

CleanAtlantic

Tackling marine litter in the Atlantic Area

Numerical models to predict marine litter fate and
map hotspots

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As part of the modelling group in CleanAtlantic: IST, IEO, INTECMAR, CEFAS, MI, DGRM,
DROTA, IFREMER

0. Why do we need to model marine litter?

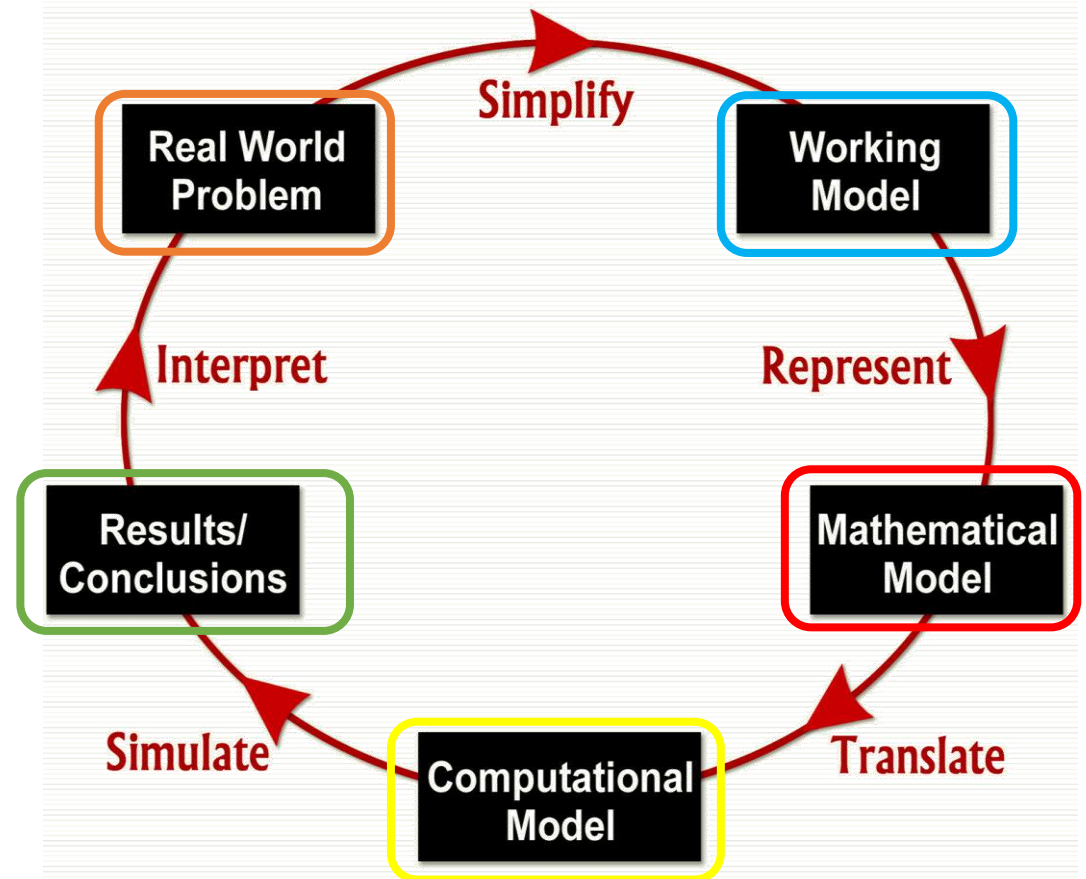
Among others...

- To predict the origin, circulation and fate of marine litter → **to impose measures to reduce the use of plastic**
- To locate hotspots of litter accumulation → **for cleaning purposes**
- To design new ways/tools to reduce marine litter emission → **support stakeholders in the decision making**

1. The modelling problem



<http://www.tonywublog.com/journal/the-problem-of-garbage-in-the-oceans>



2. Conceptual model

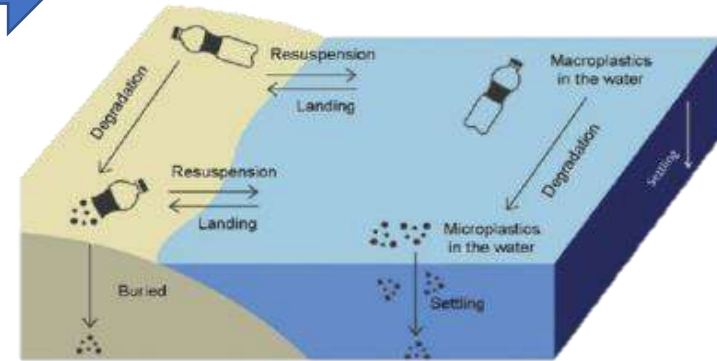
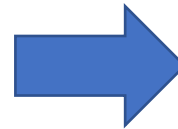
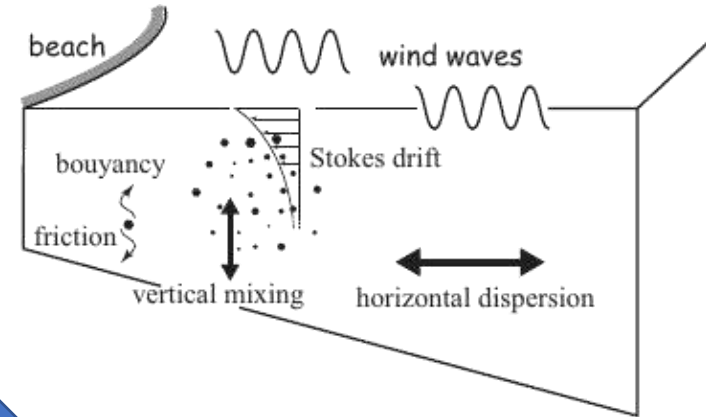


Properties

- Position
- Shape
- Size
- Density
- ...

