MOHIDing

CleanAtlantic

Tackling marine litter in the Atlantic Area

Challenges in modelling marine litter in the Atlantic area

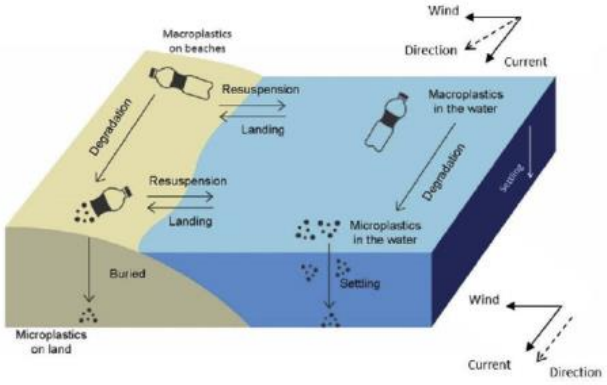
Hilda de Pablo (IST) & Daniel Garaboa (USC)

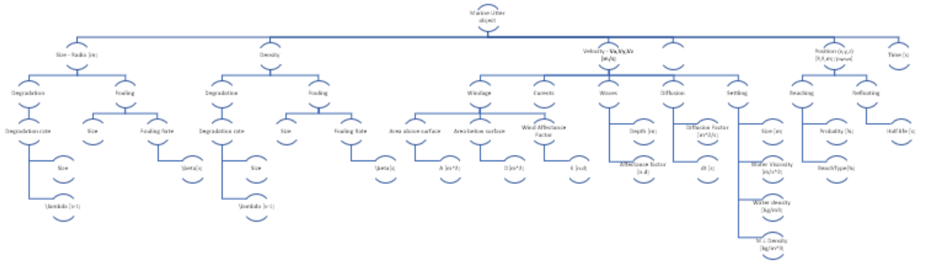
Interreg
EUROPEAN UNION
Clean Atlantic
Atlantic Area
European Regional Development Fund

A detailed look at the Actions

Action 1 - Deliverable 1: Review of the state of the art & Conceptual model

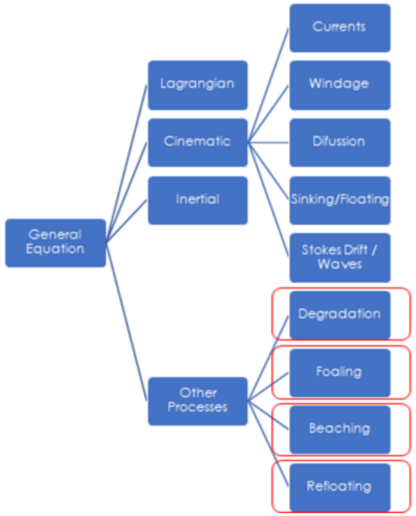
- Delay: USC gives higher priority to the modelling tool. In progress
- **D.1- Conceptual Model: First draft on the intranet.**
  - Current Stage:
    - Mendeley group - CleanAtlantic – updated references. JOIN!
    - Updating: New references and papers
    - Improvements: Problems that partners found in their scenarios.
- **Future work D.1- USC:**
    - Last correction in December.
    - Rest of the partners: Review by partners in January.
    - Deadline: February-2020





Action 1: Deliverable 1: Review of the state of the art & Conceptual model

- **D.2- Review of the state of the art. In progress.**
  - **Current Stage**
    - Draft version Intranet (Achref Marine Institute) – Base document
    - Using literature from Mendeley with updated references.
    - Review 300 papers (abstracts) to identify gaps in knowledge.
  - **Future work D.2**
    - Review → Report of the state of the art.
    - Complement the base document with this review.
    - Deadline: May-2020



Proceses	Parameters found	Parameter state	Required vars	State of knowledge	Used in:	Comments
Degradation	Size	Implicit				
	Rate	Empiric		Very Low. Gap in knowledge		Few experiment
Fouling	Size	Implicit				
	Rate	Empiric		Very Low. Gap in knowledge		Few experiment
Settling	Size	Implicit				
	Density	Implicit				
	Water Density	Implicit (approach) or derived: exact expression.	Equation of state: salinity, temperature, Depth	Good		Very well document equation.
	Viscosity	Implicit (approach) or derived: exact expression	Equation of state	Very Good		Very well document equation.
Windage	Area Above Surface	Implicit or derived	Density,size	Medium		Some literature with variations
	Area Below Surface	Implicit or derived	Density,size	Medium		Some literature with variations
	Wind Affectance	Empiric		Low		Some literature with variations
Currents						
Waves	Depth	Implicit		High		Very well documented. Analytical expression.
Diffusion	Diffusion coeficient	Empiric parameter or derived	- Turbulent energy. -Smagorinsky approach. -Other approaches	-High		Very well documented Analytical expression.
	dt	Empiric				
Beaching	Beach type	Empiric parameter		-Low		Some literaturature with variations. No agreement.
Refloating	Half life time	Empiric parameter				Some literaturature with variations. No agreement.

Action 2 Software development to include marine litter processes in open source lagrangian transport tool

The USC has collaborate actively in the development in the modelling tool

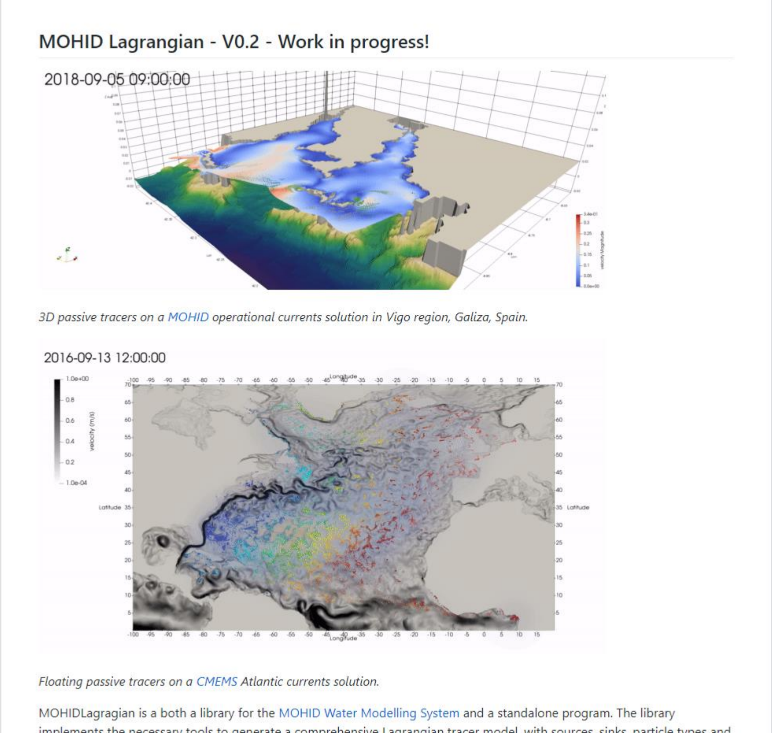
- **D.1- Lagrangian transport tool. DONE – Keep it improving**

Current Stage

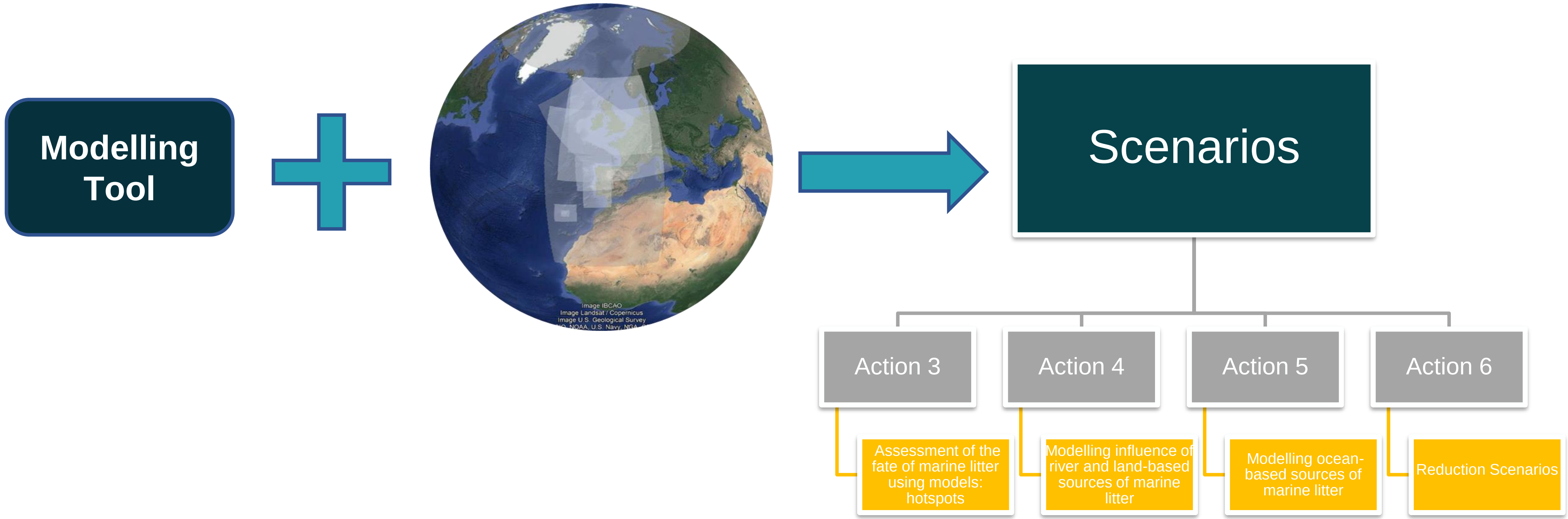
- **Processes**: Winds, waves, diffusion, degradation, buoyancy, beaching…
- Different particle types
- Emission types: lines, points, spheres, polygons, time series (rivers, population…), moving points (boats)
- Post processing package: concentrations, residence times, …
- **READY FOR RESULTS!**

Future work from USC:

- **PostProcessing package: concentrations, residence times…**
- Software: Correct errors, update and improve with partners recommendations.
- Generate documentation and tutorials.
- **Next months: Simulate, simulate and simulate!**



Actions 3-6 Assessment of the fate of marine litter using models: hotspots



USC
UNIVERSIDADE DE SANTIAGO DE COMPOSTELA

MARETEC
MARINE ENVIRONMENT & TECHNOLOGY CENTER

Actions 3-6 - Workplan

Modelling tool development → First versión → Working versión of the tool → Simulate scenarios → Report → End of Project

- Brest 2018
- Vigo 2019
- Galway 2019
- Improve the tool
- Results/Maps
- June 2020 ?

