Lagrangian simulations for tackling coastal risks in the Atlantic Area

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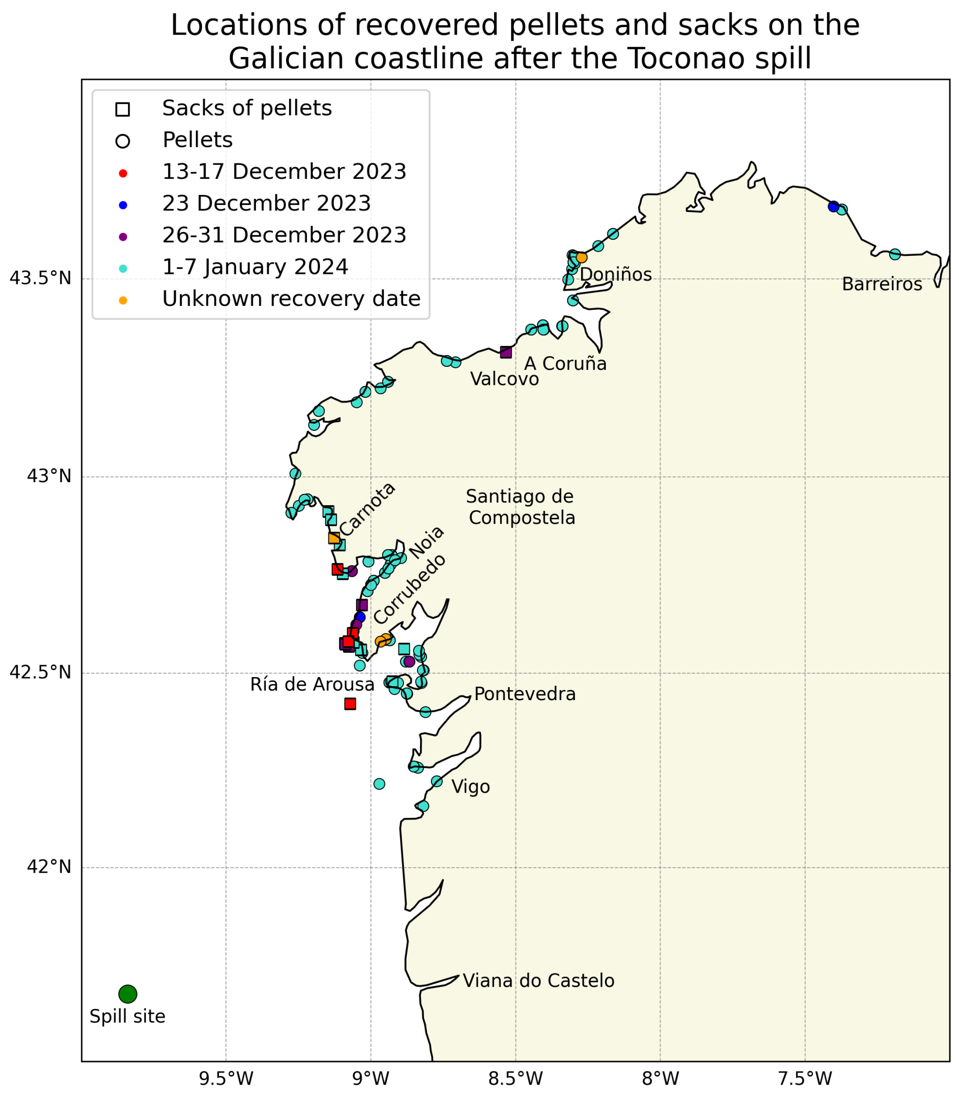
AGENCIA ESTATAL DE INVESTIGACIÓN

Toconao pellet spill

- Date of the spill: December 8th 2023
- 1050 25kg sacks of pellets from the Toconao container ship
- Spill site: aprox. 80km from Viana do Castelo, Portugal
- December 13-14th 2023 first sighted sacks on the coast (Corrubedo, Galicia, Spain)



Compilation of recovery efforts data published by Noia Limpa y Unha Vez Máis and sevaral news media (El País, El Español, elDiario.es)

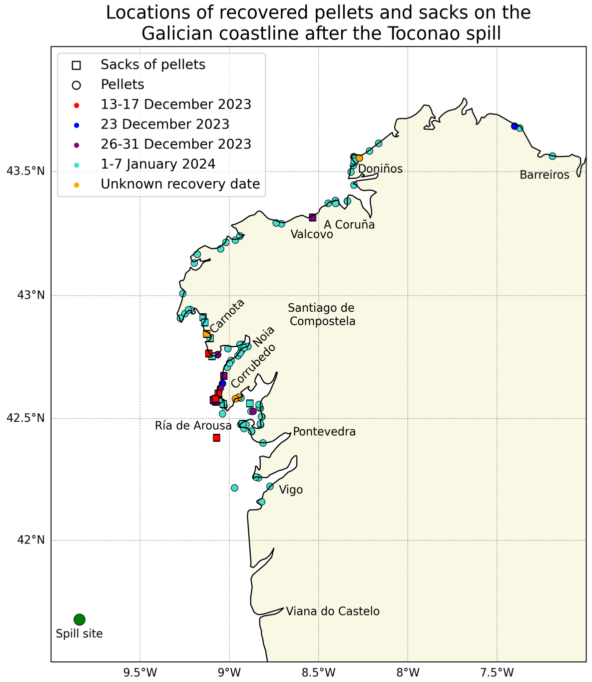
Pellets on the beach (image from El Español)

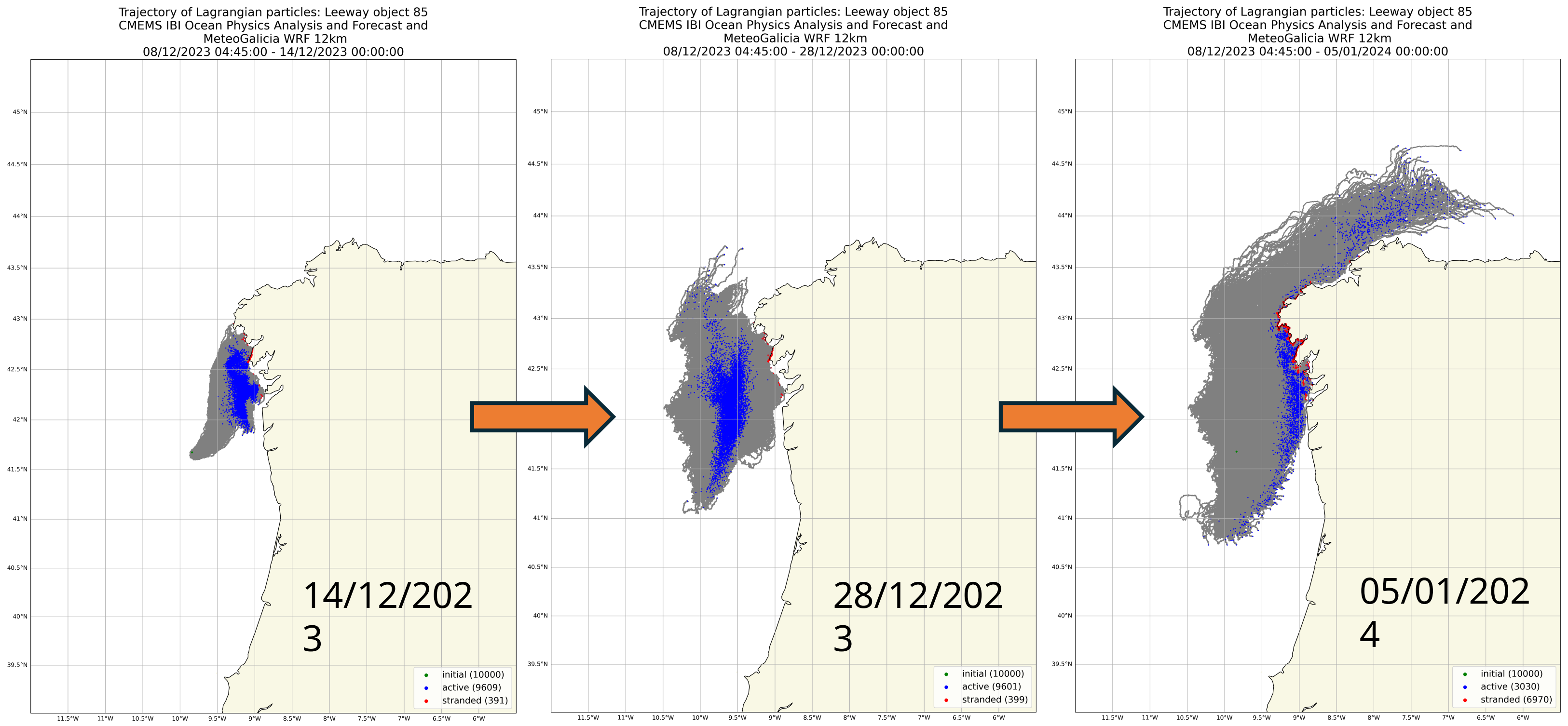
First recovered sacks of pellets in Corrubedo on December 13th 2023 (image from El Español)