Processes

- Transport
- Currents
- Waves
- Wind
- Diffusion
- Sinking
- Degradation
- Beaching
- Refloating
- ...



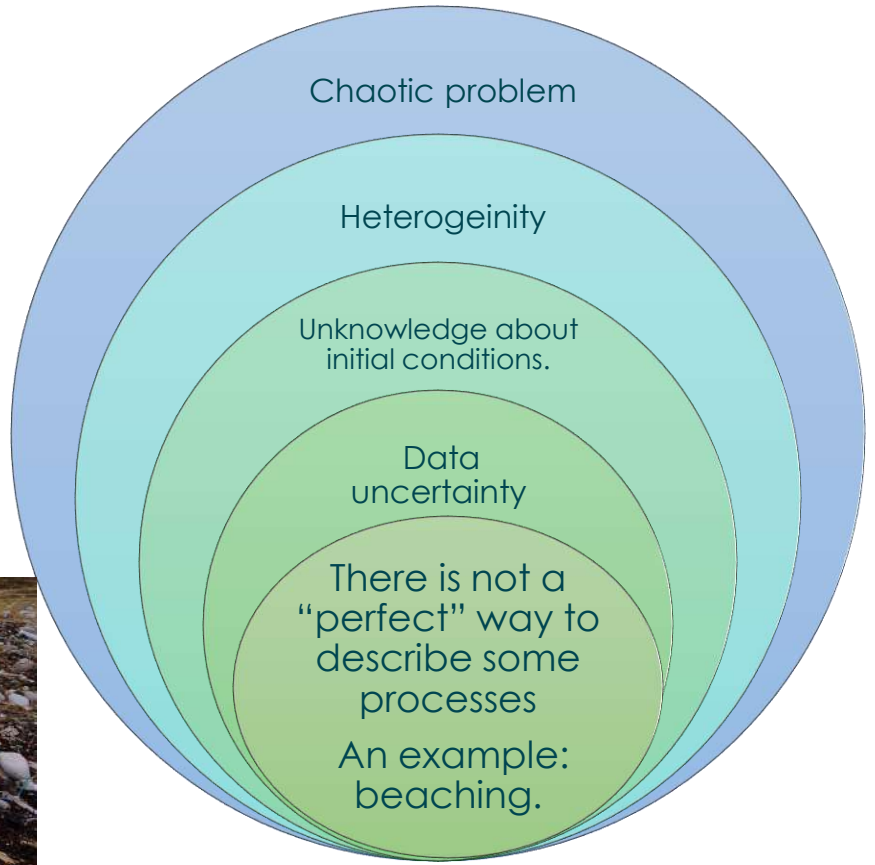
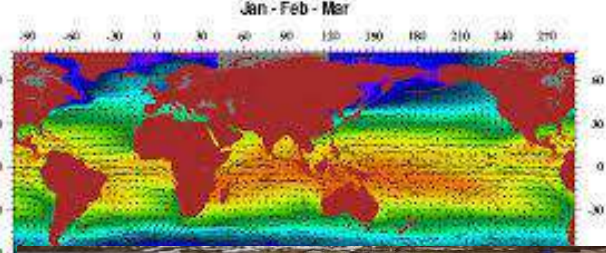
3. Computational model... Oh wait!

Top 10 Trash Items Found in the Ocean

More than one million pieces removed & reported through Drive Against Debris

1	PLASTIC BOTTLES	145,063	6	ALUMINUM CANS	53,398
2	PLASTIC BURETTS	91,222	7	NON-RECYCLED PAPER	46,137

SOURCES OF MARINE LITTER



3. Computational model. Different scenarios

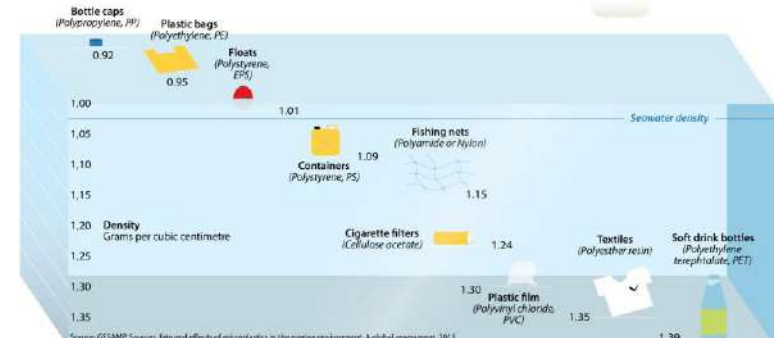
- How to simulate the different types of plastic litter?

- Uncertainties in the marine litter sources.

- Is it possible to know how much litter is in the ocean, or how much litter will reach the beaches?

- Ensemble of simulations
- Different initial conditions (vessels, rivers, costas/land, etc)
- Probability to locate plastics in the ocean (beaches, seafloor, hotspots, etc)

Which plastics float and which sink in seawater?



J.-H. Yoon et al. / Marine Pollution Bulletin 60 (2010) 448–462

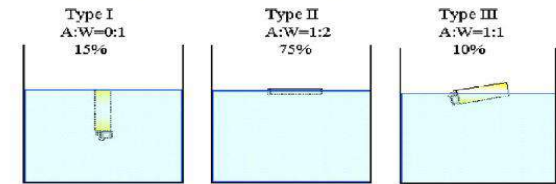


Fig. 1. Types of floating lighters. Percentages indicate the percentage among the 150 samples of lighters obtained from field surveys.