Scenarios

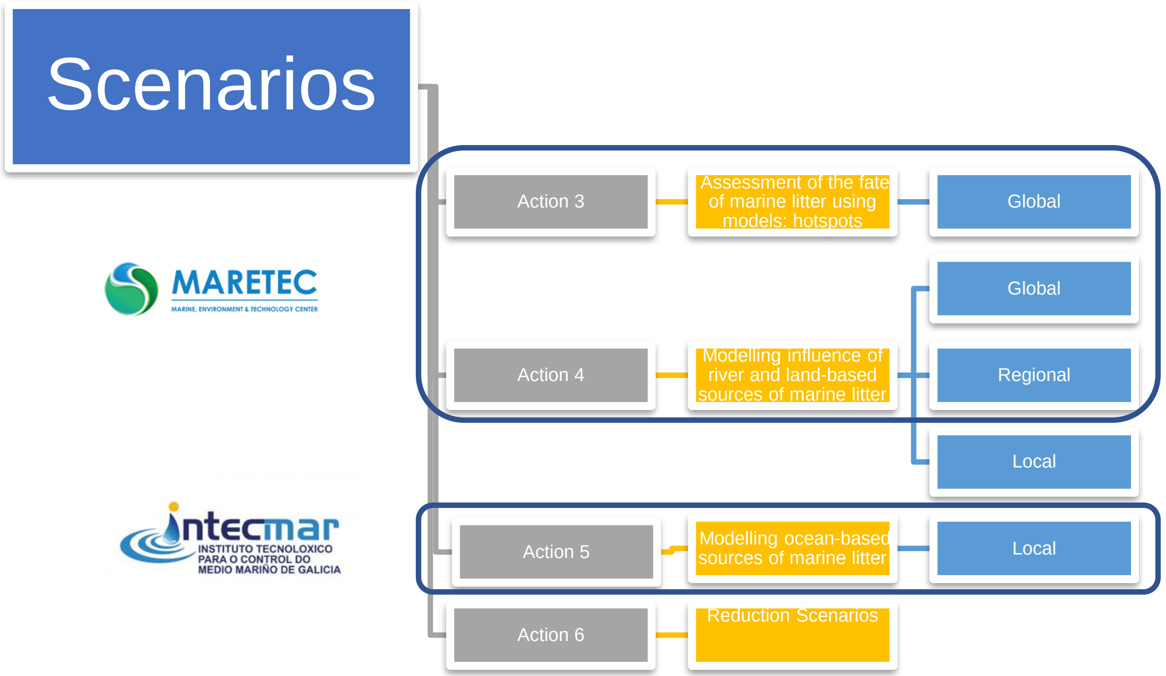
- Action 3: Assessment of the fate of marine litter using models: hotspots
- Action 4: Modelling influence of river and land-based sources of marine litter
- Action 5: Modelling ocean-based sources of marine litter
- Action 6: Reduction Scenarios

Discussion Group

Interreg
Atlantic Area
European Regional Development Fund
EUROPEAN UNION
Clean Atlantic

Actions 3-6 Workplan

- IST/USC– Defined a template to guide us with the posible scenarios to simulate for all the upcoming actions.
- Common scenarios will be done in collaboration. Example: ATLANTIC Global: USC/IST or Local Arousa: USC/Intecmar or Local Tagus IST
- The scenarios are divided mainly **by areas, emission types and particles types.**
- **The template is open for modifications**
- **Discussion group: Scenarios and results.**



	Scenario	Region	Type	Emission type	Release Frequency	Particle type	Inp
1	Scenario	Region	Type	Emission type	Release Frequency	Particle type	Inp
2	1	Atlántico Global	2D	Full domain – One emission regular surface grid	At Start	Floating	Cu
3	2	Atlantico Global	3D	Full domain – Different regular grids at surface. One per plastic types	Cold start – Time scale considered	Table types|*2| – Buoyancy/Density/Degradation	Cu
4	3	Atlántico Global	2D	Main – traffic lines	Continuous – poliline	Floating	Cu
5	4	Atlantico Global	3D	River Emission / Climate discharge / Emission function	Continuous – point discharge	Table types|*2| – BuoyancyDensity/Degradation	Cu
6	5	Regional*1l	2D	Full domain – Different regular grids at surface. One per plastic types	Cold start – Time scale of your area considered	Table types|*2| – BuoyancyDensity/Degradation	Cu
7	6	Regional*1l	3D	River Emission / Climate discharge / Emission function	Continuous – point discharge	Table types|*2| – BuoyancyDensity/Degradation	Cu
8	7	Regional|*1|	3D	River Emission (previous) + Other ocean sources important region (acualcuture, fishing grounds, marine	Continuous - point + polygon discharge	Table types|*2| – BuoyancyDensity/Degradation + given c	Cu
9	8	Local	2D	Full domain – Different regular grids surfaces. One per plastic types	Cold start – Time scale of your area	Floating	Cu
10	9	Local	3D	River Emission / Climate discharge / Same plastics type than previous as a caudal function	Continuous – point discharge	Table types|*2| – BuoyancyDensity/Degradation	Cu
11	10	Local	3D	River Emission (previous) + Other sources important region	Continuous - point + polygon discharge	Table types|*2| – BuoyancyDensity/Degradation + given c	Cu
12							
13	Comments/Ar	What is superficial? :					
14		**Windage** – Sail					
15		**Regional models**: Best input that you got? Hydrodynamic – best that you have!					
16		**Time**: 5 years is the recomendation. Some datasets maybe don't have so many time steps.					
17		**Residence Time:** Multiple methodologies to compute it. The residence time should estimate the time that a particle or concentration spent on a area. This area is the Exclusive Economic zone limits or your model domains is smaller.					
18		**Beaching:** Must be activated on local and regional escenarios.					
19		**Starting Time:** If you don't have enough data. Use you data available					
20							
21	|*1|Regional: Irlanda, RU, -, España, Madeira, Portugal Continental						
22	|*2|Second sheet for plastic types.						

1	**Generic Behaviour Name**	strongly buoyant	slightly buoyant	slightly sinking	sinking						
2	**Behaviour ID**	A	B	C	D						
3	**Description**	sinking velocity upward and large	sinking velocity upward but small	sinking velocity downward but small	nking velocity downward and moderate						
4	**Average density range**	0.92-0.99 g/cm ??	0.99-1.15 g/cm ??	1,15-1,24 g/cm ??	>1,24 g/cm ??						
5	**Average radius range**	> 2 cm ??	< 2 cm ??	< 2 cm ??	~ 1 cm ??						
6											
7											
8											
9	**Garbage ID**	1	2	3	4	5	6	7	8	9	10
10	**Common Name/ Object Name**	Bottle	Plastic Bag	Bottle cap	Floats	Containers	Fishing nets	Cigarret filters	Plastic Film	Textiles	Soft Drink Bottles
11											
12	Generic Behaviour Type	Strongly buoyant = A	Slighty buoyant = A	Slighty buoyant =B	Slighty buoyant =B	Slighty buoyant = B	Sinking =D	Slighty buoyant =C	Sinking = D	Sinking = D	Sinking = D
13	**Material name**	polyethylene terephthalate	Polyetilene	polyethylene terephthalate	Polystyrene, EPS	Polystyrene, EPS	Polyamid or Nylon	Cellulose acetate	Polyvinil chloride, PVC	Polyesther resin	ethylene, terephtalate, PET
14	**Average density**	0.92 g/cm	0.95 g/cm	0.92 g/cm	1,01 g/cm	1,09 g/cm	1,15 g/cm	1,24 g/cm	1,3 g/cm	1,35 g/cm	1,39 g/cm
15	**Density standard deviation**										
16	**Average radius**	14 cm	25.88 cm	1.3 cm							
17	**Radius standard deviation**	8 cm	12 cm	0.3 cm							
18	**Average-HalfLife / Half-Life Deviation**										
19	**Half life (years)**										
20	**Caracteristic Time Scale**	450 years -1000 years	450 years -1000 years	> 15 years							
21	**Data Source**				https://ec.europa.eu/environment/marine/good-environmental-status/descriptor-10/pdf/GESAMP_microplastics%20full%20study.pdf	vironment/marine/good-environmental-status/descriptor-10/pdf/GESAMP_microplastics%20full%20study.	nvironment/marine/good-environmental-status/descriptor-10/pdf/GESAMP_microplastics%20full%20s	vironment/marine/good-environmental-status/descriptor-10/pdf/GESAMP_microplastics%20full%20study	environment/marine/good-environmental-status/descriptor-10/pdf/GESAMP_microplastics%20full%2	environment/marine/good-environmental-status/descriptor-10/pdf/GESAMP_microplastics%20full%2	environment/marine/good-environmental-status/descriptor-10/pdf/GESAMP_microplastics%20full%2
22	**Comments**			Intact until 15 years, then it breaks into small pieces							
23	Other Parameters of Potential interest										
24	Comments: The HafLife is the time needed by the object to loss half of it mass. If this parameter cannot be provided, it would be useful to know its characteristic Time Scale as the time required to completely degradate. For the modellers, this is usefull to swicth on/off the degration particle model.										

