Marine Litter Drift Monitoring (Forecast and Hindcast) in the Channel and the North Atlantic

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Session OS4.7/EGU2020-13029 - 8 May 2020

Introduction

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Known to the Beotians:

Marine litter is a serious problem all around the word whether floating, sunk, in the water column or beached, as it generates ungainly pollution that affect the tourism, whether chemical pollution (plastics; *in fact, plastics represents up to 80% of all objects*[2,8] ,…), or mechanical pollution (fishing nets, …). Floating macro-litter (>2,5cm) items can assist invasions of alien species[3].

Rivers are the major regional source of litter input in the marine environment[1]. The other ones are fishing & shipping activities, tourism (beaching & boating activities), sewage or coastal cities.

(85 % of people doesn't want to visit a beach with more than 2 litter items per meter[4])

⇨ our objectives: *i.* support **cleaning** (to know when to clean) and *ii.* **reduce the input**

= **track back the possible sources**

1. Lebreton, L., van der Zwet, J., Damsteeg, J. et al. (2017) River plastic emissions to the world's oceans. Nat Commun 8, 15611.
2. JRC Technical reports (2018) Floating Macro Litter in European Rivers - Top Items – ISBN 978-92-79-96373-5
3. Barnes and Milner (2005) DOI 10,1007/s00227-004-1474-8
4. Balance A. How much is a clean beach worth ? South African Journal of Science 96-2000

Service description

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LITTER-TEP is designed to predict the **potential beaching** of **macro-litter** (not only plastics) introduced into sea by **rivers** in the **European North-West Shelf Seas**

The service is organised in 4 components :

1. A forecast of litter introduction in the ocean from the land through rivers:
   - it's a daily map of estimated items of litter washed out on watersheds, carried to the sea by rivers, calculated with river flow and populations assessment.
   - At this stage, the river flow id based on monthly statistics issued from 30 years of statistics

     Why ? we can't freely get hold of the European rivers' flows data in real-time.
   - We plan to develop the trigger event module from rainfall data to introduce the flood information

Service description

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2. A forecast of litter drift in the ocean from the estimated volume of litter coming from rivers every day:
   - dispersion of marine litter from each river/watershed with a 5 days' forecast;
   - total volume of floating macro-litter at sea, obtained from the integration of all river/watershed marine litter forecasts.

3. A forecast of landing litter (drifting litter back to shore)

4. A hindcast module to track back the possible source of the beaching litter observed

Our choices

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- Service Sets-up with rivers from 6 countries: Belgium, France, Germany, Ireland, Netherland, United-Kingdom.
- Currently the service runs with 37 watersheds with related main rivers. We will introduce gradually more watersheds and affluents.
- Litter from coastal cities, beach-users litter, etc… are not yet taken into account because
  - The coastal cities waste management differs from city to city
  - The beach cleaning campaign differs depending on the local communities, regions or seasons and there is little records available
  - Tourists' behaviour is different according to their origin and place of vacations
  - Public data are missing, etc…

  ⇨ need to introduce local specificities which are not yet handled

Litter index valuation

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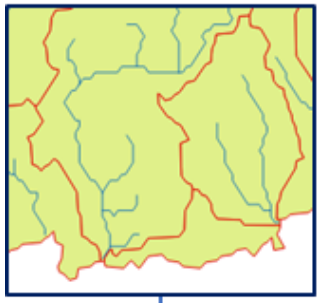
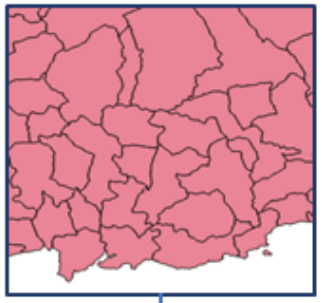
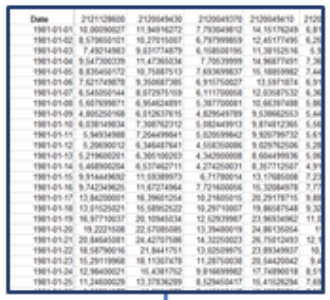
Watershed basins[1]



