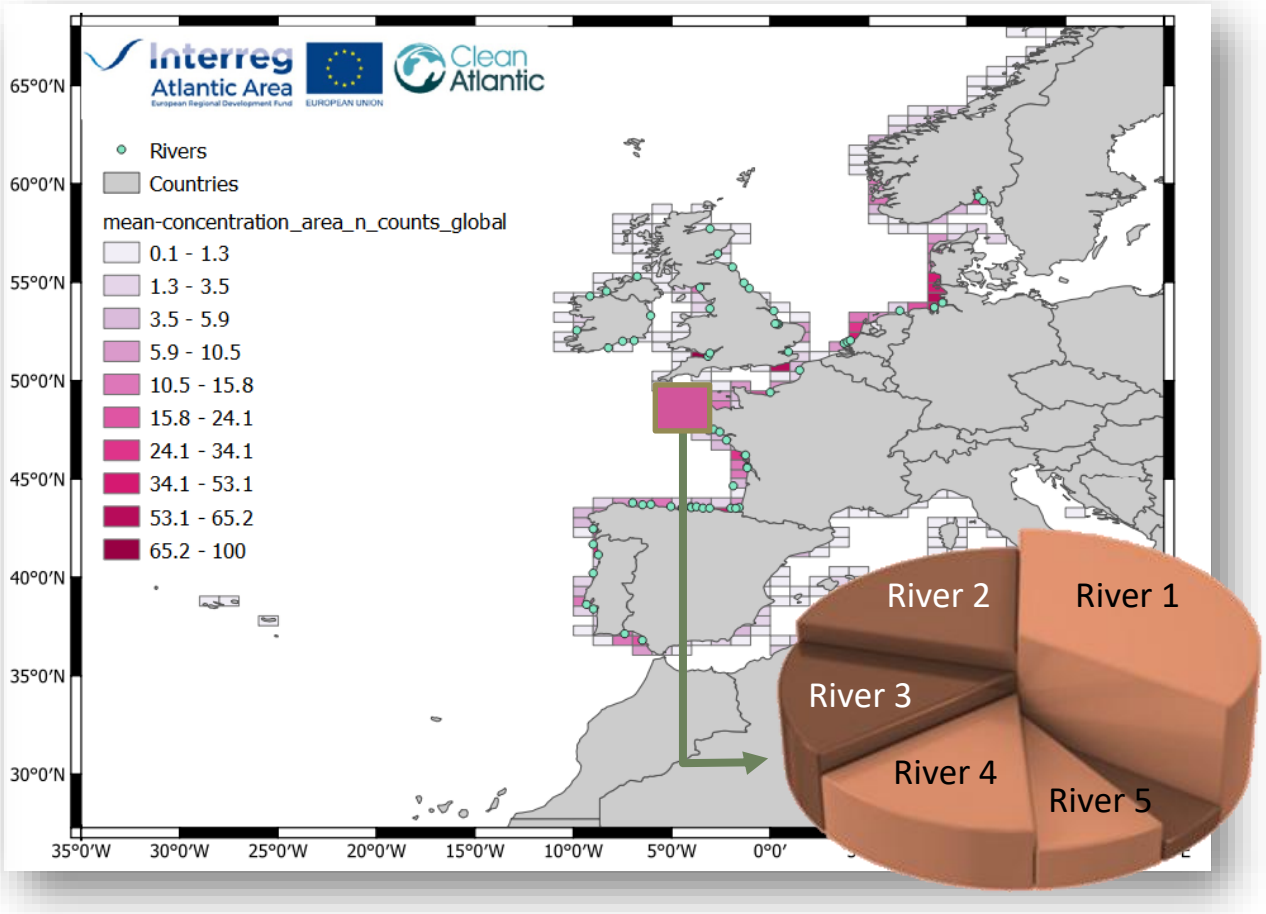
Maps with OSPAR Subregions

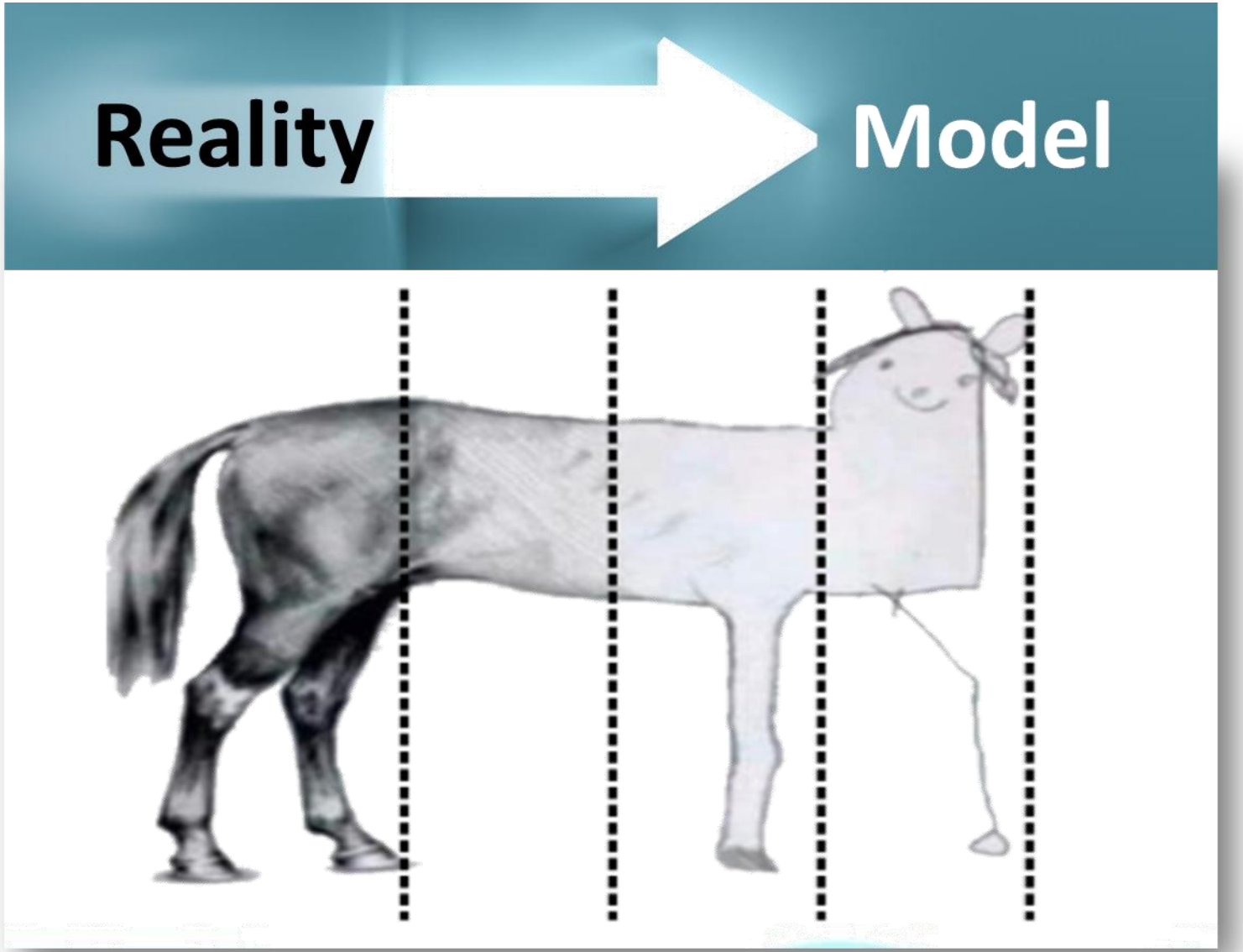
Marine Reporting Units

ICES rectangles

Statistical litter source prediction!



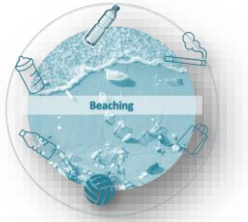



Reality
Model

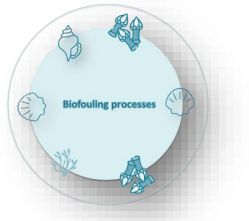
- New challenges → New project

If there is so much plastic in the ocean, why is it difficult to see it on the surface?

- Either there is more plastic beaching

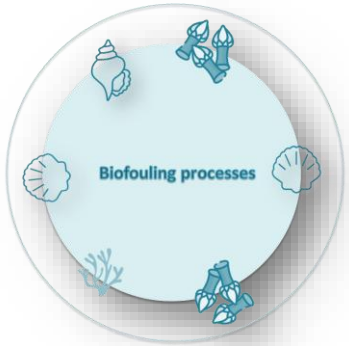


- Or it sinks: (changes density)
  - Biofouling



  - Physical degradation

- Several groups (JRC, USC, …) interested on MohidLagrangiang



Interreg Atlantic Area

Co-funded by the European Union

free litterAT

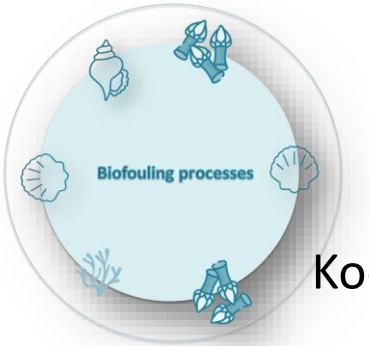
Improved modelling of macro and microplastics

PlasticParcels

First tests implemented in PlasticParcels (Lagrangian transport model based in Python) using Kooi, 2017 parametrization. This will be migrated into the MOHID-Lagrangian model.