	Euleriano						Flow			Lagrangian										
	hidrod-euleriano									Simulation					Seeding					Results
	Domine	Resolution(m)	dt (netcdf)	malha	Horizontal	Vertical	Info	Date		Inicio	Fim	BoundingBox	depth	dt (s)	Dominio	Partc_ini	x, y, z (m)	vertical	days	outputWrite
TagusReseeding	Tagus3D	200-2000		cartesiana	irregular	sigma+cartesiana				01/01/2019	15/11/2019	200,200,2	´-200,10	360	estuario	12828	200,200,1	0	5	3600
TagusRiver	Tagus3D	200-2000		cartesiana	irregular	sigma+cartesiana	Almourol	2013?		01/01/2019	11/11/2019	200,200,2	´-200,10	360	punto	f(Q)	-	0	-	3600
PCOMSReseeding	PCOMS3D	5400		cartesiana	regular	sigma+cartesiana				01/01/2019	15/11/2019	2000,2000,2	´-200,10	1800	Full	158079	2000,2000,2	0	30	10800
PCOMSRivers	PCOMS3D	5400		cartesiana	regular	sigma+cartesiana	Lambda	2013	daily average	01/01/2019	15/11/2019	2000,2000,2	´-200,10	1800	punto	f(Q)	-	0	-	10800
PCOMSMarineTraffic	PCOMS3D	5400		cartesiana	regular	sigma+cartesiana	EMODnet			01/01/2019	15/11/2019	2000,2000,2	´-200,10	1800	poligonos	f(density)	1000,1000,1	0	-	10800
PCOMSHarbour	PCOMS3D	5400		cartesiana	regular	sigma+cartesiana	EMODnet			01/01/2019	15/11/2019	2000,2000,2	´-200,10	1800	punto	f(density)	-	0	-	10800
Atlantic	CMEMS 2D(simple)	0.06-0.08 (grados)		cartesiana	regular	cartesiana				01/02/2016	11/11/2019	8000,8000,10	´-10,10	14400	Full	3168978	4000,4000,10	1*	0	43200
AtlanticRivers	CMEMS 2D(simple)	0.06-0.08 (grados)		cartesiana	regular	cartesiana	Lambda + IHCar	2013x4 2009x4	daily average	01/02/2016	20/11/2019	8000,8000,10	´-10,10	14400	punto	f(Q)	-	0	-	86400
SantanderReseeding1	Santander2D	5-200	3600	curvilinea (estructurada)	regular					01/01/1988	01/01/1989	15,15,2	´-1,1	360	Full	192952	30,30	0	5	3600
SantanderResseging2	Santander2D	5-201	3600	curvilinea (estructurada)	regular					01/01/1988	01/01/1989	15,15,2	´-1,1	360	Full	772020	15,15	0	30	3600
SantanderRiver	Santander2D	5-200	3600	curvilinea (estructurada)	regular		IHCantabria	1988	daily average	01/01/1988	01/01/1989	15,15,2	´-1,1	360	punto	f(Q)	-	0	-	3600