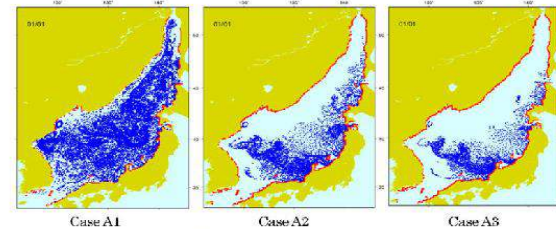
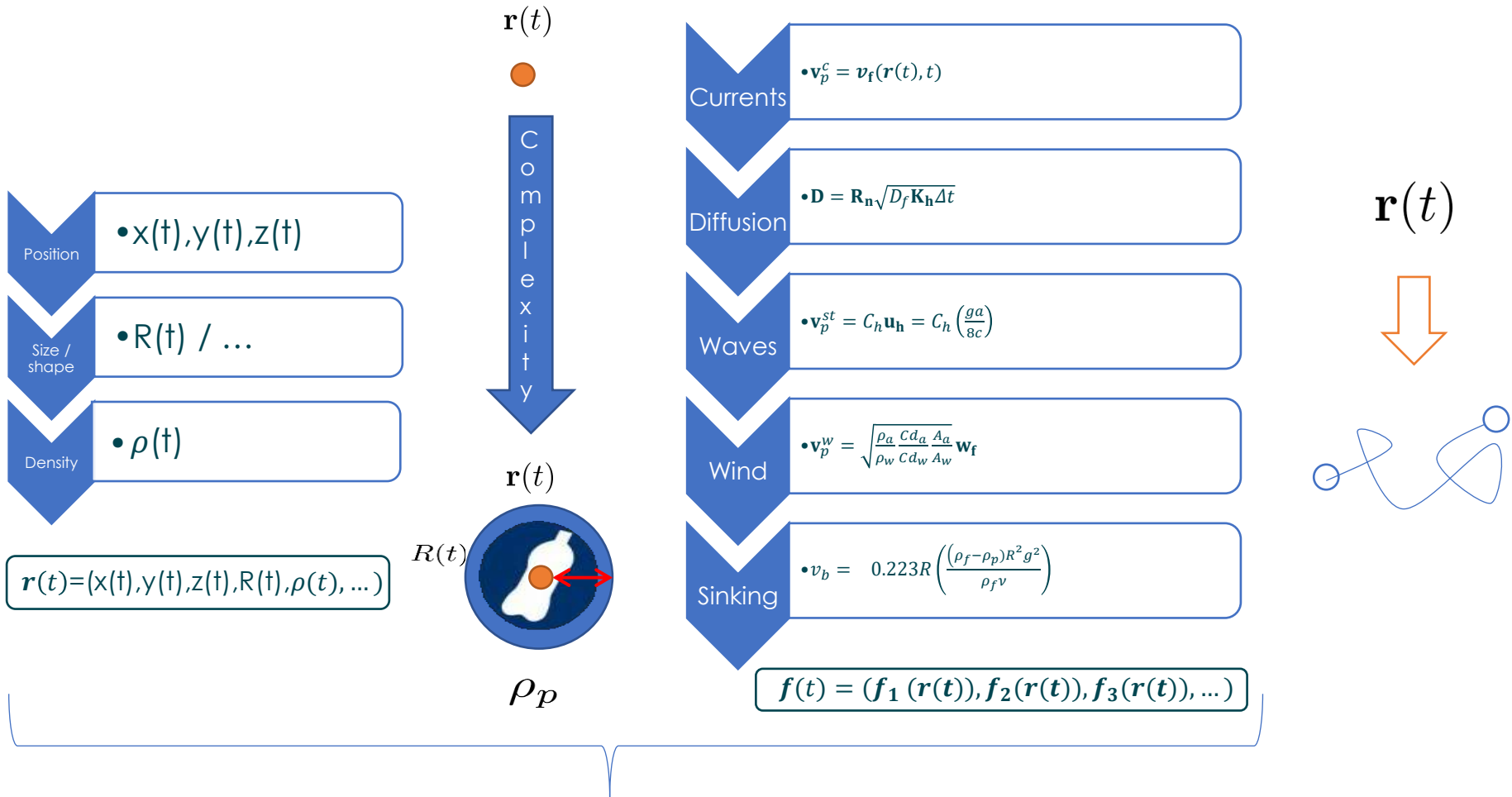