Because of the availability of biogeochemical data, we ran simulations in the Mediterranean Sea using data from Copernicus. We started using the most complete and detailed biogeochemical data (and these are from the Mediterranean) and then extrapolate the knowledge learned to our region of interest, the North Atlantic domain.

[1] Kooi, M., Nes, E. H. V., Scheffer, M., & Koelmans, A. A. (2017). Ups and downs in the ocean: effects of biofouling on vertical transport of microplastics. *Environmental science & technology*, *51*(14), 7963-7971.

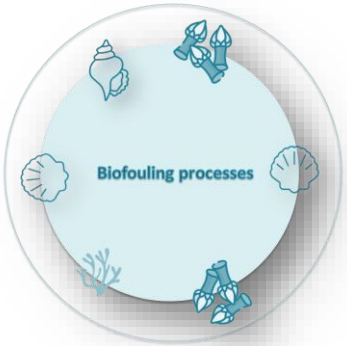


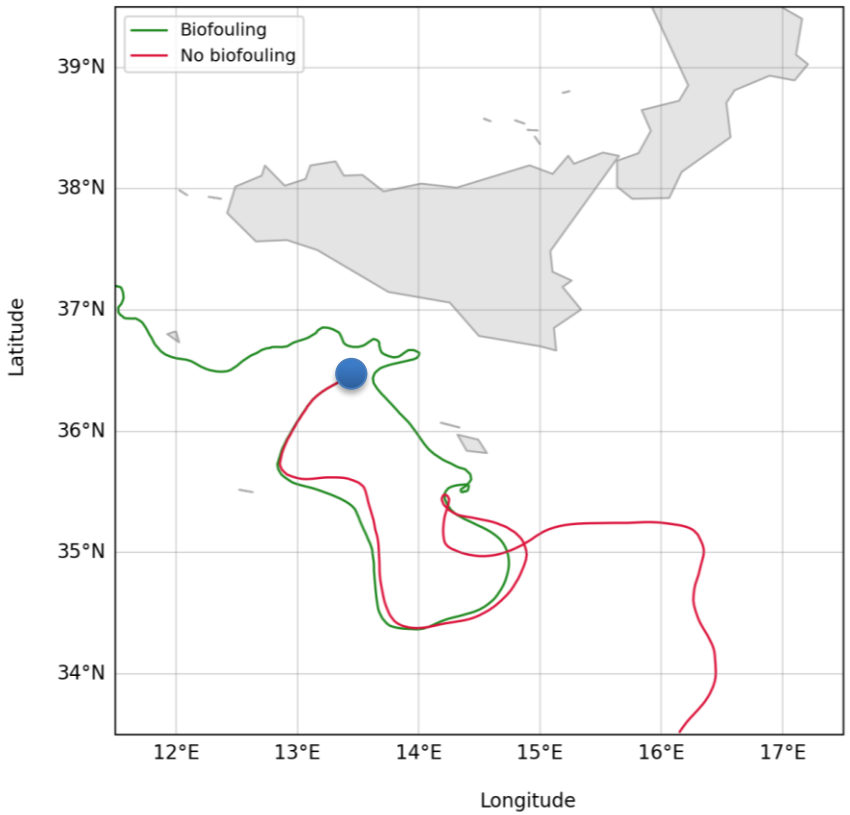
Kooi model for biofouling

$$\rho_{tot}(z,t) = \frac{r_{pl}^3 \rho_{pl} + \left[\left(r_{pl} + t_{bf}\right)^3 - r_{pl}^3\right]\rho_{bf}}{\left(r_{pl} + t_{bf}\right)^3}$$