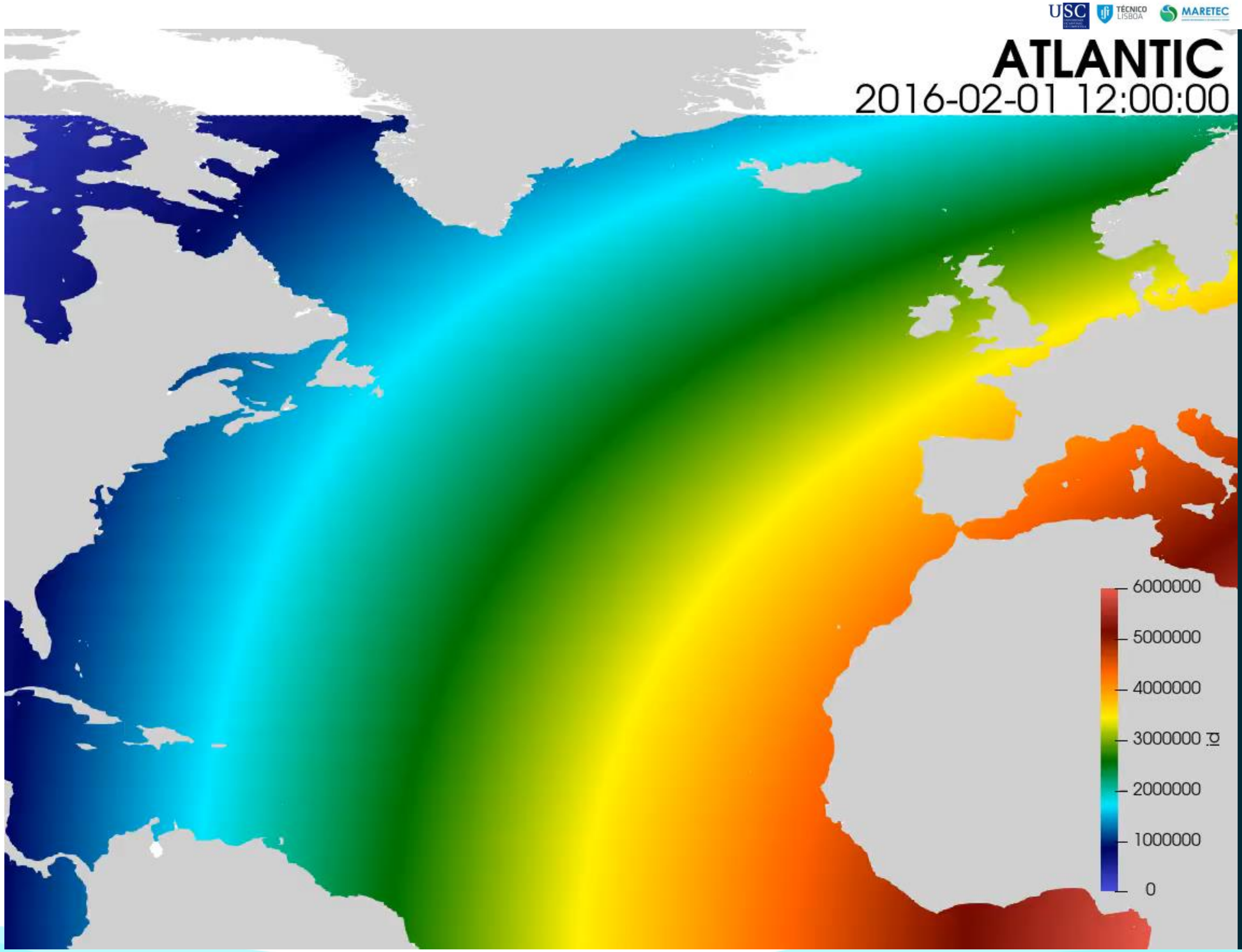
*sigma em 3D

*f(Q)
partcFinales emitidas
volumen total
volumen total/partcFinales emitidas

*f(density)
density= horas/km2/mes
ratio horas=partic (em segundos) por km2

Atlantic Scenarios

Actions 3 Assessment of the fate of marine litter using models: hotspots



- **Hydrodynamic**

CMEMS
No waves
No tide
No rivers

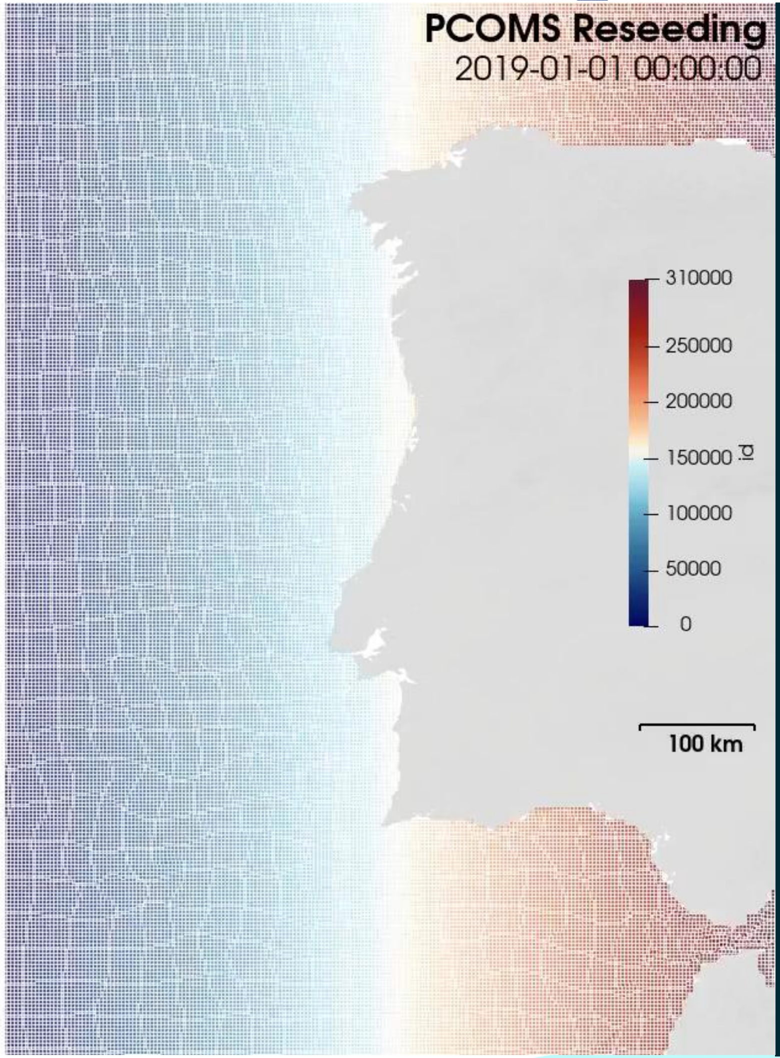
- **Lagrangian**

Lagrangian tool
Conservative particles (=water)
Surface
3 200 000 particles

- **Simulation time = 4 years**

Actions 3 Assessment of the fate of marine litter using models: hotspots

Regional Scenarios



- **Hydrodynamic**

PCOMS-3D
Tide
Wind
No waves
No rivers

- **Lagrangian**

Lagrangian tool
Conservative particles (=water)
Reseeding (30 days)
Surface
End: **500 000** particles

- **Simulation period = 2019**

Action 4 Modelling influence of **river and land-based** sources of marine litter

- **Current Stage**
  - The USC is collaborating with IST on simulating the scenarios around the Iberian area.
  - **Results of river scenarios**:
    1. **Atlantic Scenarios – IST/USC**
    2. **Regional Scenarios – IST/USC** Emissions of floating litter for 1 year of continuos emisión around Iberian Peninsula.
        1. PCOMS/IBI - Data rivers
    3. **Local Scenarios - USC**
        1. Arousa Ría Rivers – 2D floating and Tagus - 3D floating
        2. Vigo Ría Rivers – 3D rivers
- **Future work**
  - Add more rivers – Seeking for databses
  - Add other potencial sources of marine litter – Partners information
  - 3D simulations with multiple litter types
- Deadline: May - June 2020

Interreg Atlantic Area
European Regional Development Fund
EUROPEAN UNION
Clean Atlantic

Action 4 Modelling influence of **river and land-based** sources of marine litter

Atlantic Scenarios

61 European Rivers (daily average)

- **Hydrodynamic**

CMEMS
- No waves
- No tide
- No rivers

- **Lagrangian**

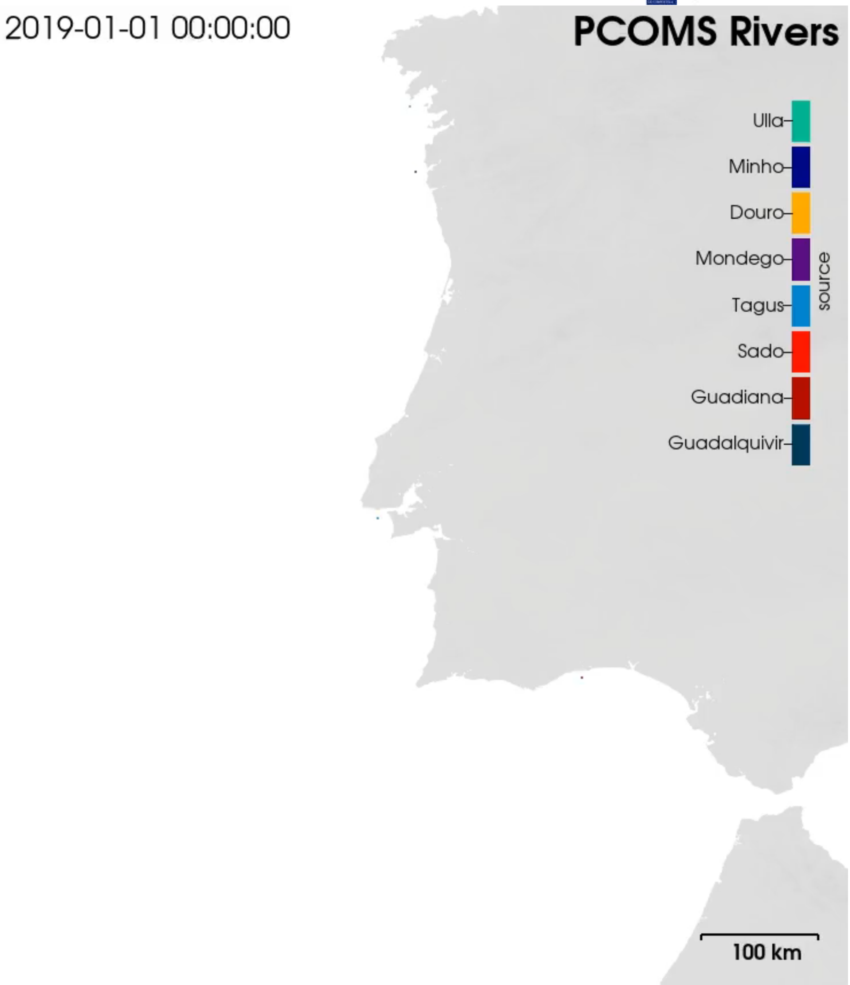
Lagrangian tool
Conservative particles (=water)
61 Rivers
Surface
1 500 000 particles

- **Simulation time = 4 years**

Action 4 Modelling influence of **river and land-based** sources of marine litter

Regional Scenarios

8 Iberian Rivers
(daily average)



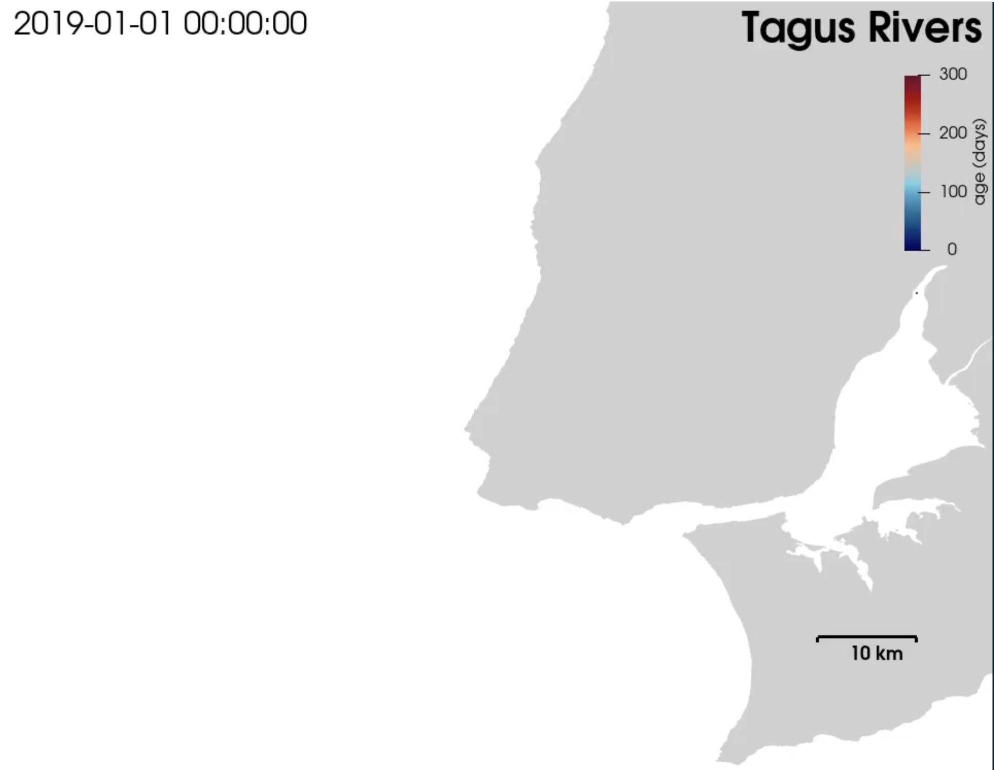
- **Hydrodynamic**

PCOMS-3D
Tide
Wind
No waves
No rivers

- **Lagrangian**

Lagrangian tool
Conservative particles (=water)
$f(flow)_{river}$
Surface

Action 4 Modelling influence of **river and land-based** sources of marine litter