Objectives of the Lagrangian reanalysis simulation

- A set of Lagrangian simulations were performed to simulate the spill using the offline trajectory model OpenDrift (https://opendrift.github.io)
- Sensitivity analysis of the Lagrangian model to
  - The type of particle simulated
  - The hydrodynamic and atmospheric models used as forcing
- To assess the impact of freshwater fronts using Lagrangian Coherent Structures (LCS)

Results of the Lagrangian simulations





Avaliable data

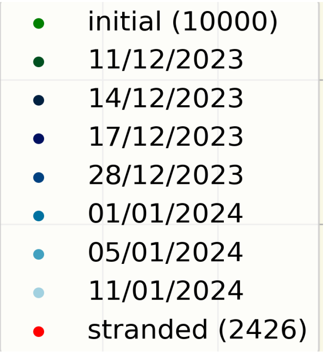
Lagrangian simulation

Copernicus Marine Service — IBI Ocean product

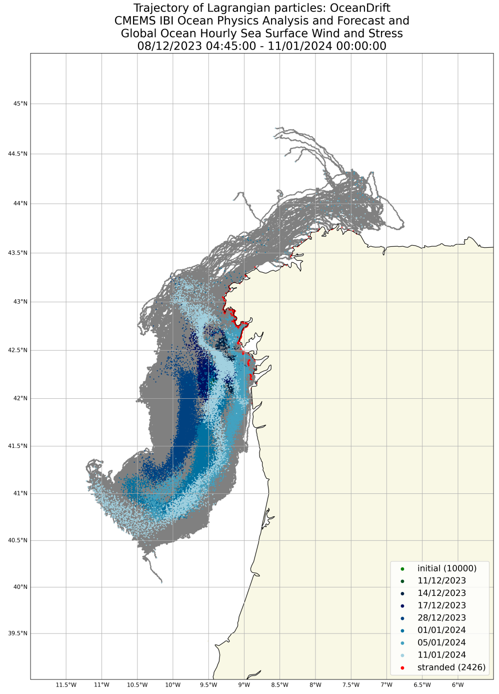
meteogalicia — WRF 12km wind product

OpenDrift — Leeway drift, small medical waste

Sensitivity to object type



- OceanDrift: particles with a direct wind drag
- Leeway: objects with downwind and crosswind drag empirical-based coefficients
  - Object 85: Medical waste, syringes, small
  - Object 78: Sewage floatables, tampon applicator
  - Object 70: Bait/wharf box, holds a cubic metre of ice, lightly loaded
  - Object 66: Fishing vessel debris



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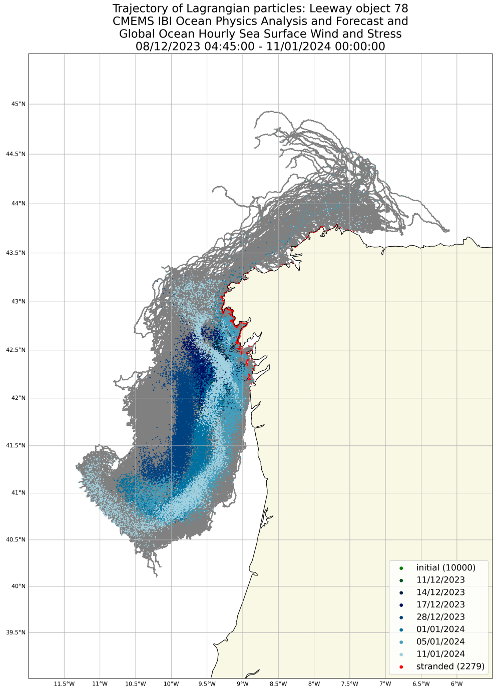
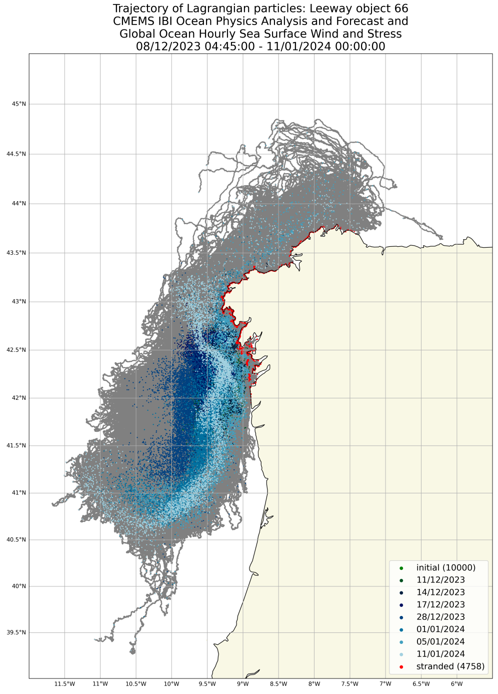


Leeway ob.
78



Leeway ob.
66

OceanDrift vs Leeway model

$$\frac{dx_i}{dt} = u_{sea}(x_i, t) + C_D u_{wind}(x_i, t) + R(2K_h d^{-1} dt)^{1/2}$$

OceanDrift vs Leeway model

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Current horizontal advection

Current horizontal dispersion (random walk)

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Wind drag

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OceanDrift vs Leeway model

OceanDrift: 2%

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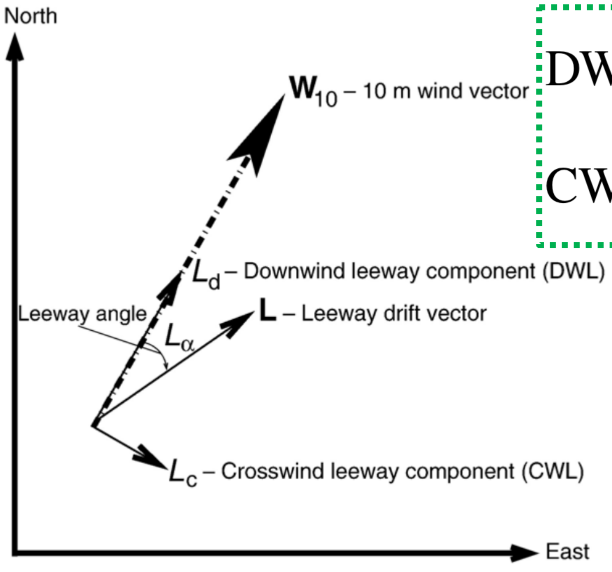
$$\text{DWLeeway} = \left(a_{dw} + \frac{\epsilon_n}{20}\right) \cdot \mathrm{W}_{10} + b_{dw} + \frac{\epsilon_n}{2},$$

$$\text{CWLeeway} = \left(a_{cw} + \frac{\epsilon_n}{20}\right) \cdot \mathrm{W}_{10} + b_{cw} + \frac{\epsilon_n}{2}.$$



Breivik and Allen (2007)

OceanDrift vs Leeway model

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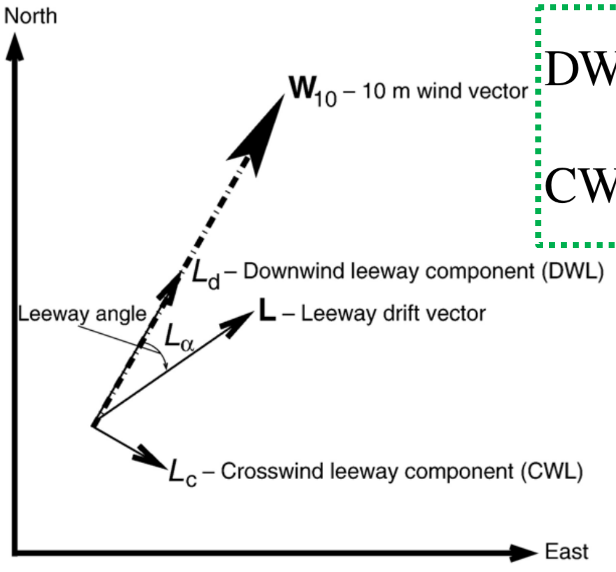

Breivik and Allen (2007)

Object	a_{dw}	b_{dw}	ϵ
85. Medical waste, syringes, small	**1.79%**	0.00 cm/s	**2.40 cm/s**
78. Sewage floatables, tampon applicator	1.79%	0.00 cm/s	3.10 cm/s
70. Bait/wharf box, holds a cubic metre of ice, lightly loaded	**2.53%**	9.01 cm/s	3.05 cm/s
66. Fishing vessel debris	1.97%	0.00 cm/s	**8.30 cm/s**