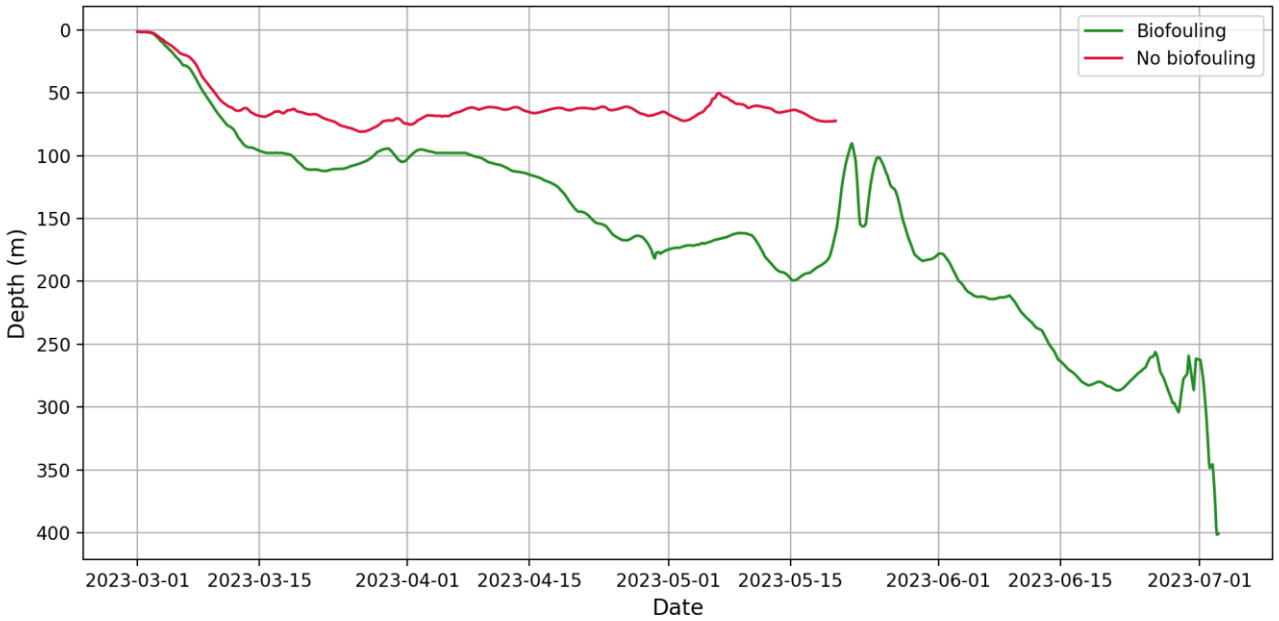
$$BT = \left(\frac{3V_{tot}}{4\pi}\right)^{1/3} - R_0, \qquad V_{tot} = V_b + V_0, \qquad V_0 = \frac{4\pi R_0^3}{3}, \qquad V_b = V_A S_0 A$$

$$\frac{dA}{dt} = \frac{\beta_A A_A}{S} + \mu(T,I)A - m_A A - Q_{10}^{\frac{T-20}{10}} R_A A$$