- **Hydrodynamic**

Tagus-3D
Tide
Wind
No waves
No rivers

- **Lagrangian**

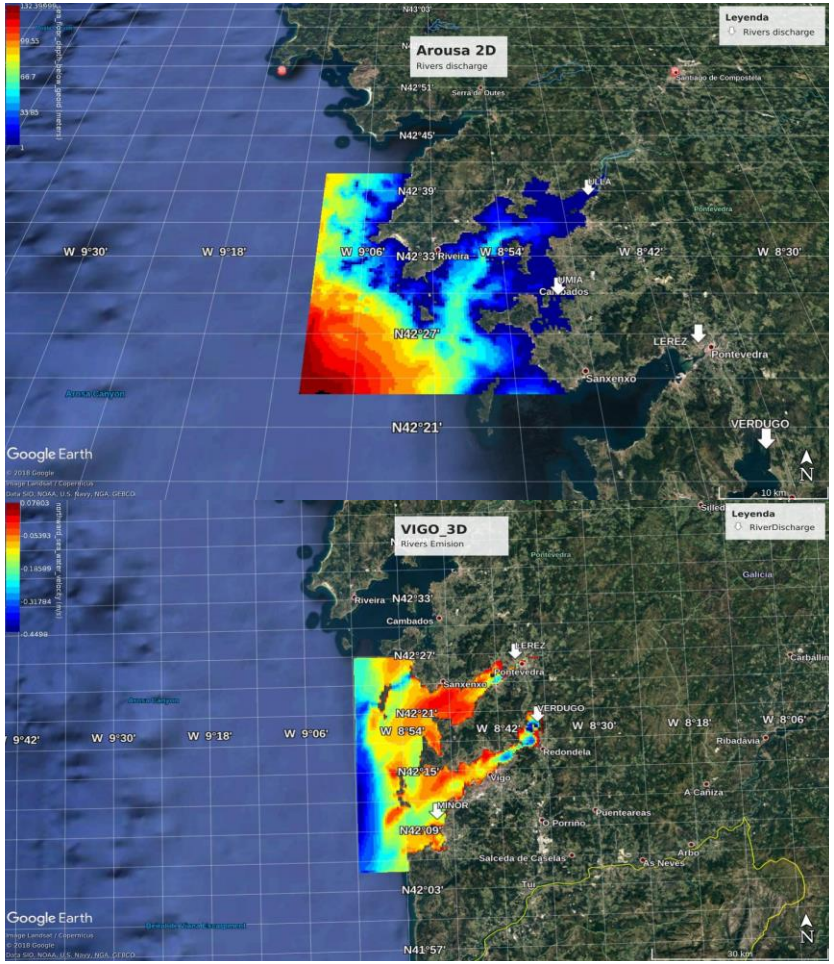
Lagrangian tool
Conservative particles (=water)
f(flow)river
Surface

Action 4 - Modelling influence of river and land-based sources of marine litter – Regional Scenarios

- **Current stage**
  - 2D Floating litter
  - IBI Model from CMEMS
  - Waves from CMEMS
  - Wind data from ECWMF
  - 41 Rivers with dayly discharge
  - 1 year of simulation
- **Future work**
  - 3D and multiple types of marine Litter
  - More rivers

Action 4 Modelling influence of **river and land-based** sources of marine litter

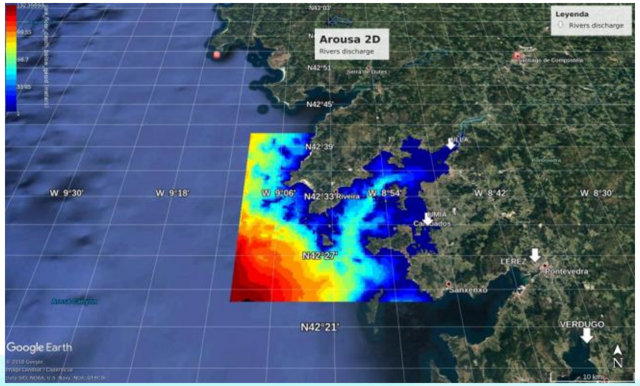
- **Current work**
  - **2 scenarios:**
    - Rivers daily discharge data:
      - MeteoGalicia stations
    1. **Arousa 2D**: in collaboration with Intecmar
       - 2D - Floating litter
       - 8 – months of simulations
    2. **Vigo 3D**
       - 3D – 4 types of marine litter
       - Test – 1 week of simulation
- **Future work**
  - 3D for longer times -1 year
  - More sources and more realistic plastic types
  - Obtain long term concentration maps

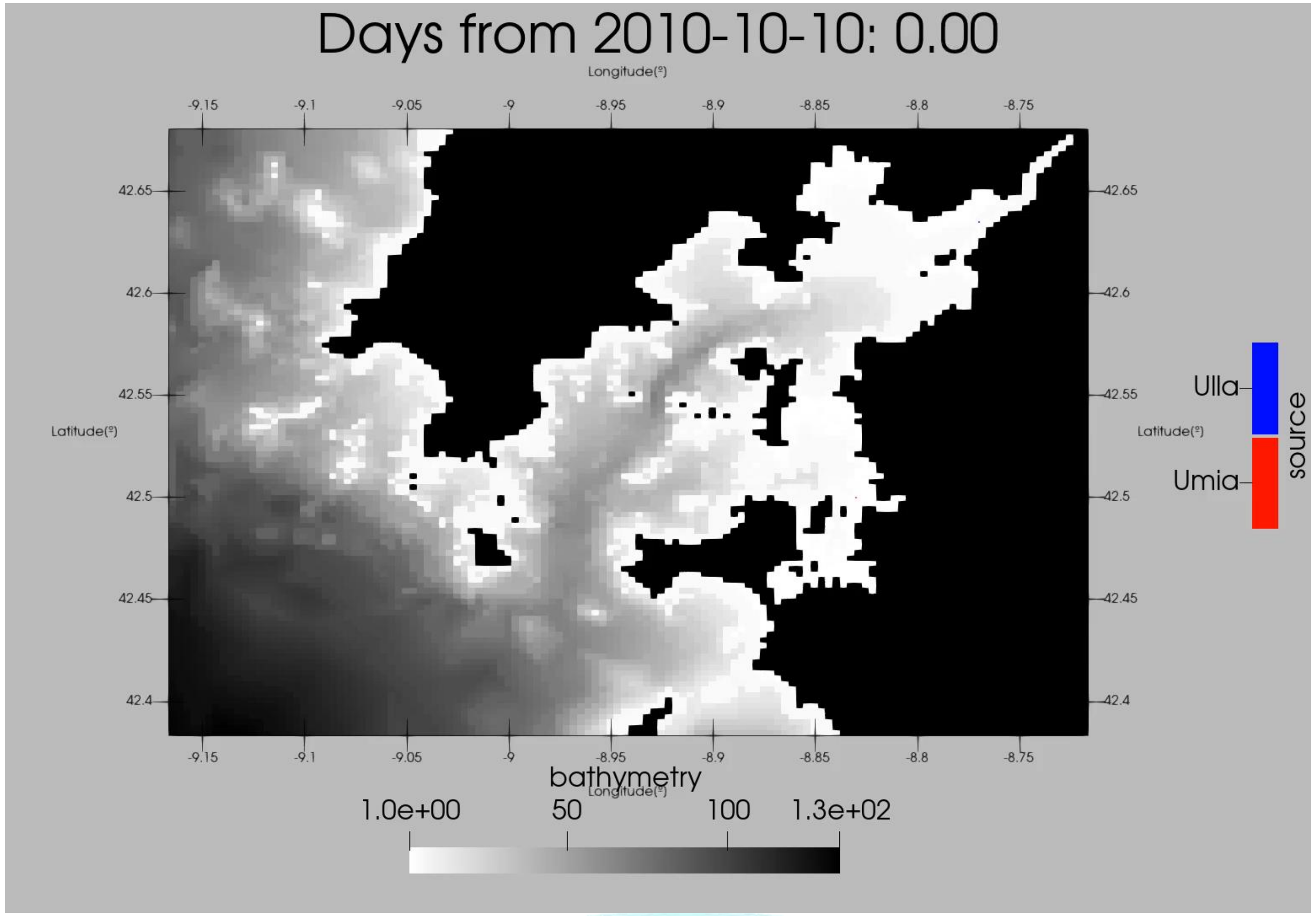


Local Scenarios

Arousa – 2D - Rivers

- 3 Rivers daily discharge data from MeteoGalicia river stations
- Hydrodinamic, fields from Meteogalicia - MOHID.
- 2d Floatting litter
- 8 months of simulations