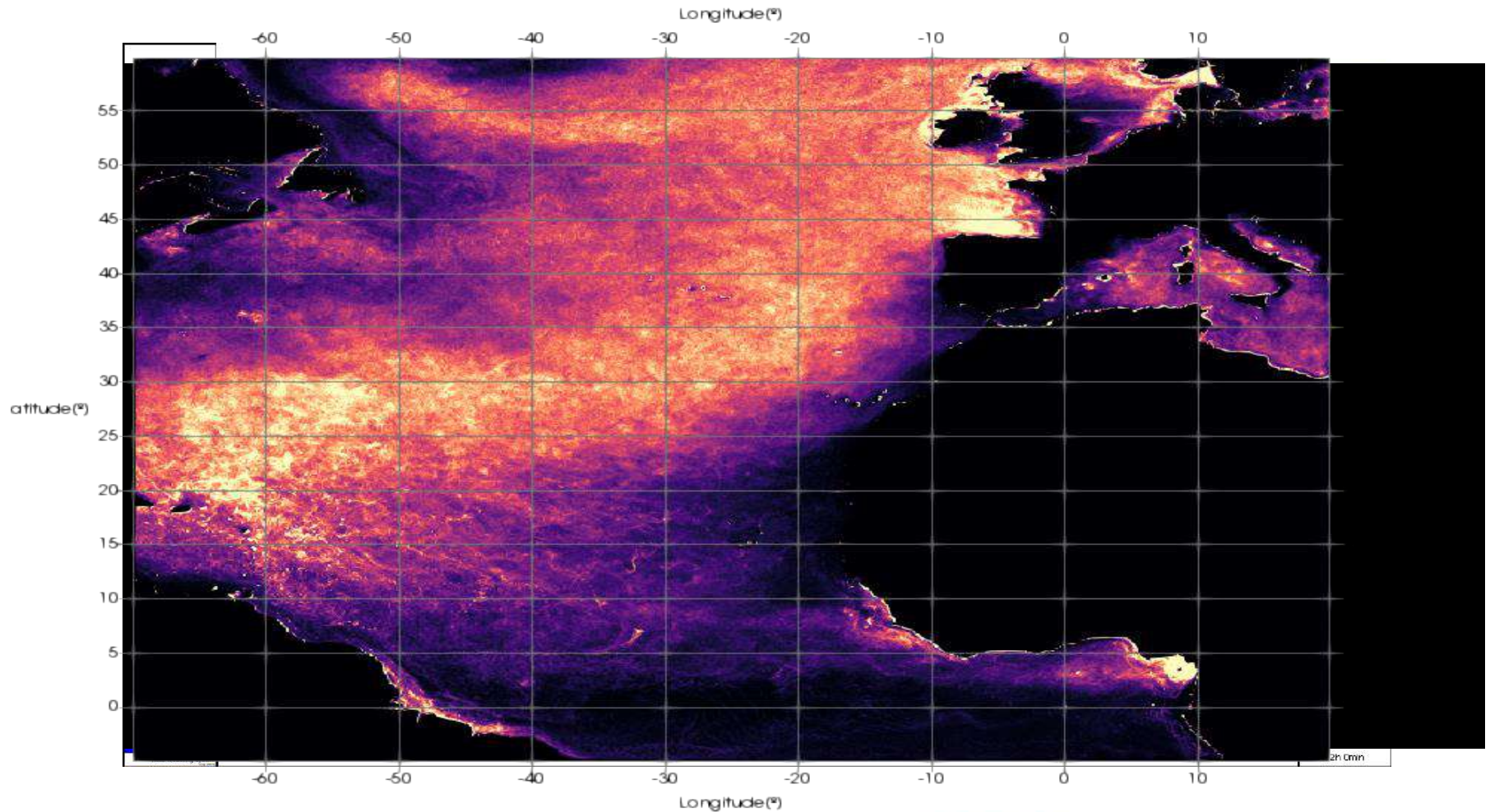
Fig. 2. Distributions of particles after 1 year for Cases A1–A3. The blue color and red points indicate floating and beached particles, respectively. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

4. The mathematical model: Equations



$$d\mathbf{r}/dt = \mathbf{v}_f(\mathbf{r}(t), t) + \mathbf{R}_n \sqrt{D_f K_h \Delta t} + C_h \left(\frac{ga}{8c} \right) + \sqrt{\frac{\rho_a C d_a A_a}{\rho_w C d_w A_w}} \mathbf{w}_f + 0.223R \left(\frac{(\rho_f - \rho_p)R^2 g^2}{\rho_f \nu} \right) + \dots$$