PlasticParcels



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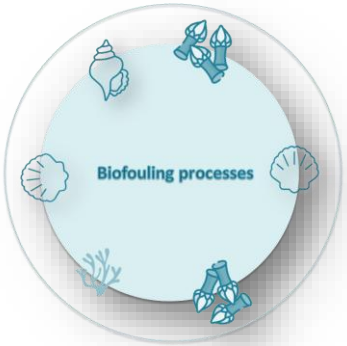
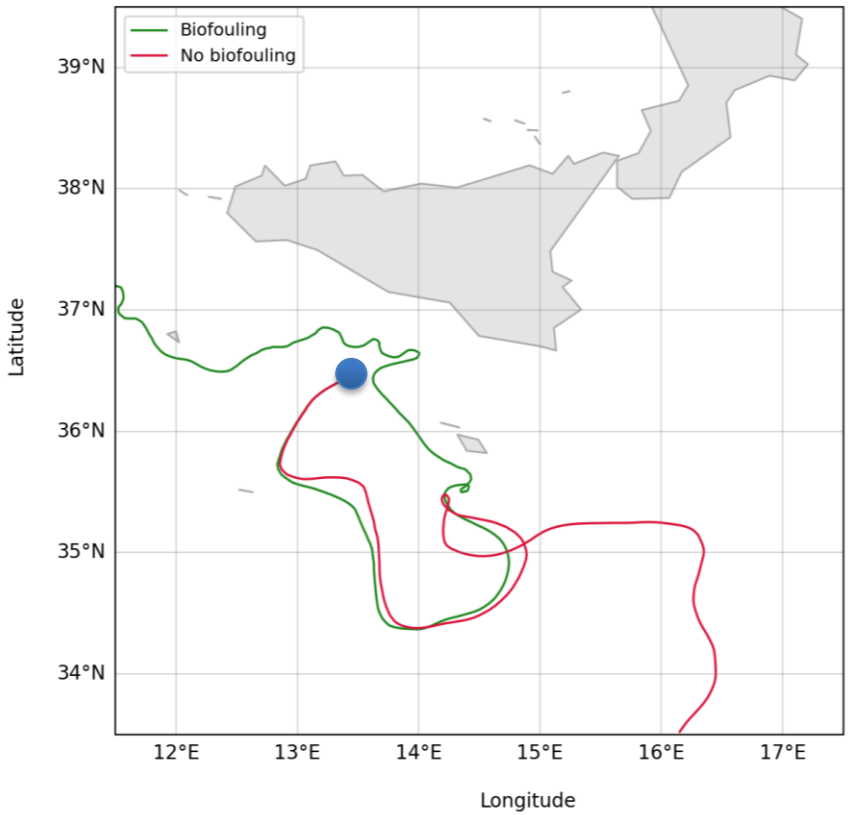
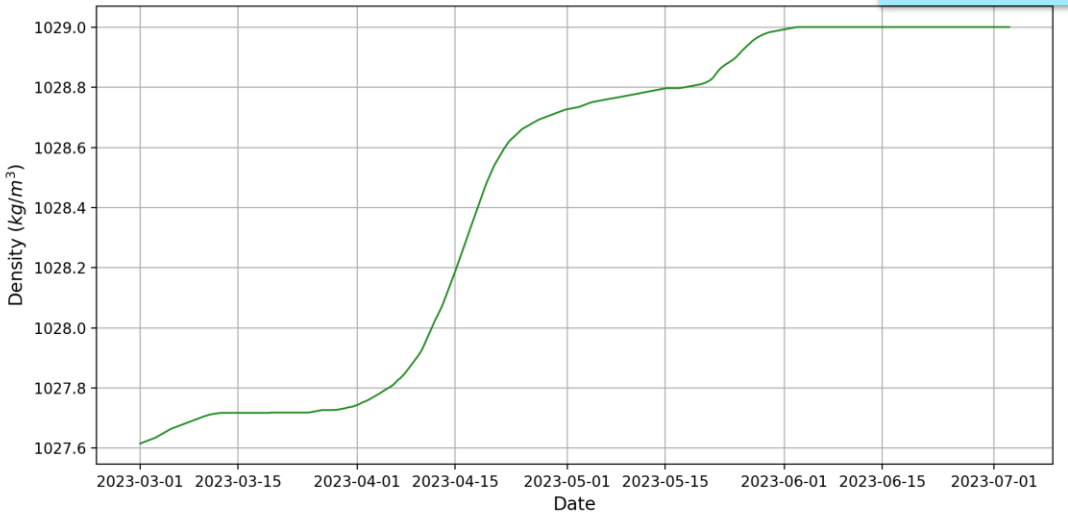
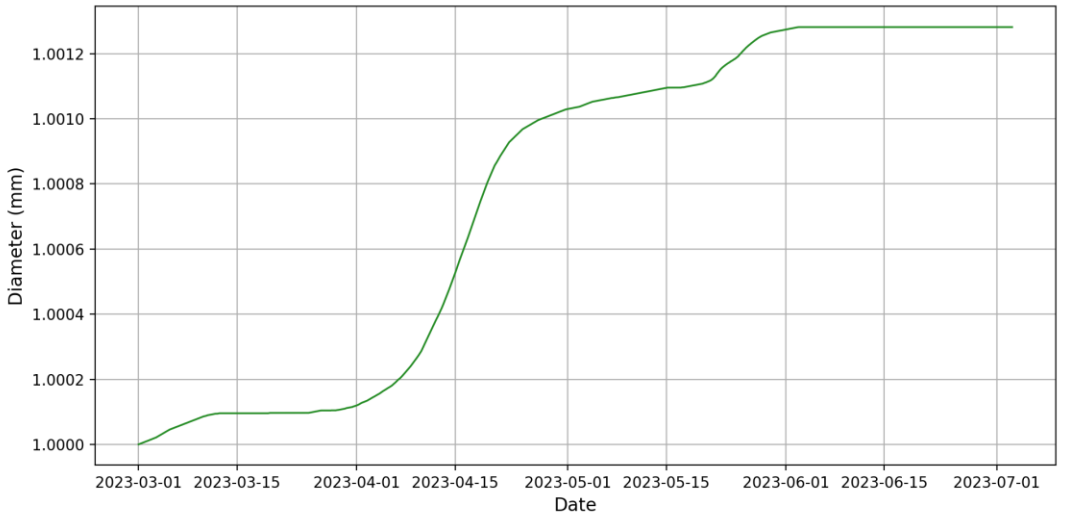
June 25, Lisbon





PlasticParcels





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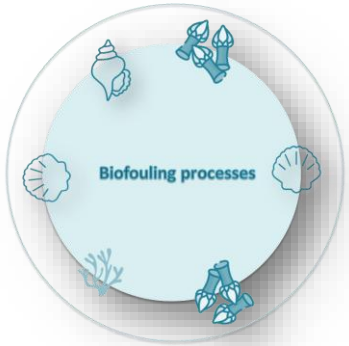