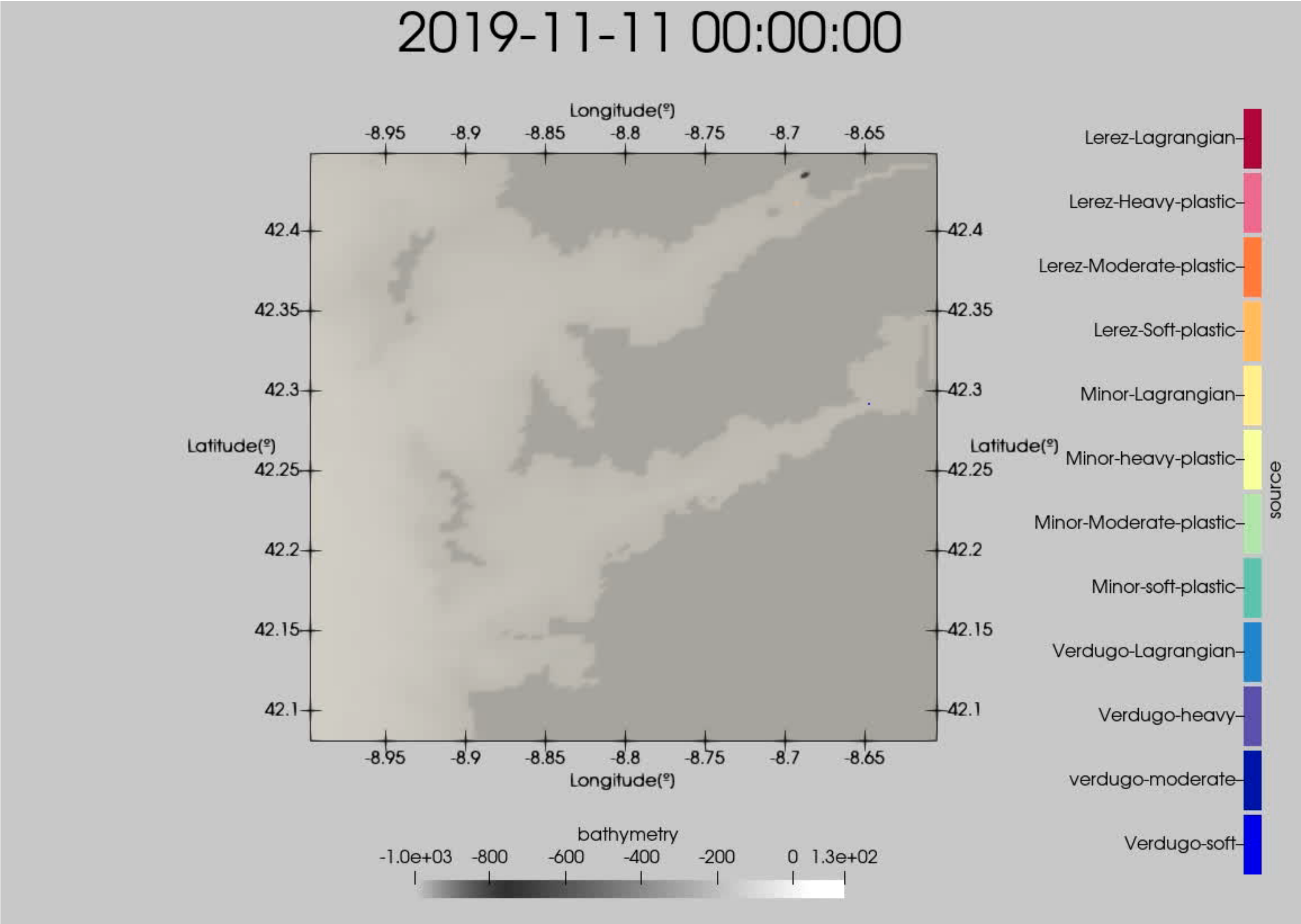


Interreg Atlantic Area
European Regional Development Fund
Clean Atlantic

Local Scenarios

Vigo 3D

- 3 Rivers daily discharge data from MeteoGalicia river stations
- Hydrodinamic, temperature and salinity fields from Meteogalicia - MOHID.
- 4 types of MarineLitter per river
- Water density (Lagrangian), light, moderate, heavy
- Same size
- 10 days of simulation
- 200000 particles at 10 days.

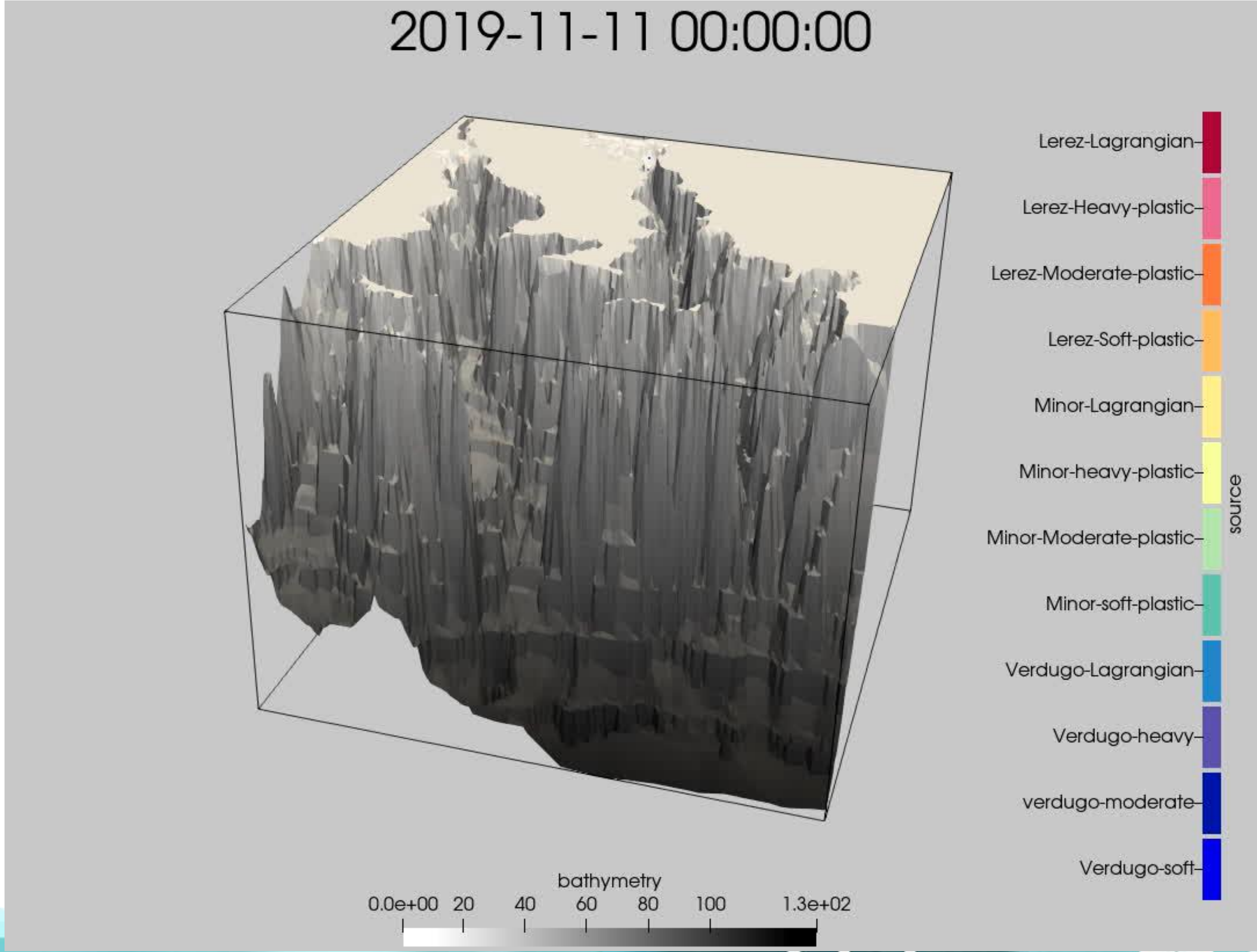


USC UNIVERSIDADE DE SANTIAGO DE COMPOSTELA

Local Scenarios

VIGO-3D

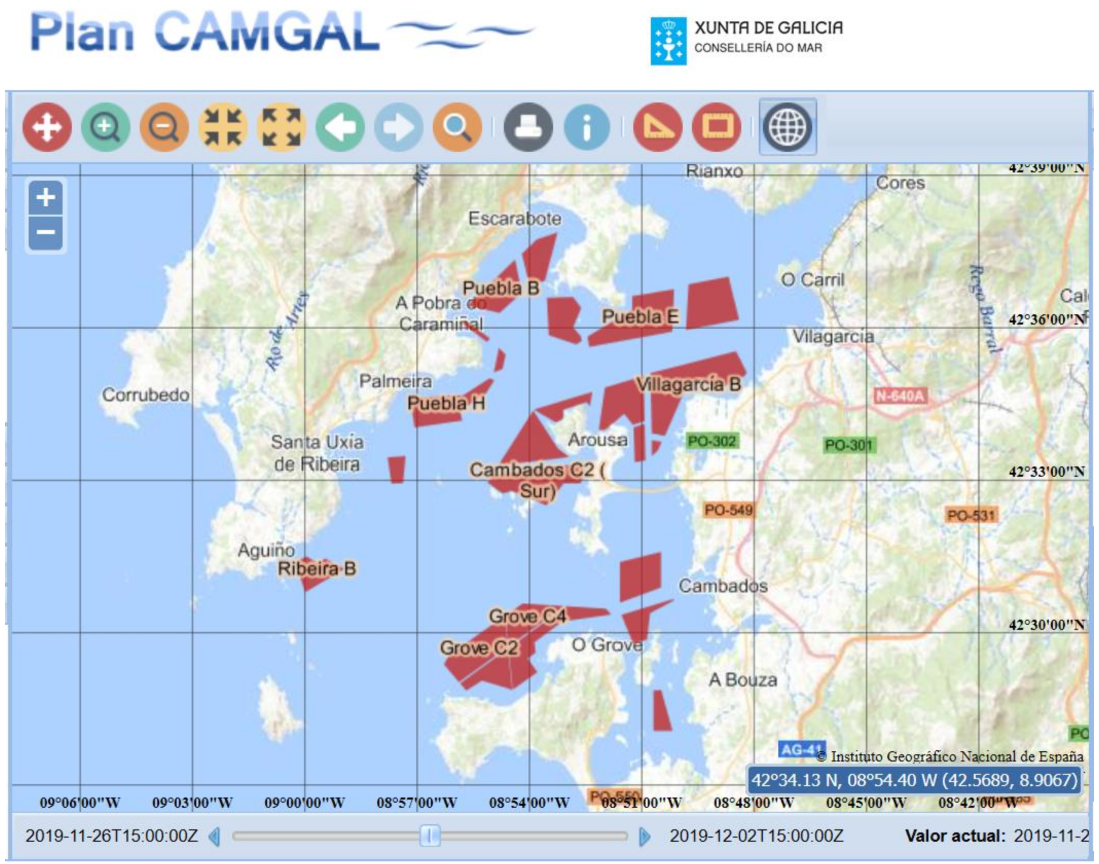
- 3 Rivers daily discharge data from MeteoGalicia river stations
- Hydrodinamic, temperature and salinity fields from Meteogalicia - MOHID.
- 4 types of MarineLitter per river
- Water density (Lagrangian), light, moderate, heavy
- Same size
- 10 days of simulation
- 200000 particles in 10 days.