Hot Spots in the Atlantic Ocean



MARETEC

MARINE ENVIRONMENT & TECHNOLOGY CENTER

1.5e-04

concentration_accum

0.5

1

1.5e+00



Clean Atlantic



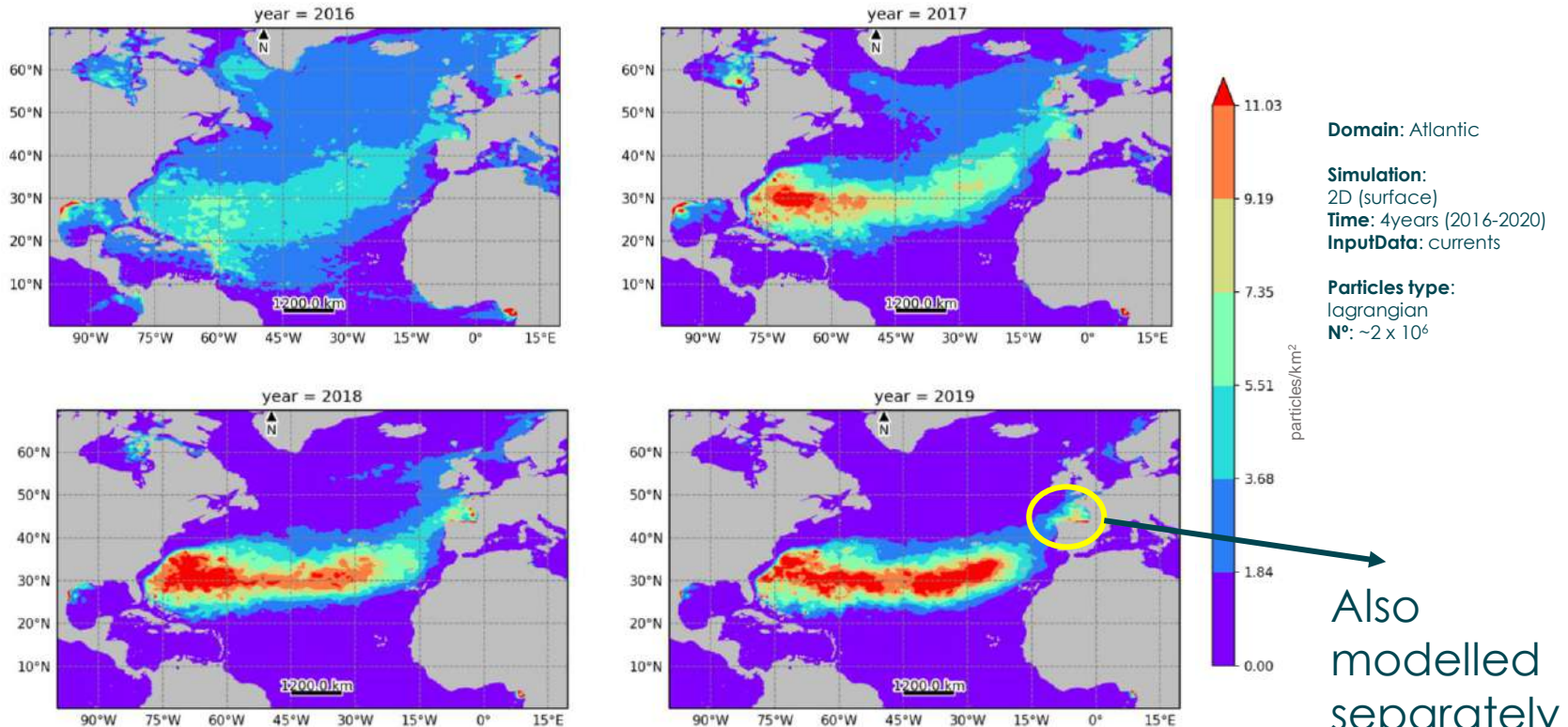
Interreg Atlantic Area

European Regional Development Fund



Hot Spots in the Atlantic Ocean

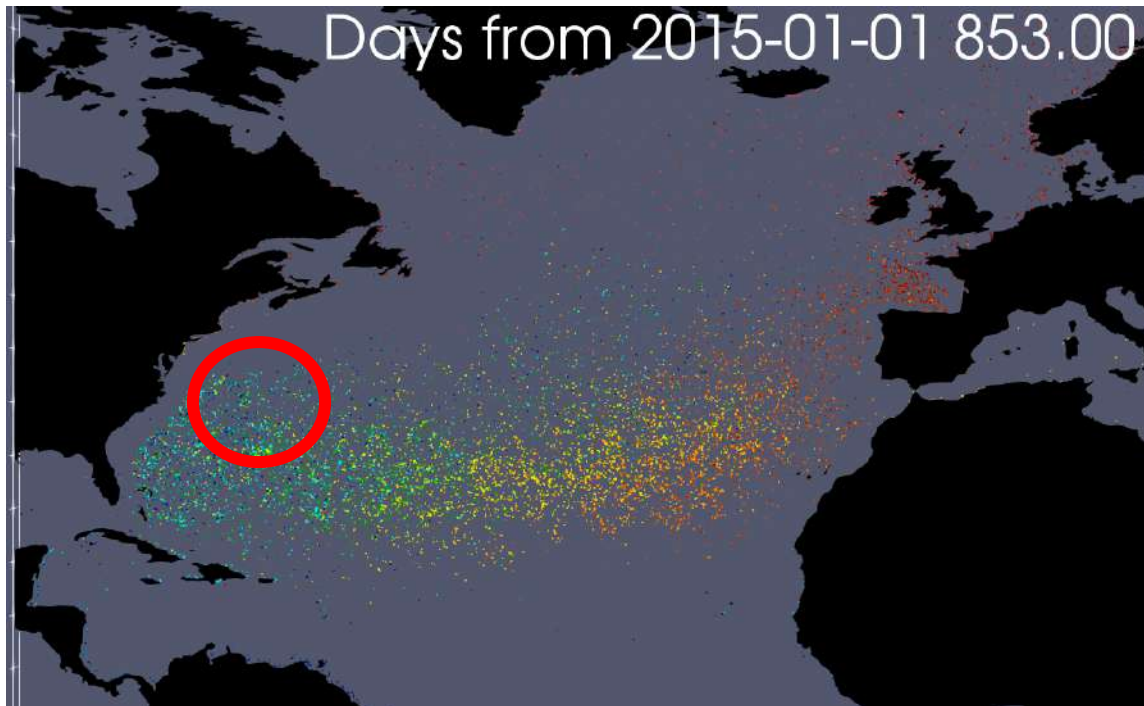
Method: mean (particles/km²)