ELSEVIER

Science of The Total Environment

Volume 822, 20 May 2022, 153338

Validation of a Lagrangian model for large-scale macroplastic tracer transport using mussel-peg in NW Spain (Ría de Arousa)

Sara Cloux [a], Silvia Allen-Perkins [b], Hilda de Pablo [c], Daniel Garaboa-Paz [a], Pedro Montero [b], Vicente Pérez Muñuzuri [a]

ELSEVIER

Marine Pollution Bulletin

Volume 209, Part A, December 2024, 117110

A regional Lagrangian model to evaluate the dispersion of floating macroplastics in the North Atlantic Ocean from land and river sources in the western coast of Spain

Sara Cloux [a b], Patricia Pérez [c], Hilda de Pablo [d e], Vicente Pérez-Muñuzuri [a]

The Challenge - A Project Adrift

- After CleanAtlantic Project

June 2023

Clean Atlantic Project

Finished

Mohid Lagrangian without parents

September 2024

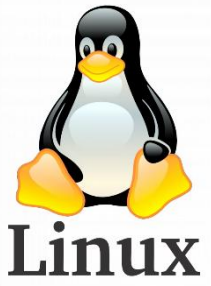
- Several groups (JRC, USC, …) are interesting on MohidLagrangiang
- Issues to compile in Linux
- Python scripts not working

The Solution - A Collaborative Effort

- MOHID Lagrangian Working Group: A dedicated group was formed inJanuary 2025.
- Lead by +ATLANTIC CoLAB, with members from UAçores, Intecmar, ULusofona, USC, MI & Bentley Inc.
- Meetings every month.
- **Objective:** Address and maintain the compilation processes for MOHID.

The results - Compilation & updated scripts

- Succeful compilation with Intel ifx compiler (v. 2025.0) linking with previous HDF5 libraries.
- Intel ifx compiler version 2025.1 has a recognized bug



- Linux is more complex, since prior compilation of essential libraries is required (HDF5 1.8.17)
- Posible using ifort 2023. Thanks Manuela!

- Python libraries updated to Python 3.13.
- Issues with deprecated libraries solved

Beyond Compilation - Current Status & Future Steps

- Current Status:
  - Updated instructions and processes to compile in Windows and Linux
  - Python preprocessing and postprocessing scripts updated.
  - Cookbook for newies.
  - All uploaded to GitHub

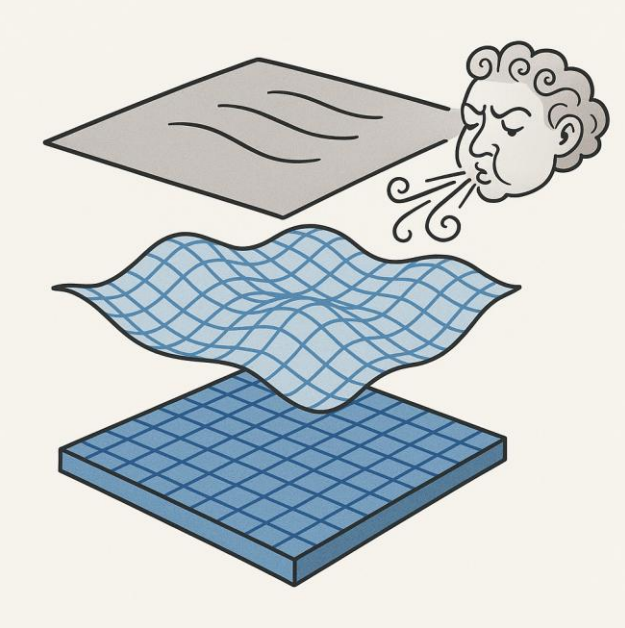
- Key Decisions Moving Forward
  - Linux Compiler Choice: Switch to Intel ifx or stick with ifort 2023?
  - HDF5 Library Update: If ifx, update HDF5 1.8 to 1.14? This means modifying HDFmodule.f95.
  - Code Governance: Establish a clear framework of roles and responsibilities.
  - Code Maintenance: Define a plan for its long-term sustainability.

New MOHID-Lagrangian User Guide UPDATE!!!!