Local Scenarios

Action 5 Modelling ocean-based sources of marine litter

- Current Work
- In collaboration with Intecmar
  - Arousa
    - 2D – Mussel Pegs - > Floating litter
    - Processes: Currents, difusion and beaching
    - 8 months of simulations
    - Real data work polygons from Intecmar
    - Emission rate – Working Time
  - Future work
    - Improve the emission scenarios
    - Validate data with measures from Intecmar
    - Obtain long term concentration maps

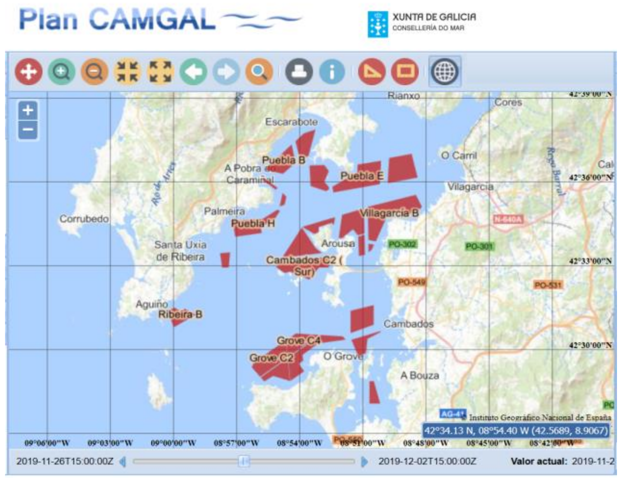


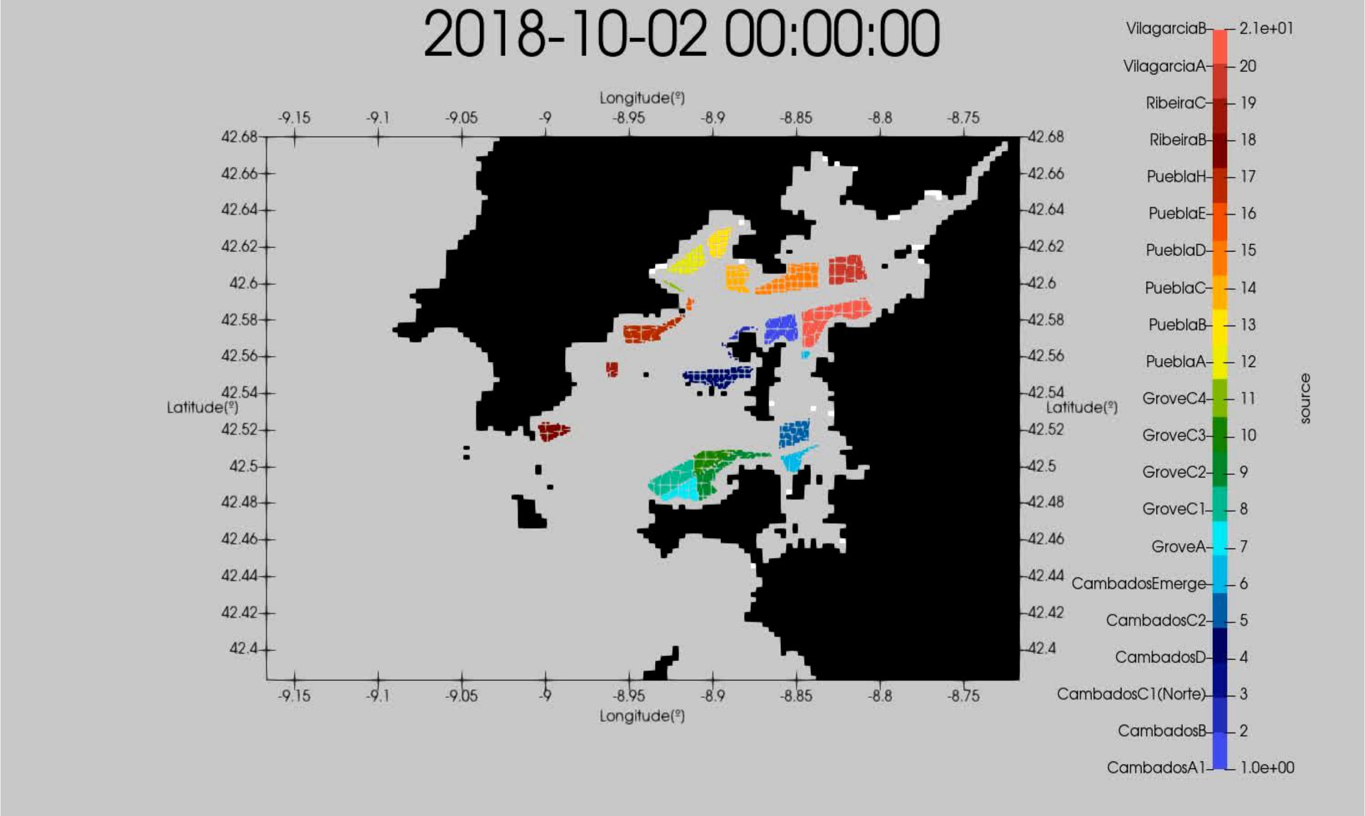
Interreg Atlantic Area
European Regional Development Fund
Clean Atlantic

Local Scenarios

Action 5 Modelling ocean-based sources of marine litter – Local Scenarios

- **Arousa**
  - 2D – Mussel Pegs - > Floating litter
    - Processes: Currents, difusion and beaching
  - 8 months of simulations
  - Real data work polygons from Intecmar
  - Emission rate – 2 mussel pegs per day per "batea" - Working Time 8-14

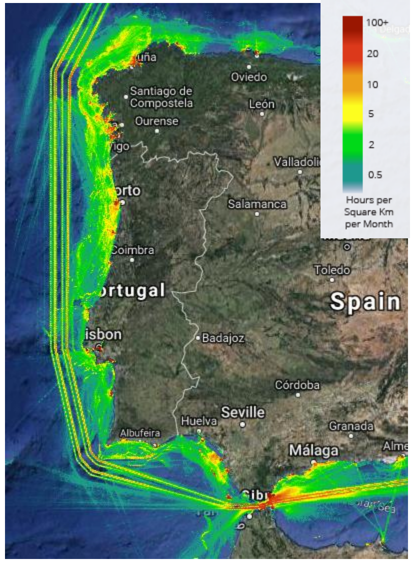




Interreg Atlantic Area
European Regional Development Fund
EUROPEAN UNION
Clean Atlantic

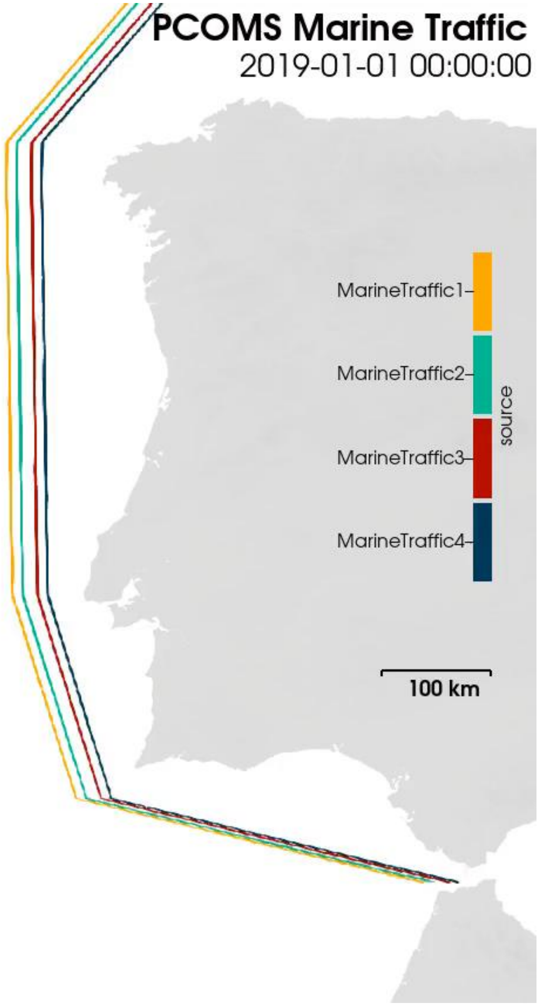
Action 5 Modelling ocean-based sources of marine litter