OceanDrift vs Leeway model

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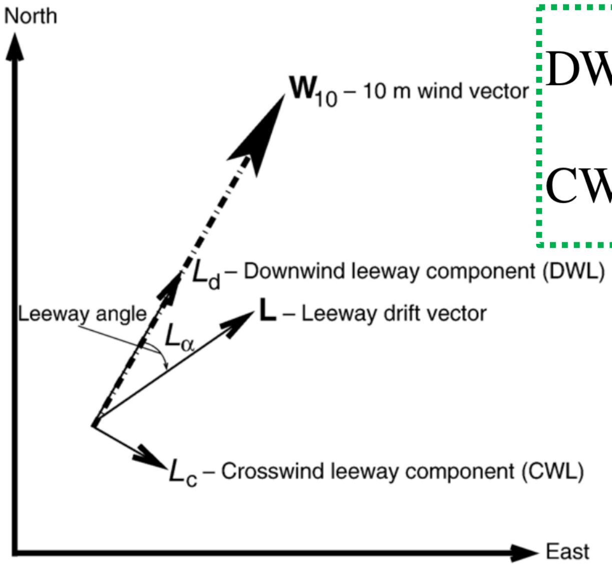
$$\epsilon_n = rdw \cdot \epsilon$$

$$rdw \in N(0,1)$$



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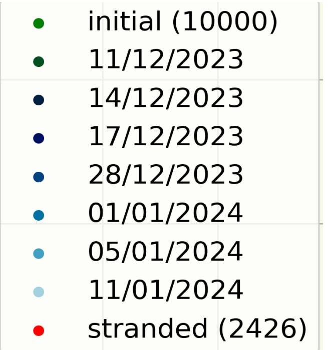
Sensitivity to forcing



Copernicus Marine Service

- IBI Ocean Physics Forecast and Analysis (2km)
- Global Ocean Hourly Sea Surface Wind and Stress from Scatterometer and Model (9.5km)

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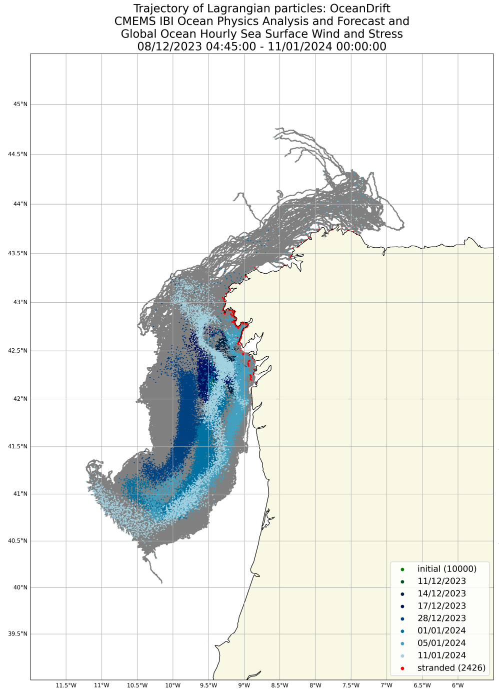
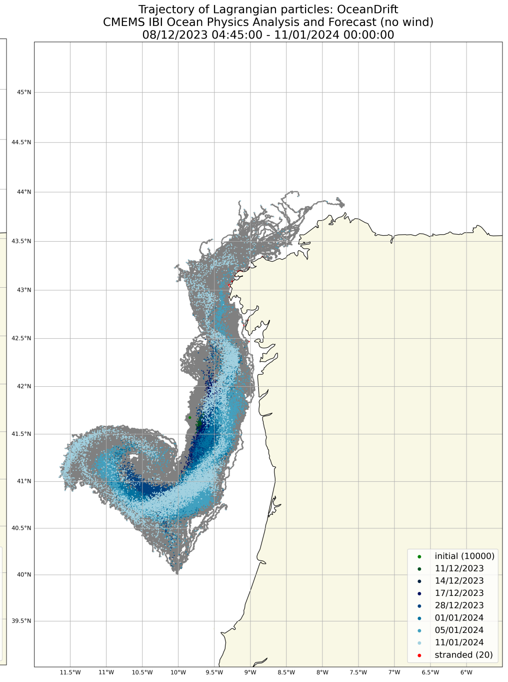
- ROMS 2km
- WRF 12km

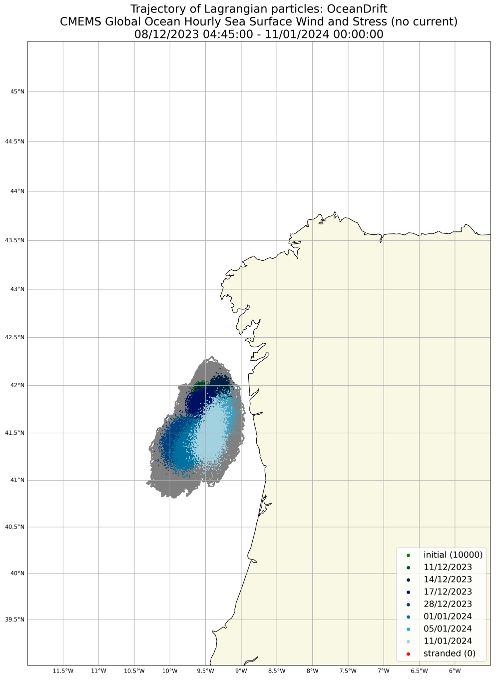
Experiments only explain the spill if both hydrodynamic and atmospheric models are used as forcing



Currents and wind



Only currents



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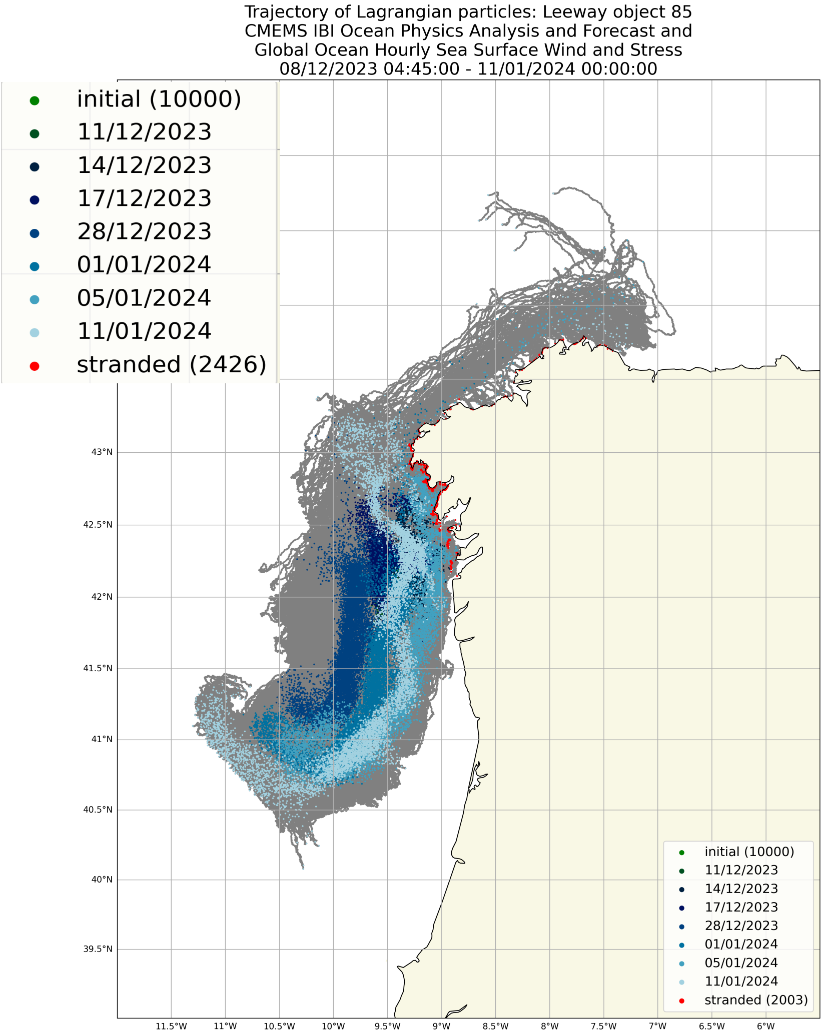