Litter accumulation after 4 yrs

Hot Spots in the Atlantic Ocean

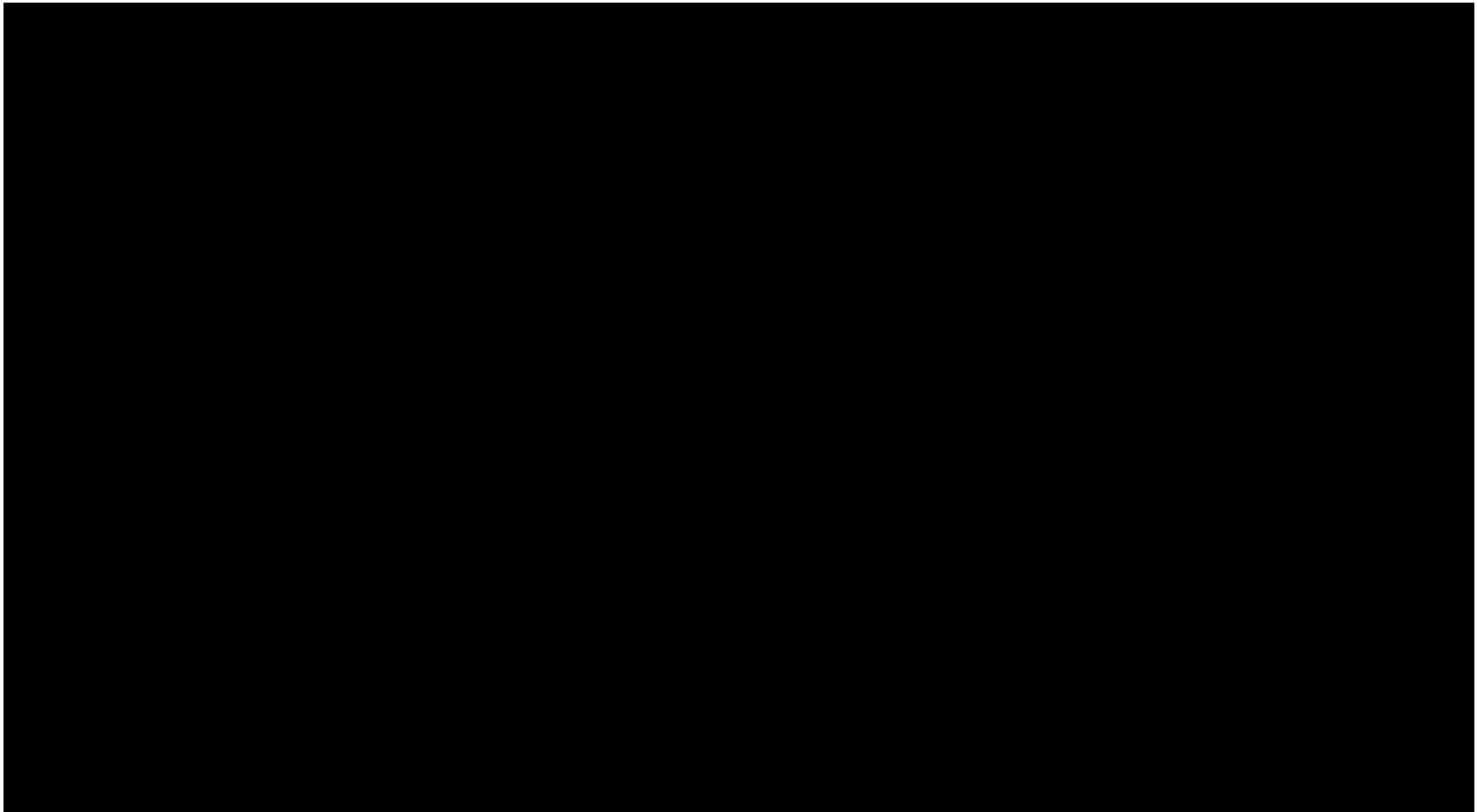
- Not permanent patch
- Reproduced previously



<https://www.independent.co.uk/news/science/now-atlantic-is-found-to-have-huge-garbage-patch-2057402.html>