Administrative units with population data[2]



Rivers flow data[3]

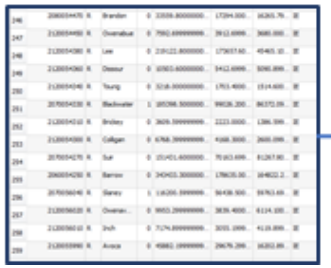


- Data from waste collection on beach campaing
- Scientific studies

Spatial & data processing

Calibration of the index

+



- Seasonal rivers flow
- Total Population & density

Litter index valuation

Sources:

1. hydrosheds.org
2. National Institutes/Agencies
3. hypeweb.smhi.se

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Litter index valuation

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Macro-litter volume with a riverine source is more difficult to quantify than micro-litter, that can be measured from in-situ samples (most studies on marine litter are about the micro-litter or/and plastics).

It is foressen that the majority of the litter material may be deposited in coastal regions closed to their source[5][6][7].

= **beach litter analysis** seems to be the best mean to model/estimate land litter sources :

- several years of beach litter observation in Cornwall-UK, concludes that the beach visitors contribute to 10% in winter to 30 % in summer with an average of 18%, Fishing activities provide 32%, shipping 4%[8]and 40% are un-sourced;
- another study based on 9 years of regular beach surveys in UK conclude 36 % from beach visitors, 15% from fishing and 40% un-sourced[9].

= could we consider that 40% of beach litter have a riverine source (the un-sourced part) ?

Can we estimate the relation between the 40% of un-sourced beach litter and the volume carry out by rivers ? i.e. what is the rate of riverine macro-litter destined to beach

5. William A.T. et al. (1997) Journal of coastal research 4 pp 1159-1165
6. Willis, K. (2017) DOI:10.1038/srep44479
7. Galgany, F. (2000) https://doi.org/10.1016/S0025-326X(99)00234-9
8. Watts, A.J.R et al. /http://dx.doi.org/10.1016/j.envpol.2017.05.2016
9. Nelms S.E. et al. /http://dx.doi.org/10.1016/j.scitotenv.2016.11.137

Litter index valuation

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it has been estimated that up to 70 per cent of the marine litter that enters the sea ends up on the seabed, whereas half of the remaining amount is found on beaches and half floating on the water surface[10].

⇨ We assume that the 40% of the un-sourced litter is the 15% of the riverine litter destined to beach.

10. UNEP 2005. Marine Litter, an analytical overview

Litter index valuation

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Next enhancements are the source's modelling and estimation of volume of litter introduced to the sea:

- first improvement, in the mid-term, targets the discharge models, using refined hydrologic schemes for the watersheds, linked with
  - *meteorological* events, and better estimates of
  - *habitats* (rural, urban, industrial, …)

  to obtain a daily accurate volume of litter from each river.
- Second enhancement, driven by users' requirements, is to improve the land discharge model vide collection of litter seeing with *citizen crowdsourcing apps*, and *records of beach litter surveys, and beach cleaning campaigns*, probably closed to river mouths.

1- Drift Model

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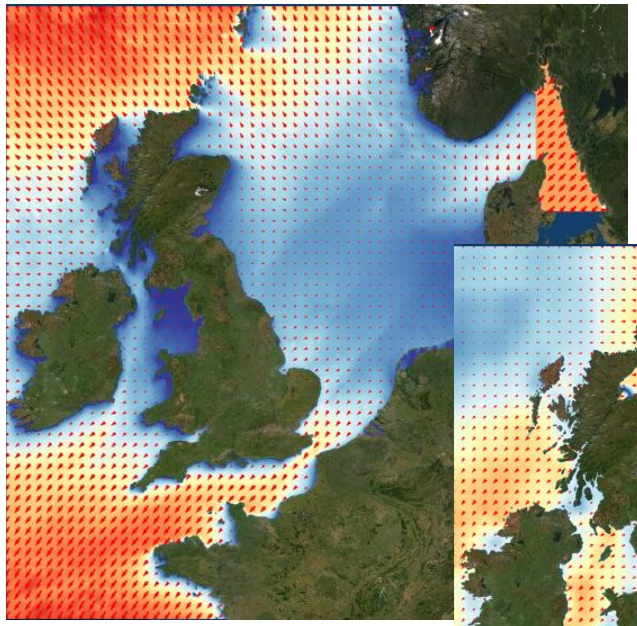
Stokes currents [1] +