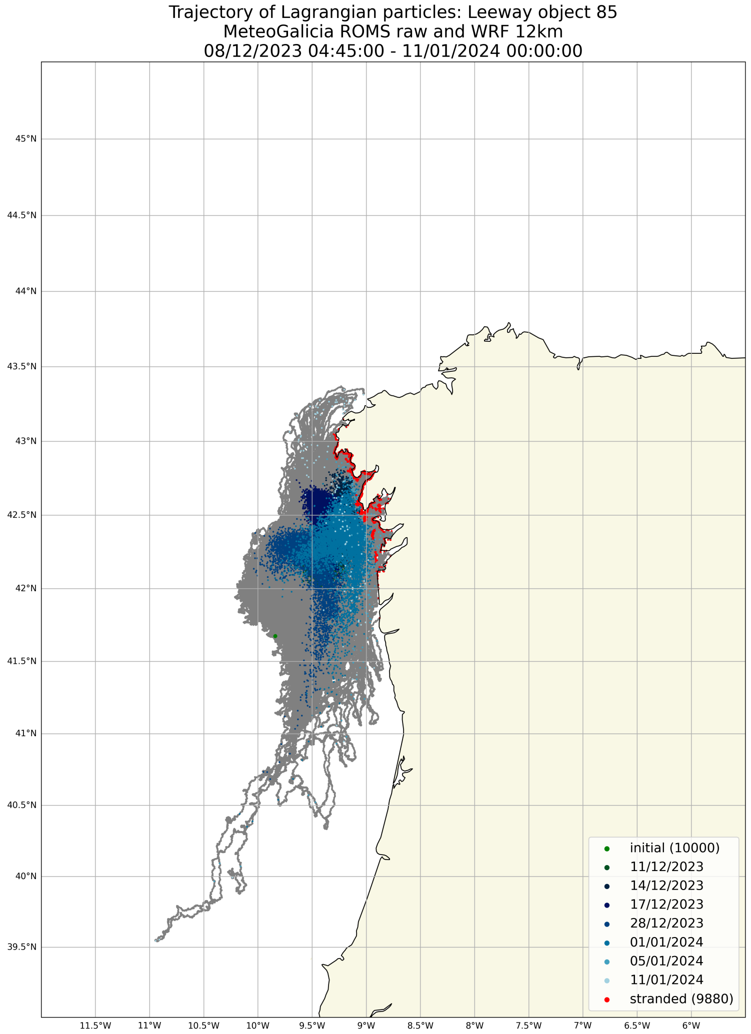

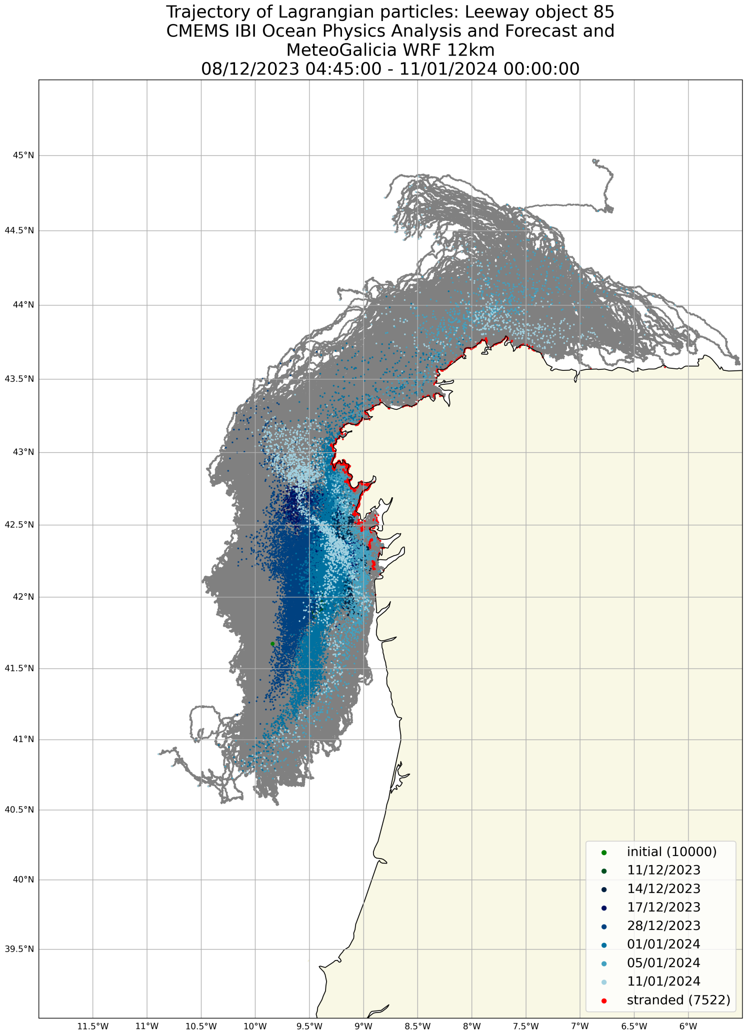

Copernicus Marine Service

Currents and wind

meteogalicia

Currents and wind

Copernicus Marine Service

Currents

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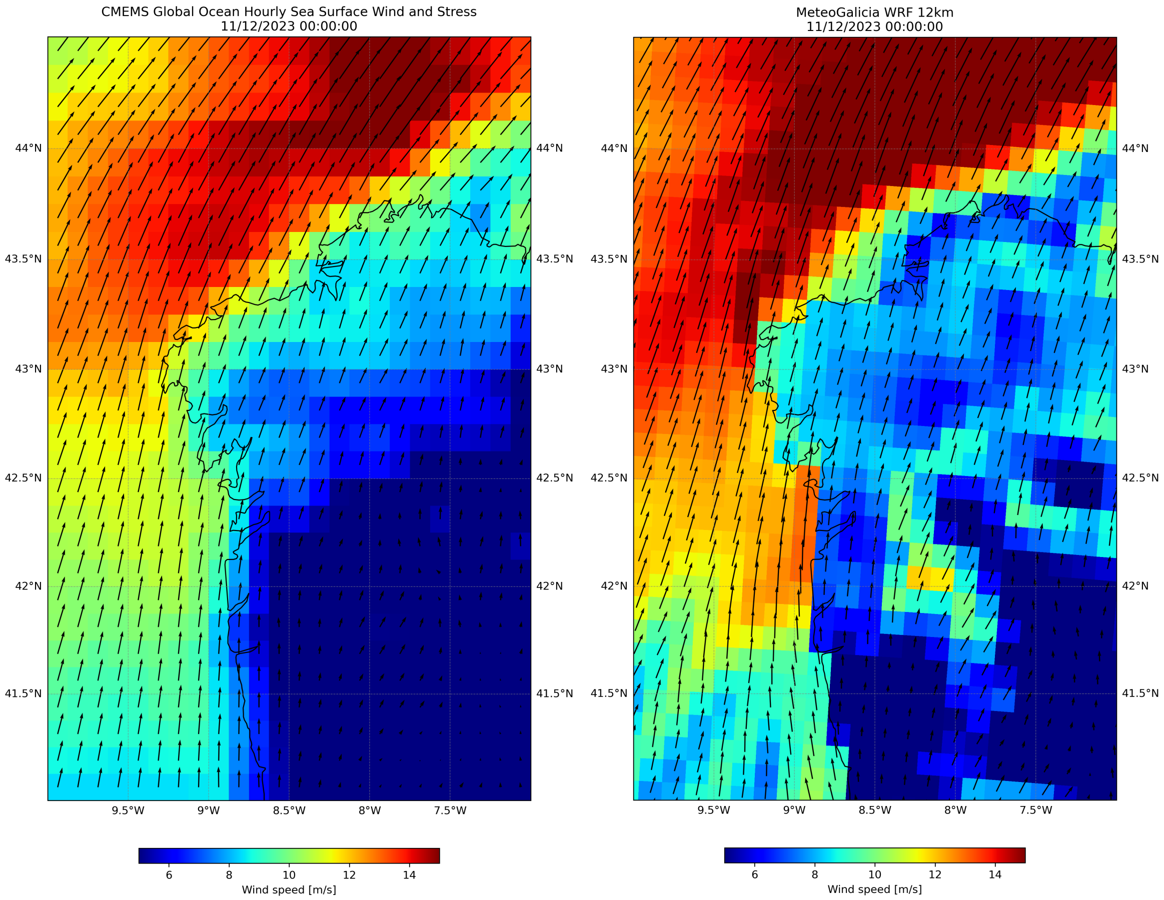

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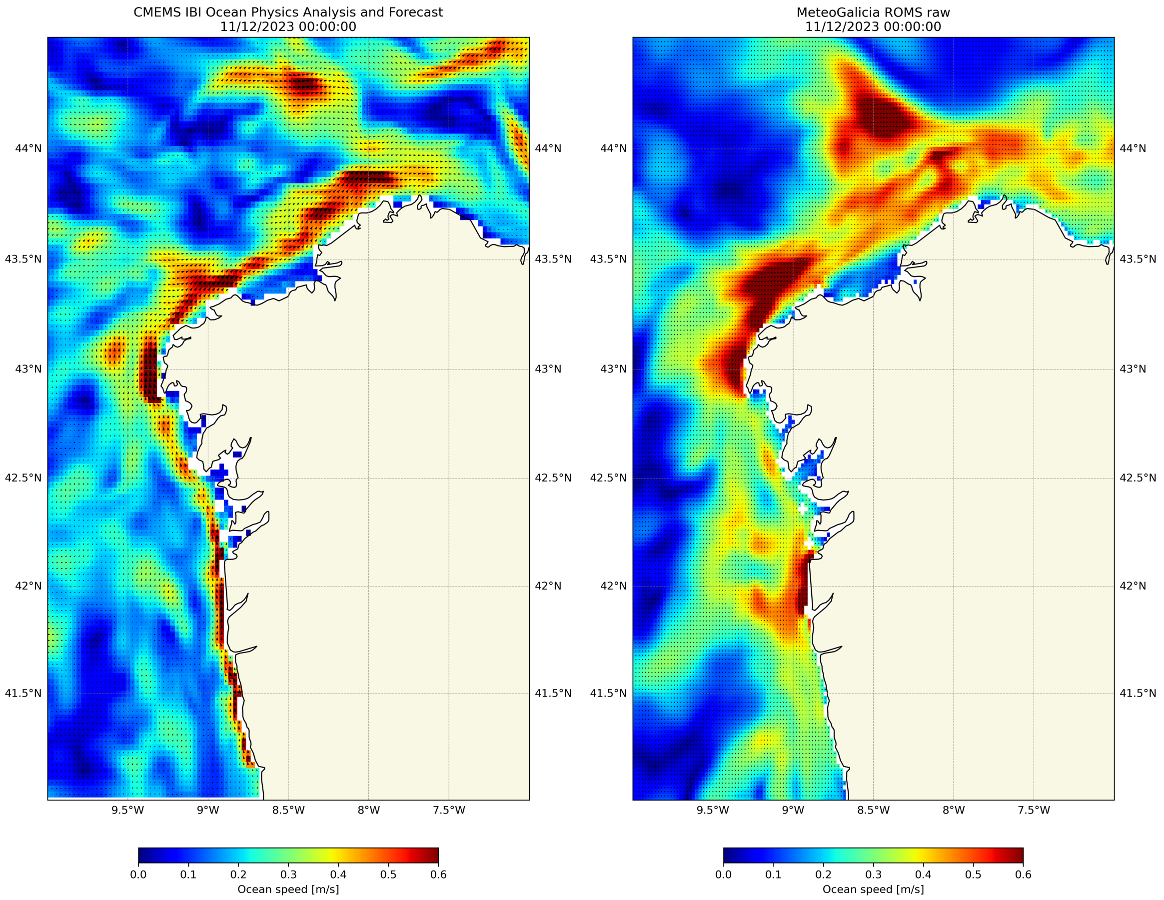
Wind velocity field