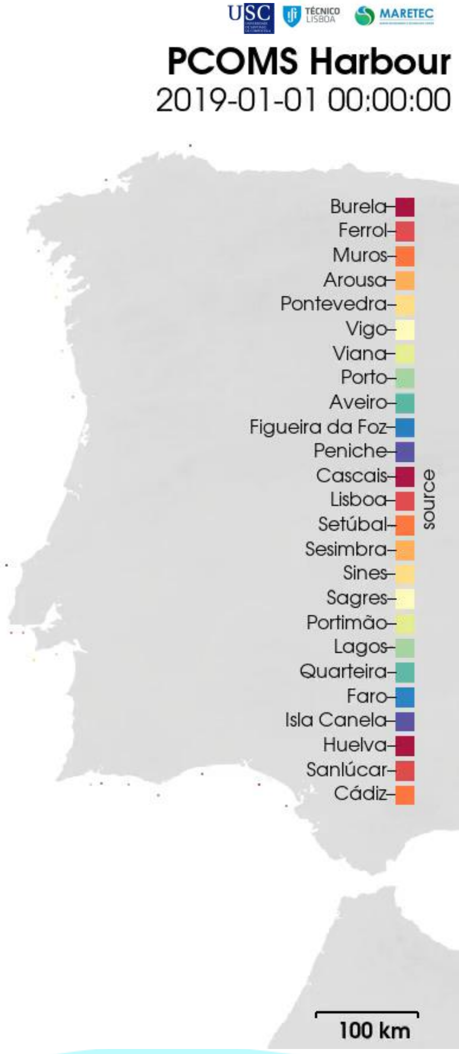
Regional Scenarios



5, 20, 10, 30 hours/km^2/month

https://www.emodnet-humanactivities.eu/view-da





- **Hydrodynamic**

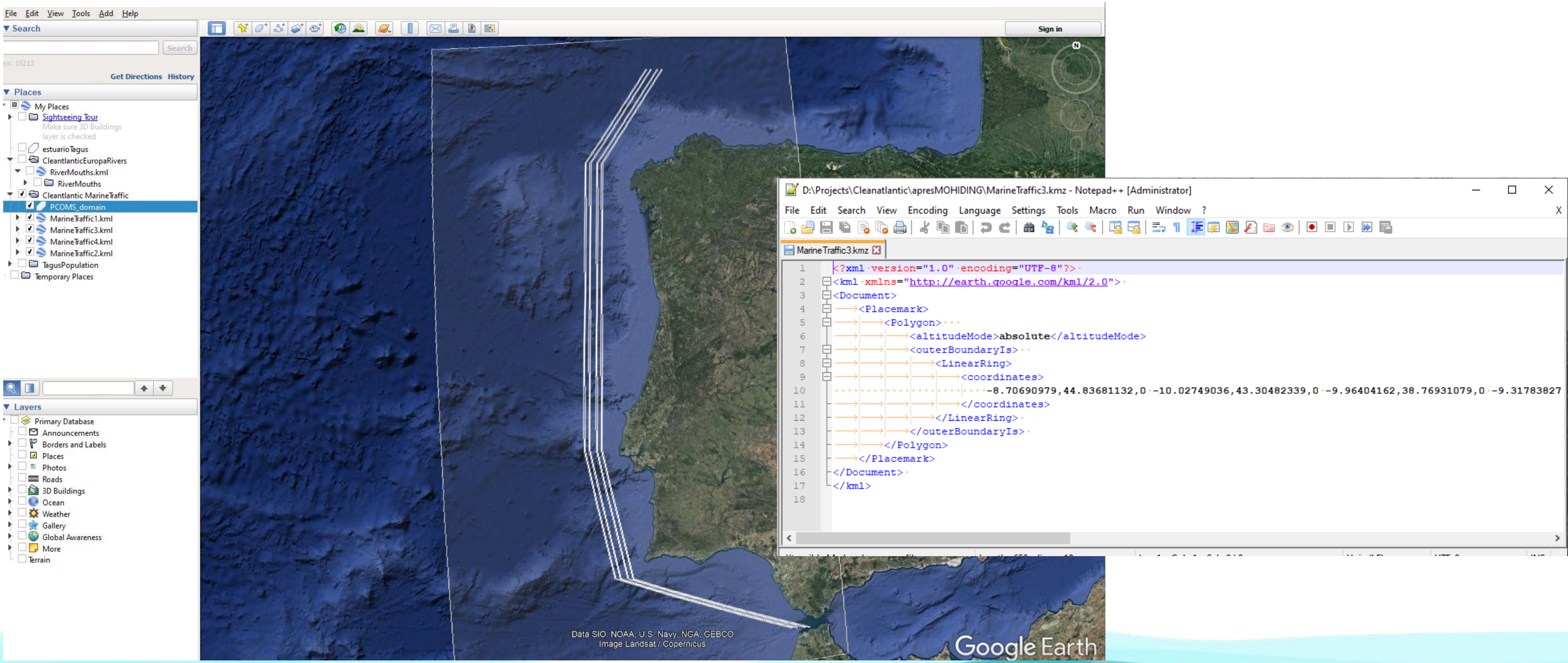
PCOMS-3D
Tide
Wind
No waves
No rivers

- **Lagrangian**

Lagrangian tool
Conservative particles (=water)
f(density)$_{\text{trajectories}}$
Surface

MARETEC
MARINE ENVIRONMENT & TECHNOLOGY CENTER

Polígonos Marine Traffic



Interreg Atlantic Area
European Regional Development Fund
EUROPEAN UNION
Clean Atlantic

D:\Projects\Cleanatlantic\apresMOHIDING\PCOMS_MarineTraffic.xml - Notepad++ [Administrator]

File Edit Search View Encoding Language Settings Tools Macro Run Window ?

MarineTraffic3.kmz | PCOMS_MarineTraffic.xml


```xml
<?xml version="1.0" encoding="UTF-8" ?>
<case>
    <execution>
        <parameters>
            <parameter key="Start" value="2019 01 01 00 00 00" comment="Date of initial instant" units_comment="space delimited ISO 8601 format up
            <parameter key="End"   value="2019 11 25 00 00 00" comment="Date of final instant" units_comment="ISO format" />
            <parameter key="Integrator" value="2" comment="Integration Algorithm 1:Euler, 2:Multi-Step Euler, 3:RK4 (default=1)" />
            <parameter key="Threads" value="4" comment="Computation threads for shared memory computation (default=auto)" />
            <parameter key="OutputWriteTime" value="10800" comment="Time out data (1/Hz)" units_comment="seconds" />
        </parameters>
        <outputFields>
            <file name="data/outputFields.xml"/>
        </outputFields>
        <variableNaming>
            <file name="data/ncNamesLibrary.xml"/>
        </variableNaming>
<!--        <postProcessing>
            <file name="Post_scripts/PostRecipe.xml"/>
        </postProcessing> -->
    </execution>
    <caseDefinitions>
        <inputData>
            <inputDataDir name="/samba/thredds/MOHID_WATER/PORTUGAL_0.06DEG_50L_3H/FORECAST" type="hydrodynamic"/>
        </inputData>
        <simulation>
            <!-- <resolution dp="1500" units_comment="metres (m)"/> -->
            <resolution x="2000" y="2000" z="2" units_comment="metres (m)"/>
            <timestep dt="1800" units_comment="seconds (s)"/>
            <BoundingBoxMin x="-12.56" y="34.42" z="-200" units_comment="(deg,deg,m)"/>
            <BoundingBoxMax x="-5.14" y="44.96" z="10" units_comment="(deg,deg,m)"/>
        </simulation>
        <sourceDefinitions>
            <source>
                <setsource id="1" name="MarineTraffic1" />
                <resolution x="1000" y="1000" z="1" units_comment="metres (m)"/>
                <rateTimeSeries>
                    <file name="data/DischargeMT1.dat" comment="name of csv file with discharge information (time and rate columns)"/>
                    <scale value="1" comment="scales the data on the file by this factor (not time)" />
                </rateTimeSeries>
                <active start="0" end="end" comment="example: start='12.7' end='end'; start='0.0' end='95' " units_comment="seconds (s)" />
                <polygon>
                    <file name="data/MarineTraffic1.kmz"/>
                    <verticalBoundingBox min="-1.0" max="0.0"/>
                </polygon>
            </source>
            <source>
                <setsource id="3" name="MarineTraffic3" />
                <resolution x="1000" y="1000" z="1" units_comment="metres (m)"/>
                <rateTimeSeries>
                    <file name="data/DischargeMT3.dat" comment="name of csv file with discharge information (time and rate columns)"/>
                    <scale value="1" comment="scales the data on the file by this factor (not time)" />
                </rateTimeSeries>
                <active start="0" end="end" comment="example: start='12.7' end='end'; start='0.0' end='95' " units_comment="seconds (s)" />
                <polygon>
                    <file name="data/MarineTraffic3.kmz"/>
```


eXtensible Markup Language file | length : 7,423 lines : 149 | Ln : 1 Col : 1 Sel : 0 | 0 | Unix (LF) | UTF-8 | INS

Polígonos tagus ☹ Poliline tagus ☺