We include an self-content example in the Ria de Arousa

Before starting to run the MOHID-Lagrangian

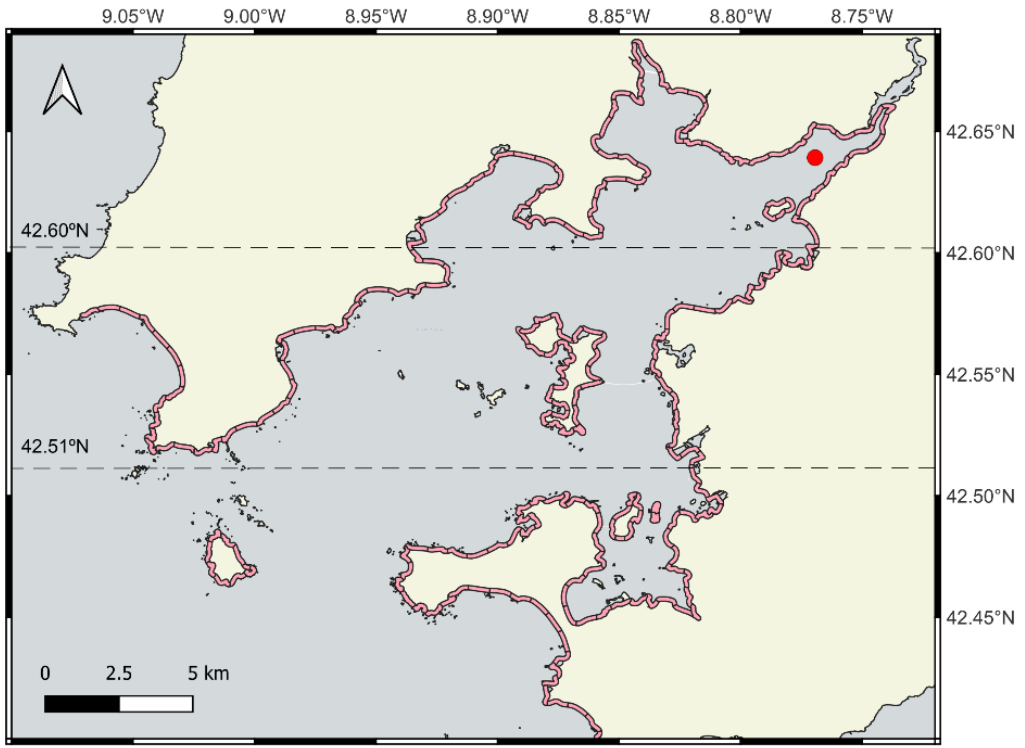
Get the input fields



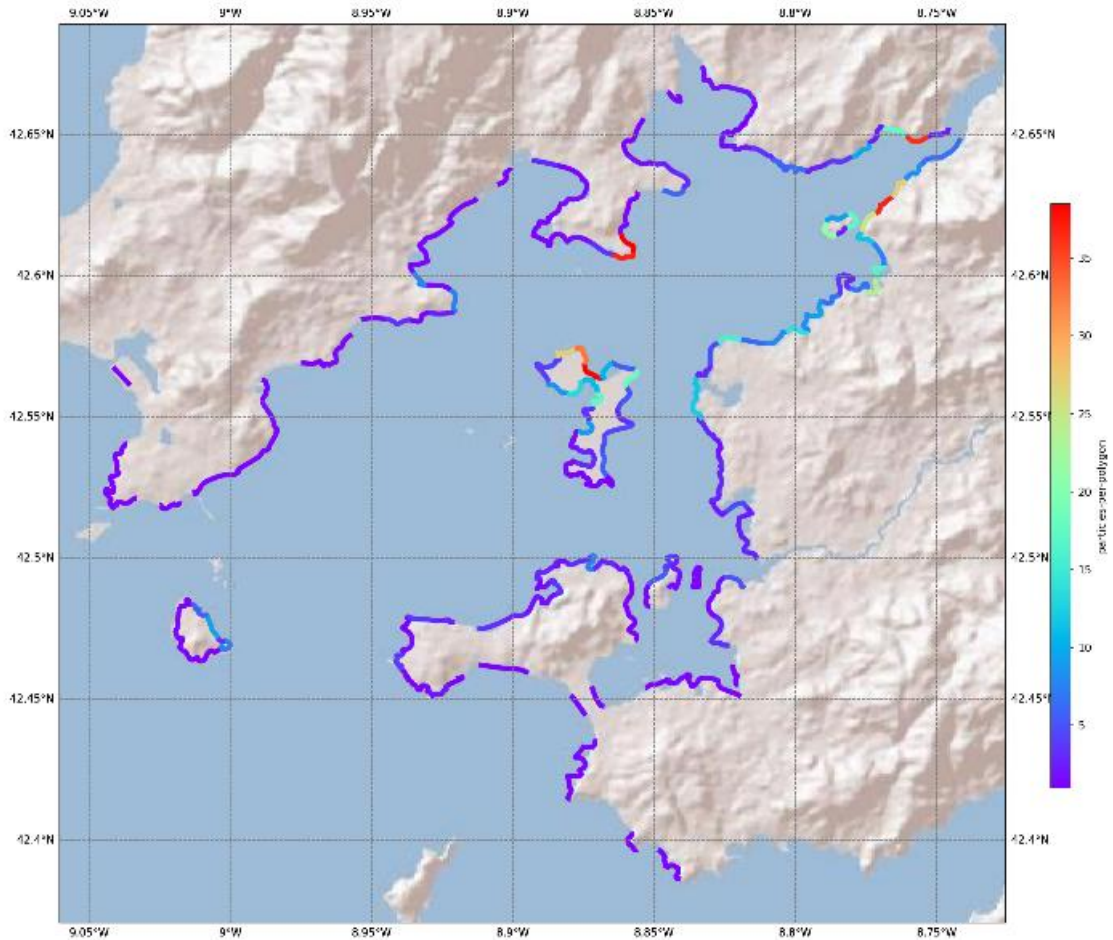
Set the sources

Self contained exemple

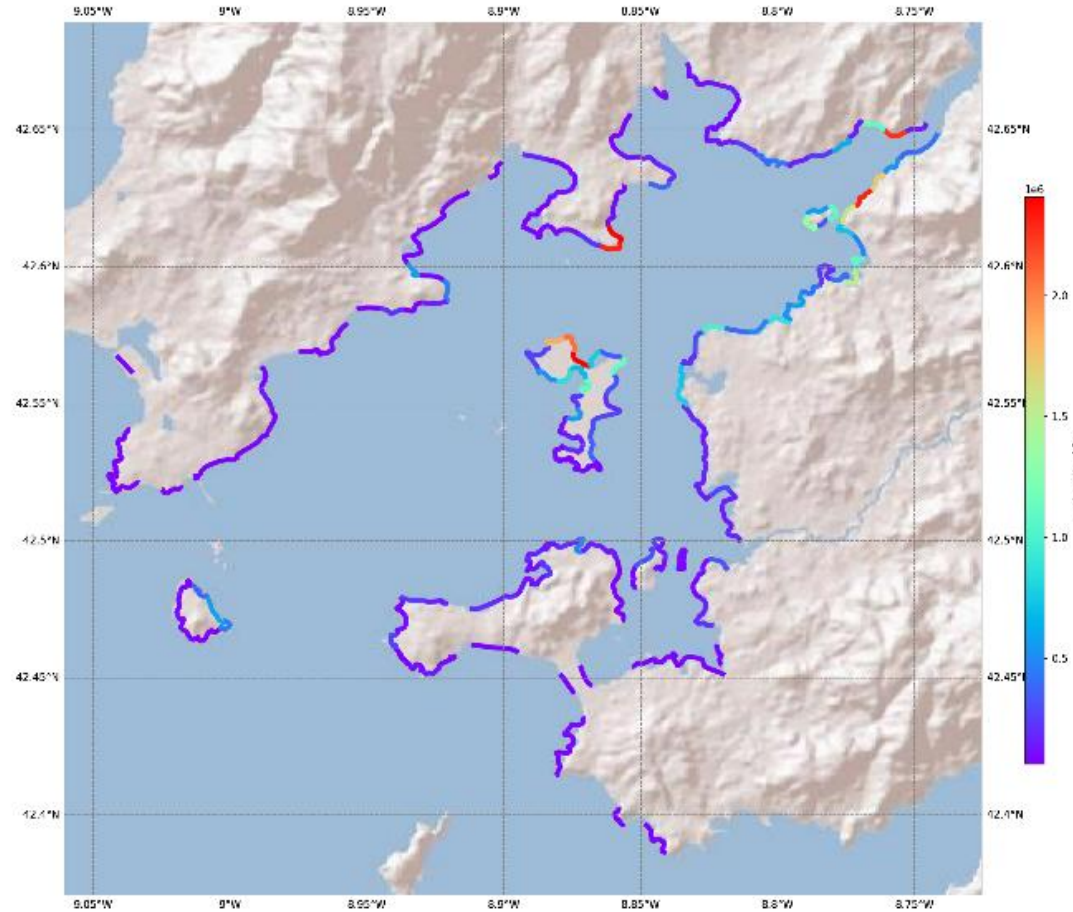
- ✓ 1 month of wind and hydro data.
- ✓ 1 point source with variable emission, the Ulla river.



Method : mean(n_counts_(t))
Source : Ulla



Method : mean(concentration_area_(t))
Source : concentration_area_Ulla



Thanks a million for your time and attention!!