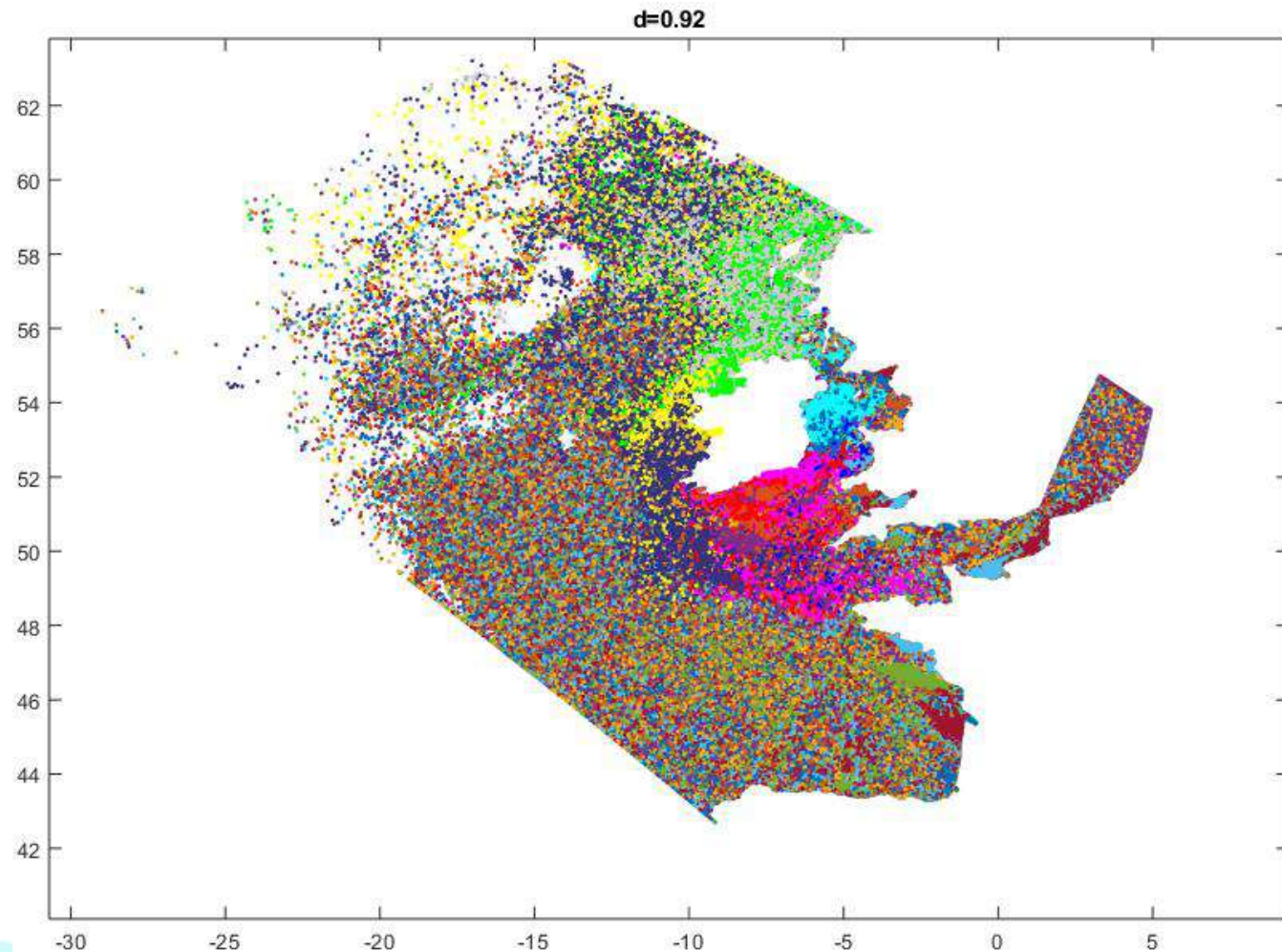


Regional scenarios: River sources



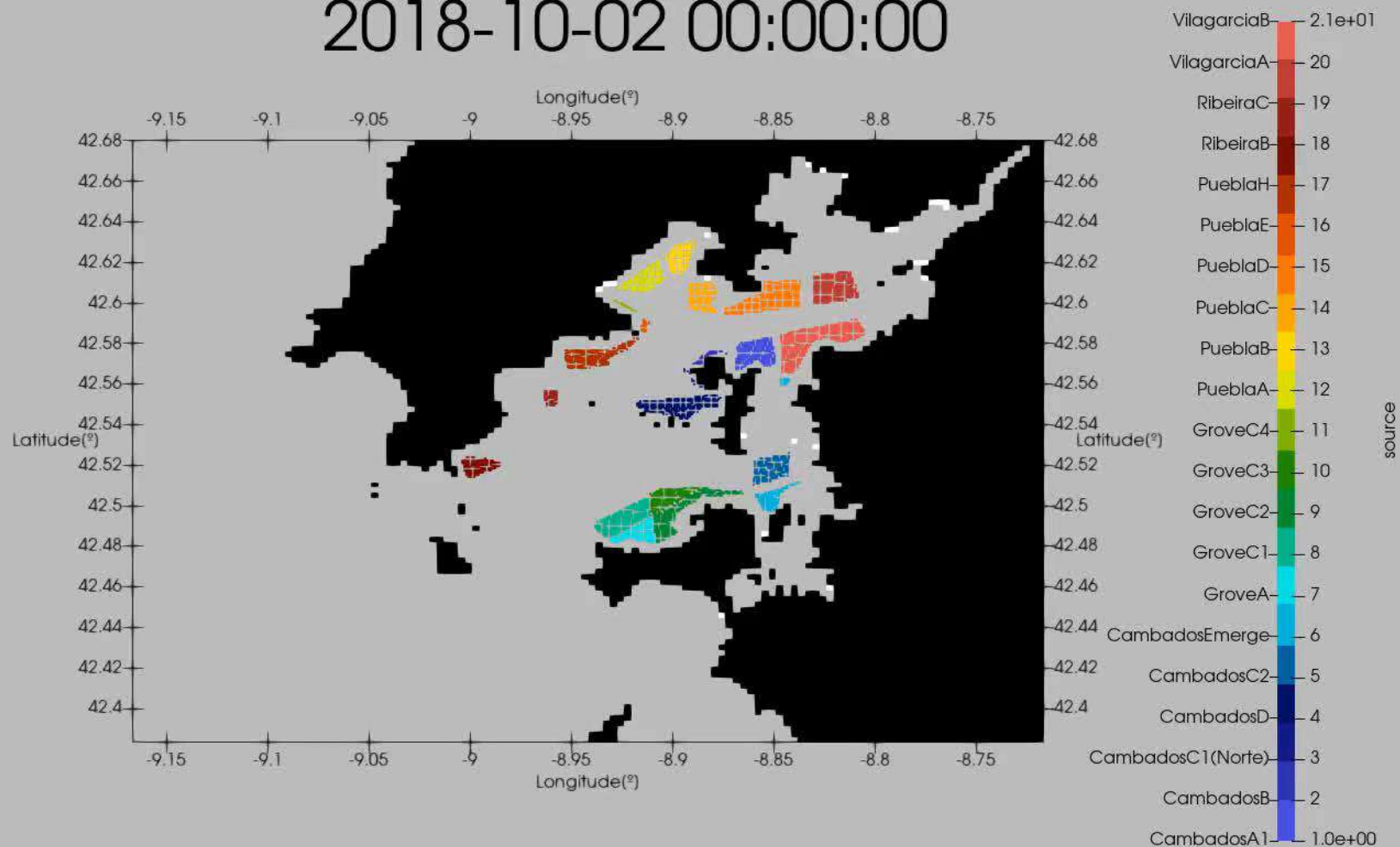
Regional scenarios: Ireland

Strongly buoyant litter distribution after 2 years simulation. Particles were released from 29 rivers implemented in the North East Atlantic model. The number of particles released is scaled by the discharge of each river. Simulations extends from 1st January 2018 to 31st December 2019.