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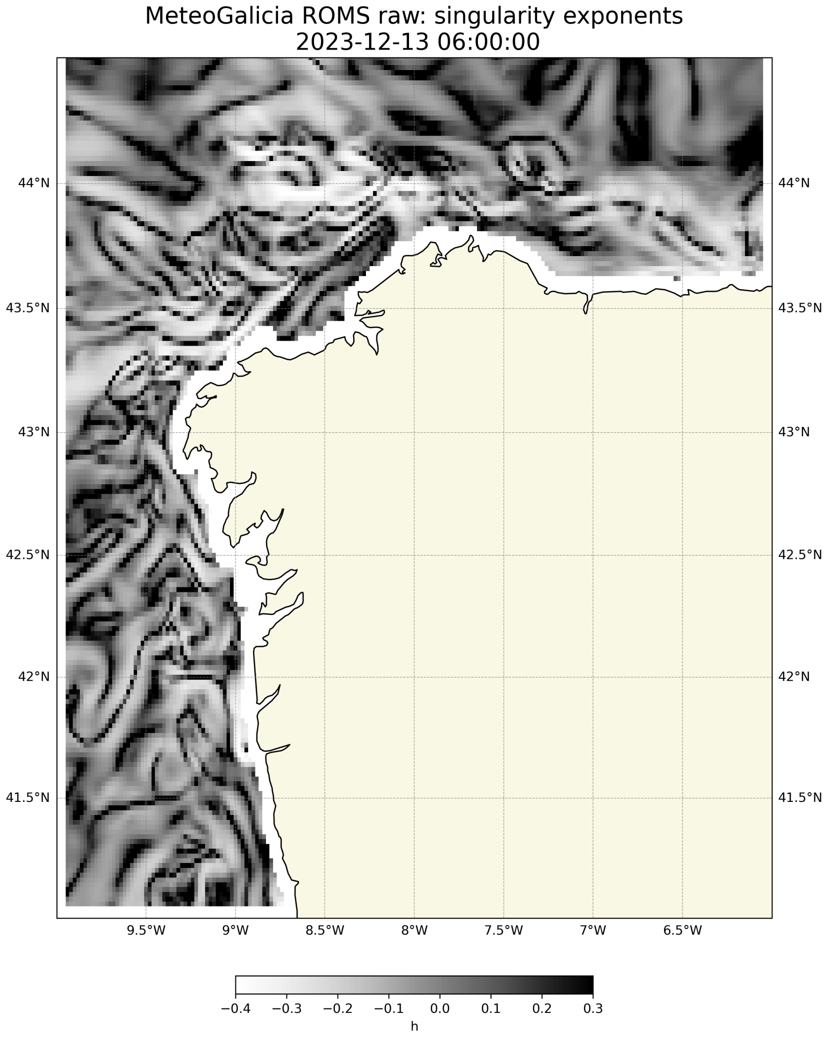
Current velocity field

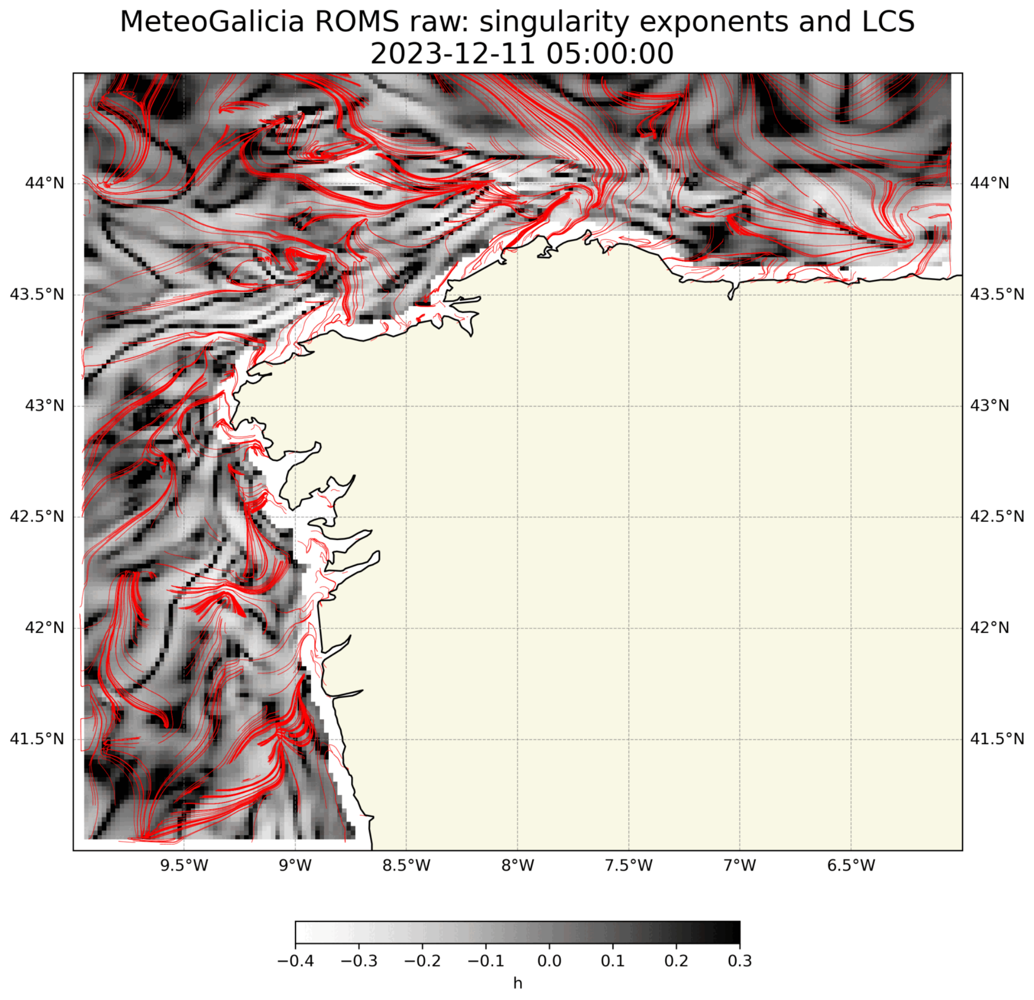
Singularity exponents (SE)

- SE are a metrics for front intensity
- At intense fronts (high gradients) exponents are smaill
- SE for every variable: velocity SE do not show a clear relationship with temperature and salinity SE