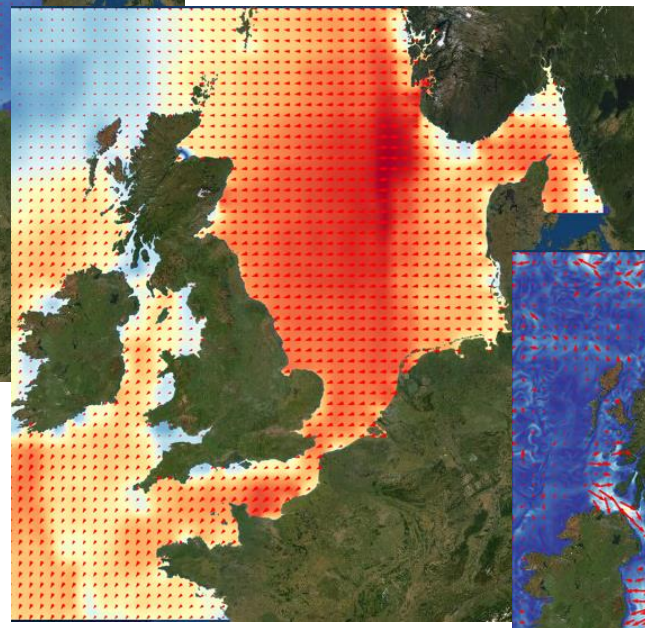


$$\Delta_X = U_{Current}(X\,n\,,t\,n) + U_{Stokes}(X\,n\,,t\,n) + \rho_W * U_{Wind}(X\,n\,,t\,n) + G(X\,n\,,t\,n))$$

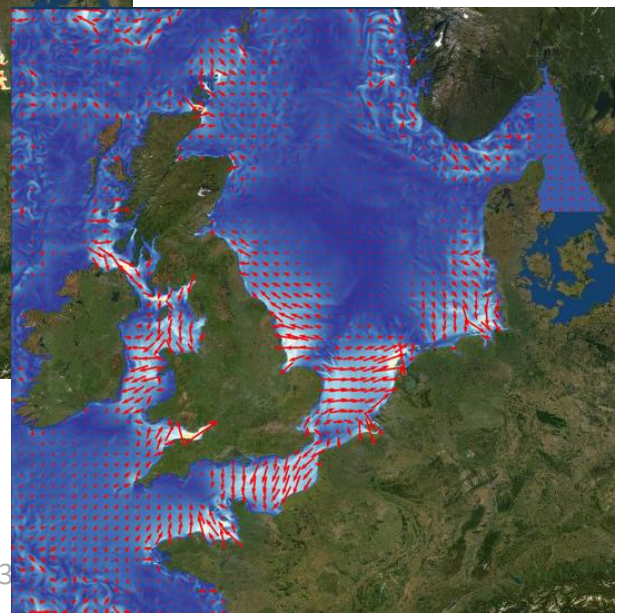
ρ_W *is the coefficient of wind effet estimated at* 3%