Local scenarios: Mussel Rafts

2018-10-02 00:00:00



Local scenarios: Mussel Rafts. Validation

Comparison with observational data

Arousa survey

Professional survey

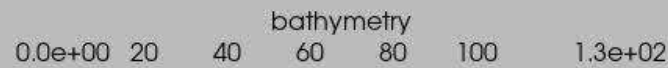
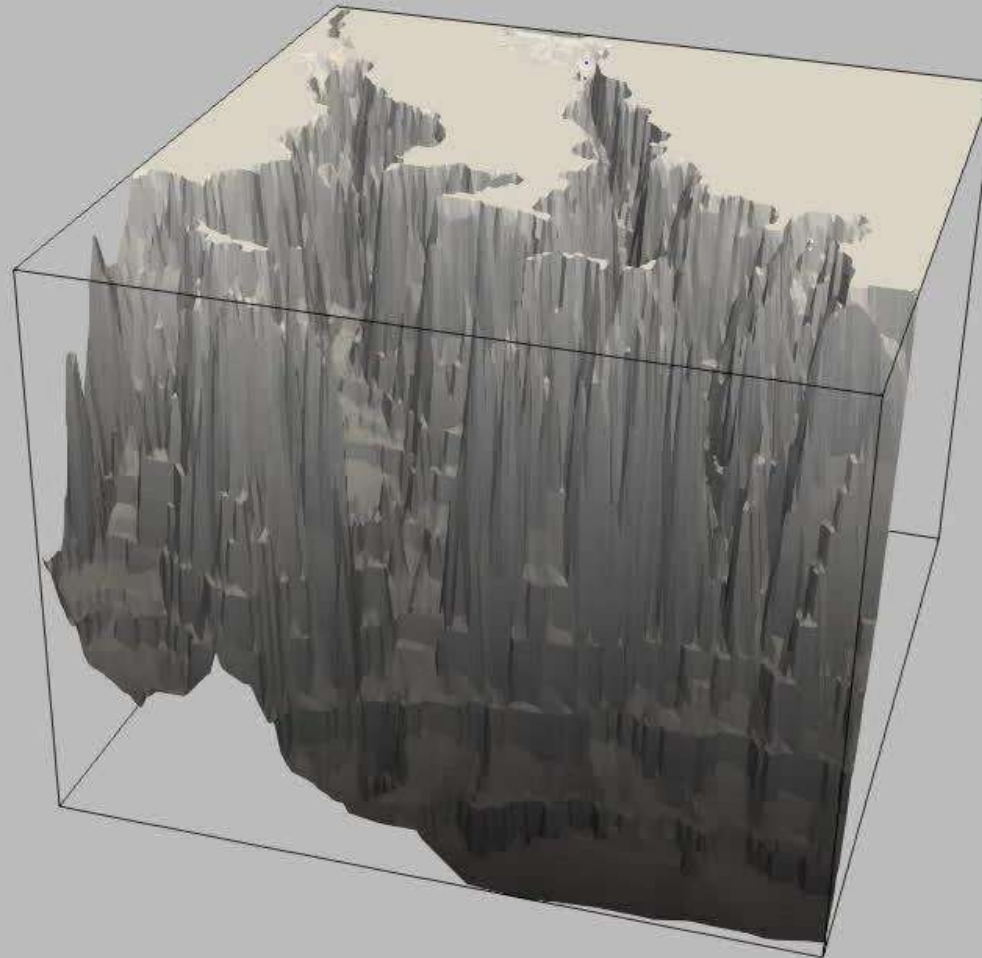
Drone survey

Pilled areas in Arousa depending on meteorological situations

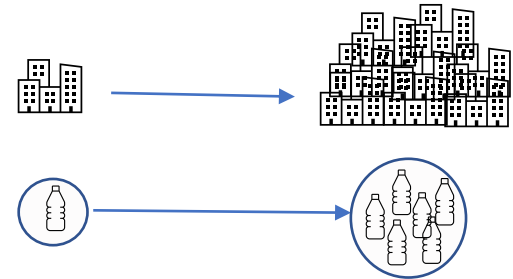
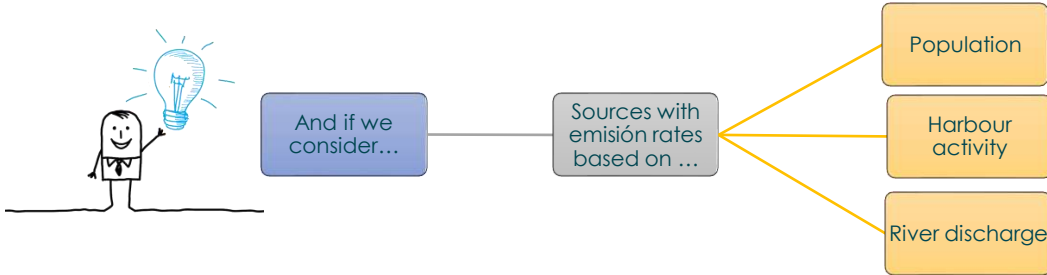


Local scenarios: 3D model simulations

2019-11-11 00:00:00



Weight Sources



Example: cities with high population weight more than those ones with lower population.

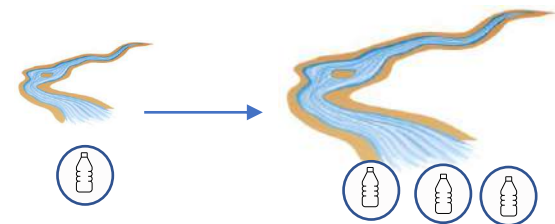
Two options

1. Weight sources (just for cte sources)

- Add a weight to particles emitted by the corresponding sources.
- One particle with more weight – it contributes more.
- One simulation can be weighted with different sources.

2. Emission rate

- Emission rate (fixed or variable) proportional to the quantities considered.






Example: Particle emission and river flow

Conclusions

- Our work inside of CleanAtlantic Project is to develop mathematical models to describe the motion of marine litter in the ocean.
- Mathematically, marine litter is a complicated object to simulate due to the many physical and chemical processes that may modify their transport.
- A **tool has been developed** to simulate scenarios and provide useful information for those areas with higher accumulations of marine litter to support stakeholders in the decision making.



Thank you very much!

- www.cleanatlantic.eu
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-  @Cleanatlanticproject
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