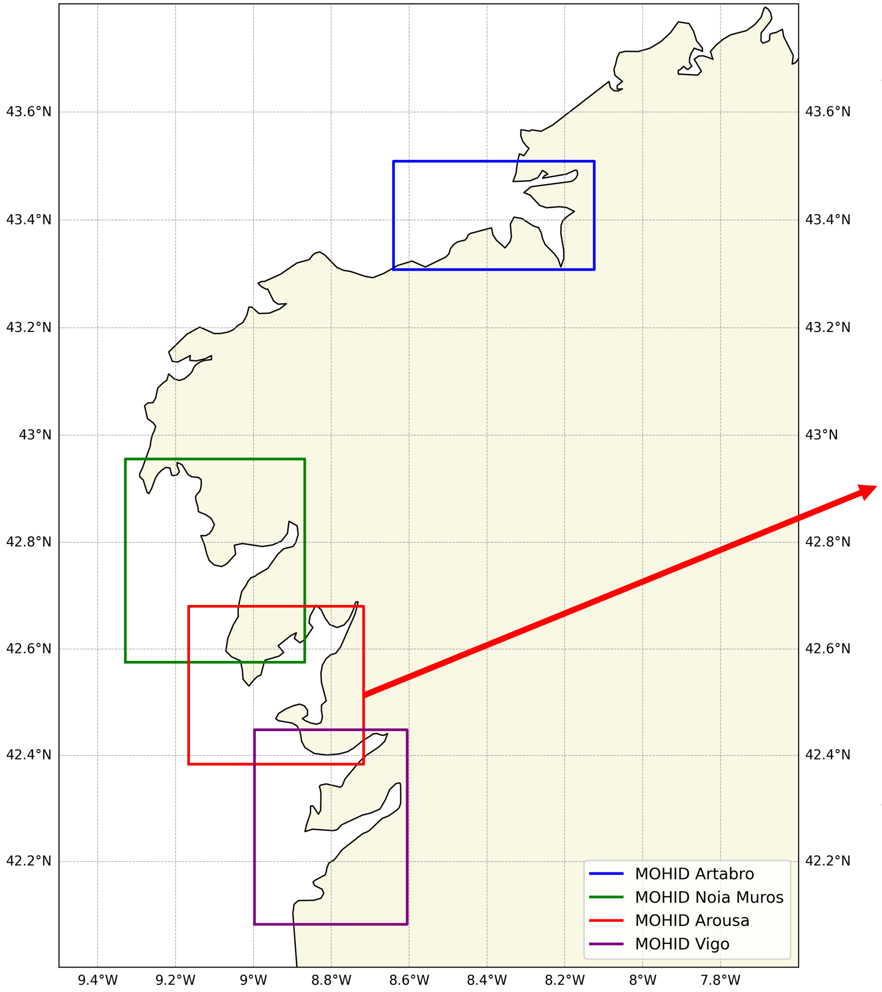


SE vs LCS

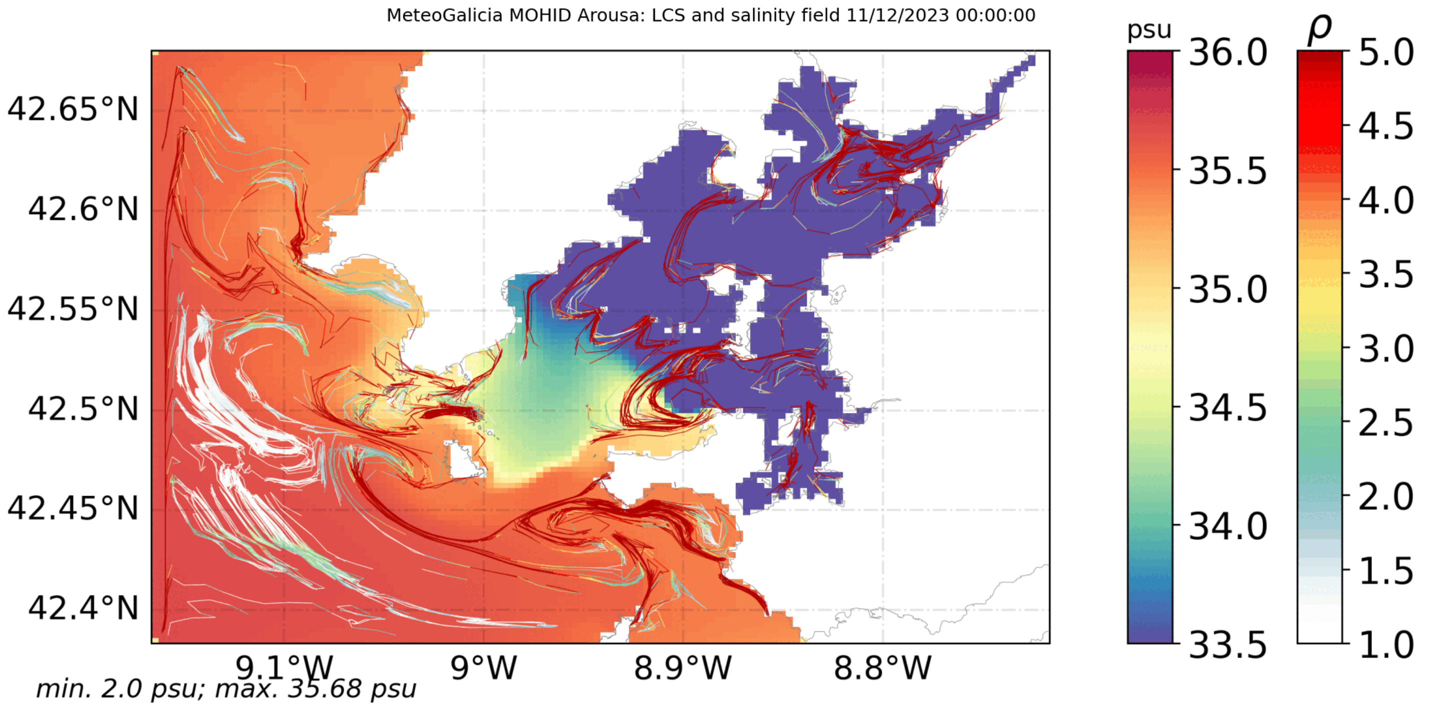
- SE are instantaneous while LCSs are obtained by integrating over a time interval (6h in our exercise)
- SE calculation is computationally less expensive
- With SE calculation, near-shore cells are lost
- SE can be calculated for satellite images, which allows validation of models
- SE and LCS are related



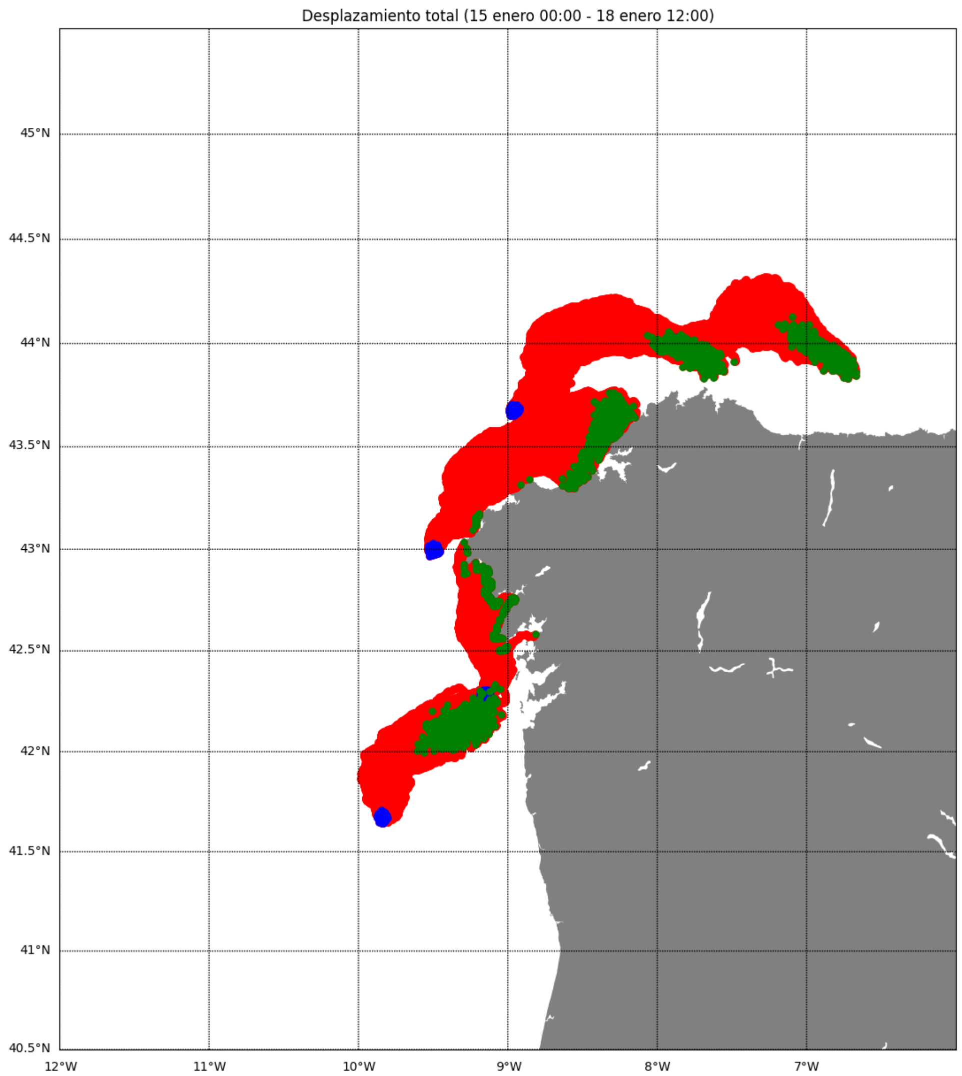
High resolution model for the Rias: MOHID

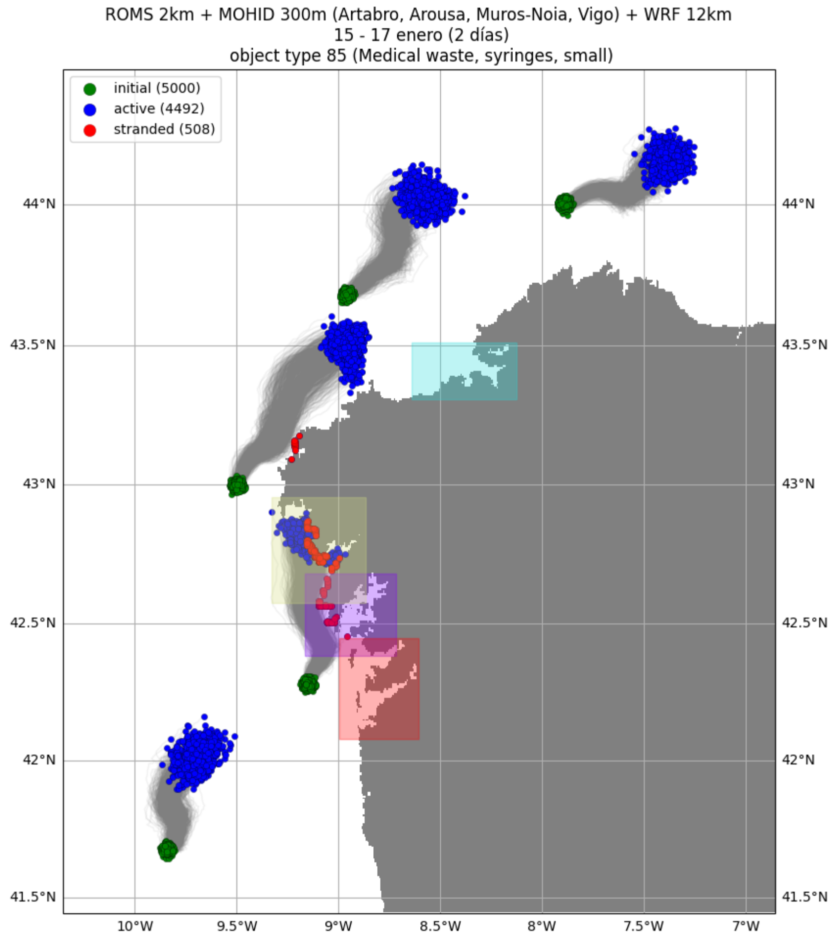


MeteoGalicia MOHID domains



Simulations at the time of the spill





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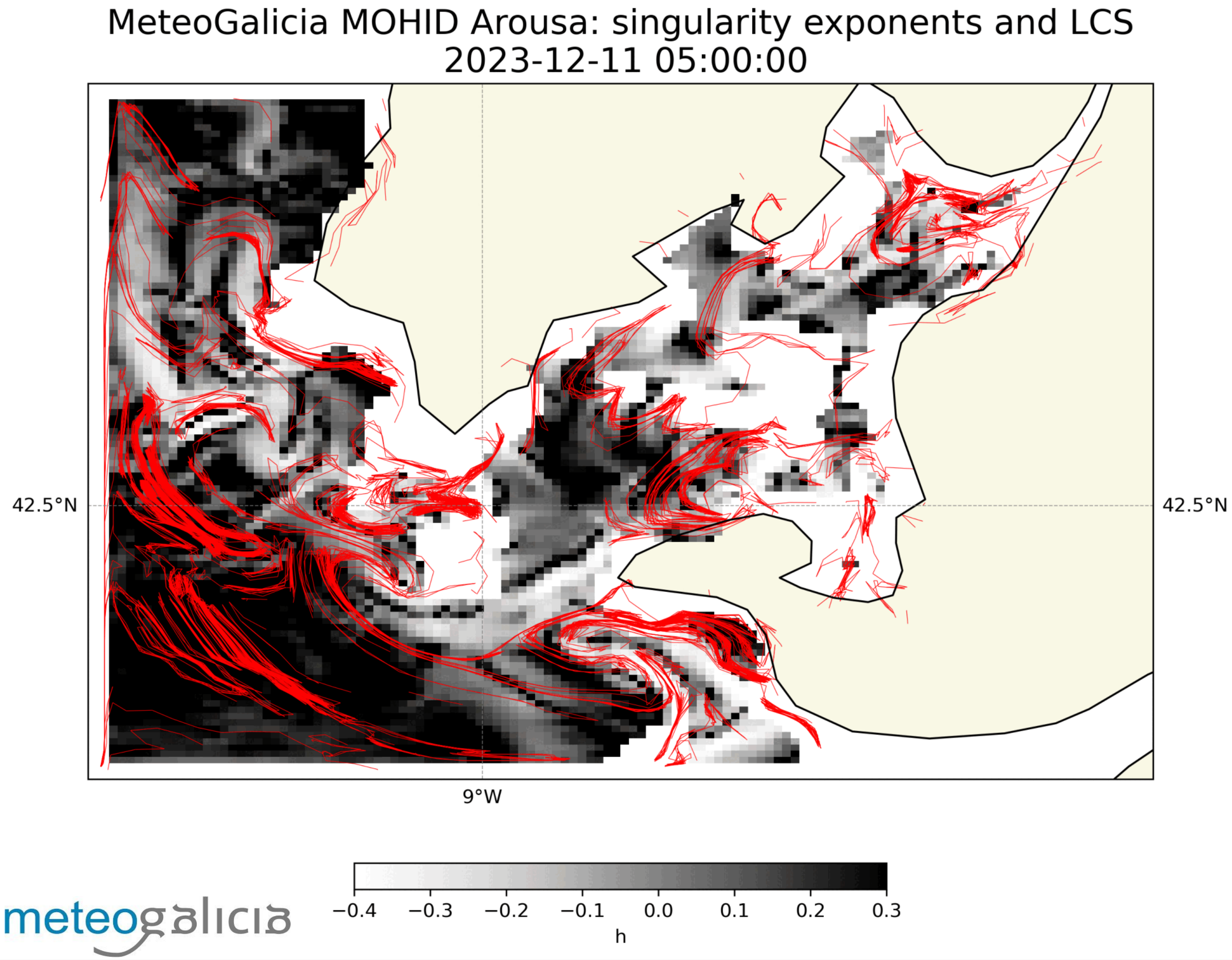
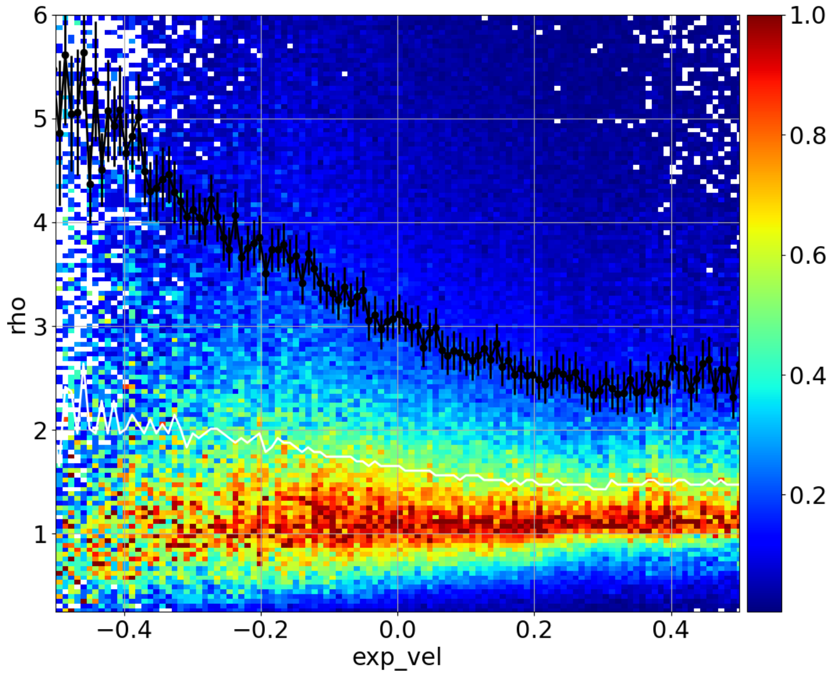
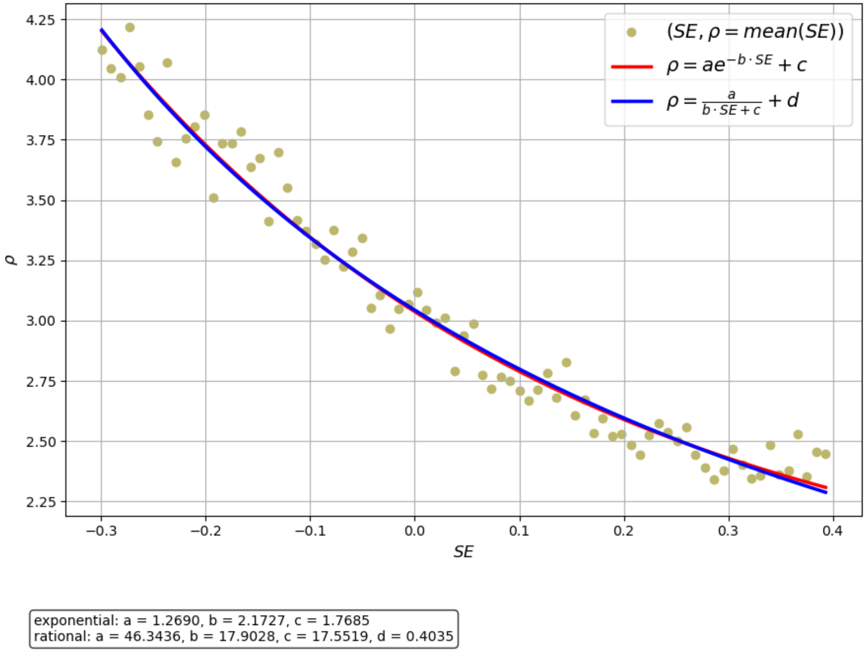
SE and LCS for MOHID







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Simulación da deriva desde o dia 8 de decembro ata 15 de xaneiro

Publicado por **Administrador CAMGAL** en CAMGAL_TOCONAO Predicións el 12 Xaneiro , 2024 .

Modelización da traxectoria de obxectos vertidos ao mar o día 8 de decembro simulada a partir de datos de modelos atmosféricos e hidrodinámicos.

Para descargar video clique aquí simulacion toconao

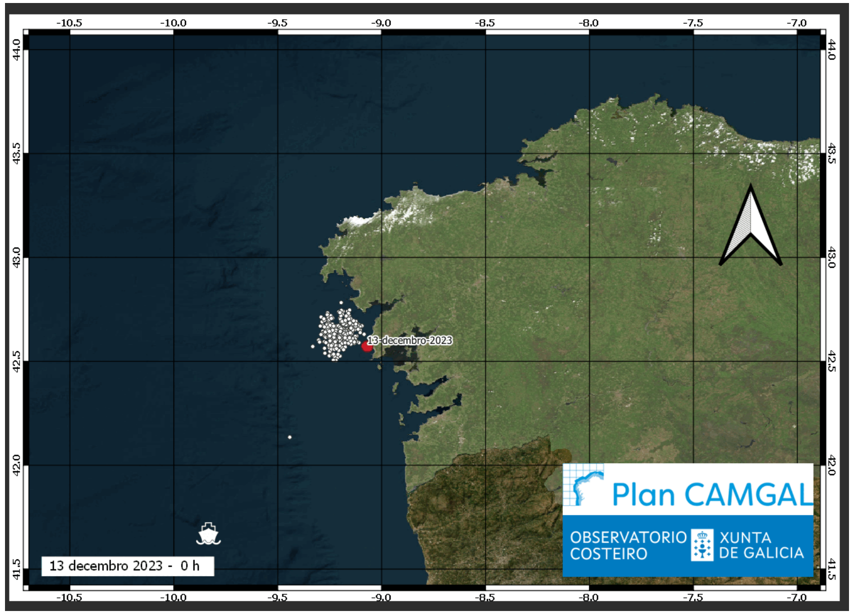
Características da simulación:

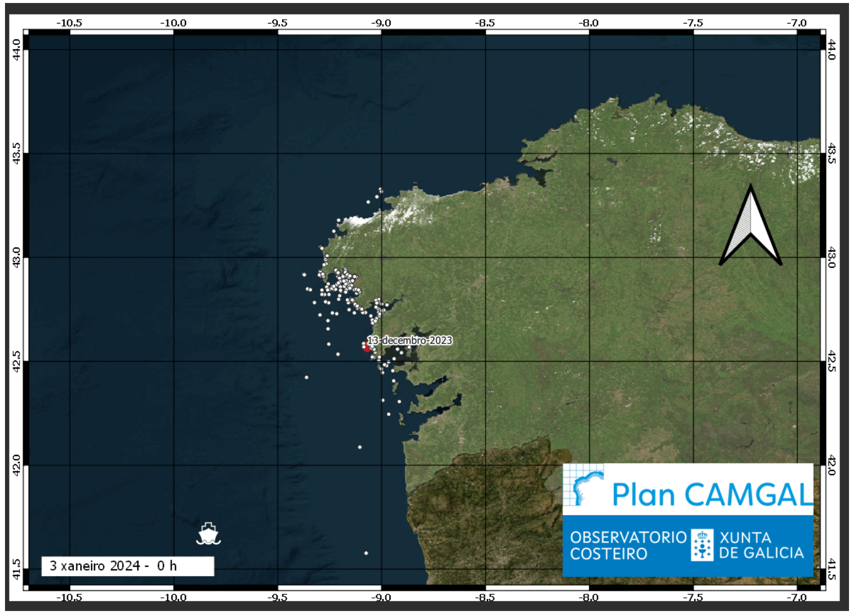
Forzamentos:

Vento: Modelo WRF operacional do Observatorio Costeiro (MeteoGalicia).

Hidrodinámica: Modelo ROMS operacional do Observatorio Costeiro (MeteoGalicia).

Execución: Unidade de Observación Próxima (Plan Camgal-Intecmar) a través do servizo Aquasafe (Hidromod)





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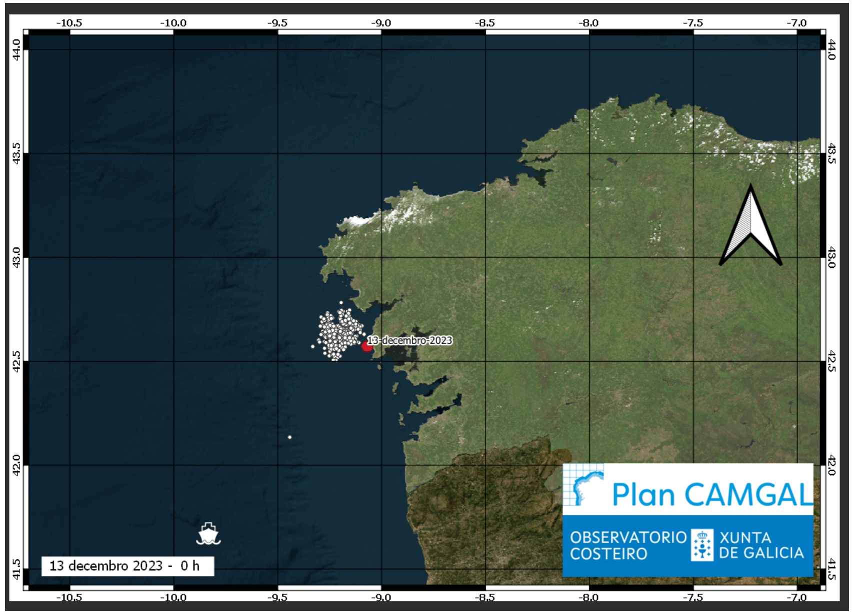

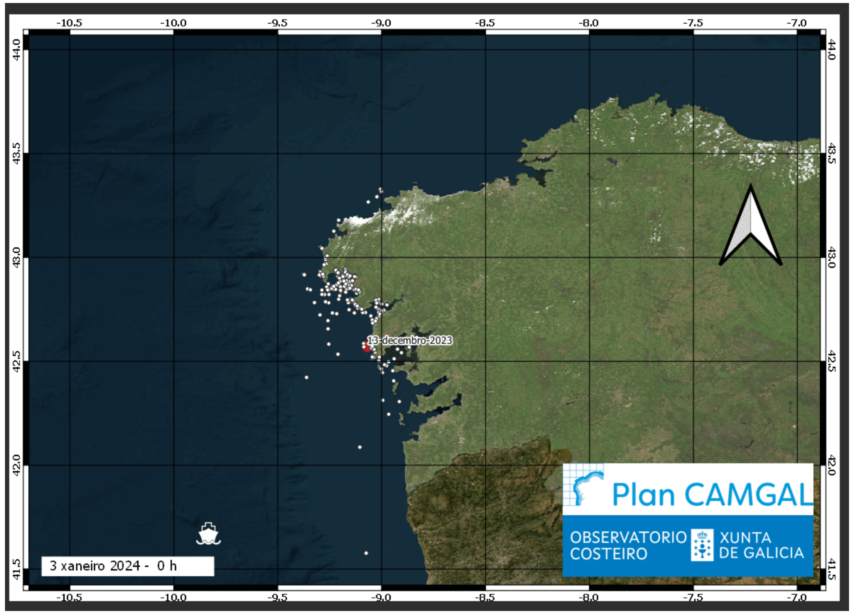

Opendrift vs MOHID Lagrangian

Conclusions

- Our Lagrangian reanalysis simulations show coherence with the spill data
- Only using both hydrodynamic and atmospheric models as forcing observations are explained
- The Lagrangian model is influenced by the choice of the floating particle type
- The Lagrangian model is influenced by the choice of forcing models (hydrodynamical and meteorological
- LCS are useful for assess the impact of freshwater fronts in the dynamics of the Galician Rías
- High resolution configurations like MeteoGalicia MOHID configuration provide detailed description of the dynamics
- Outlook: Evaluation of MOHID Lagrangian vs OpenDrift, Assessing the impact of waves in dispersion

This contribution is part of Project DEMON (Dissipation of Energy in Ocean Models and Connectivity)

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