and G *a* Gaussian *random distribution for stochastic componants*

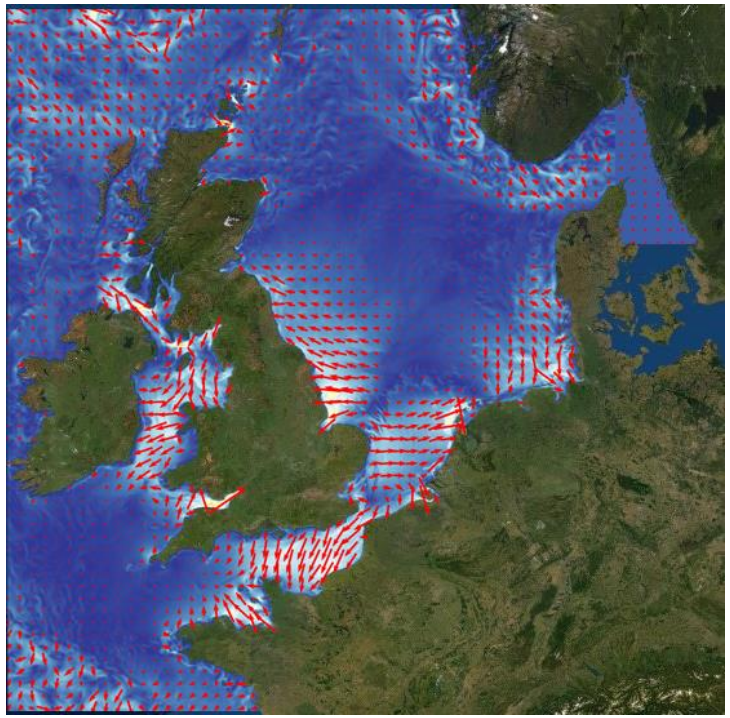
Wind speed[2] +



Sea currents[1] =



Drift speed



Sources: Copernicus Marine Service

1. NORTHWESTSHELF_ANALYSIS_FORECAST_PHYS_004_013
2. WIND_GLO_WIND_L4_NRT_OBSERVATIONS_012_004

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2- Landing Model

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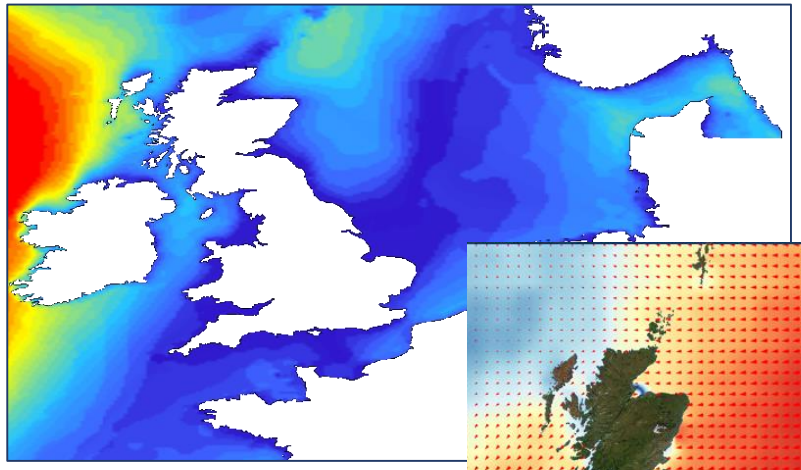
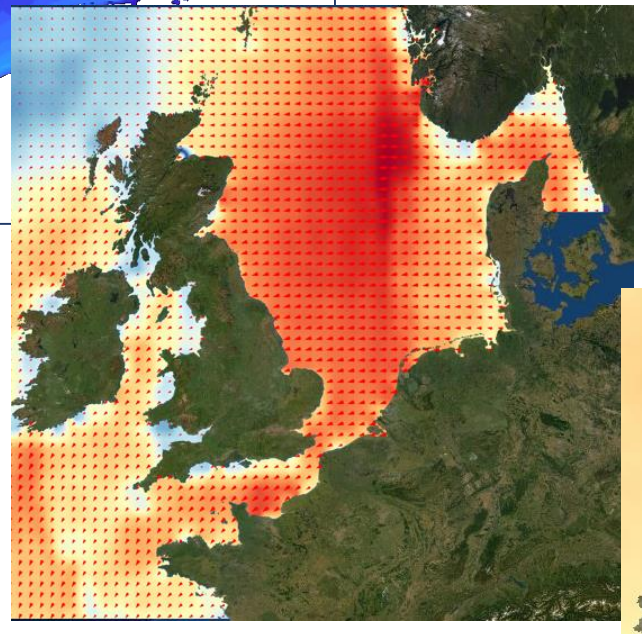
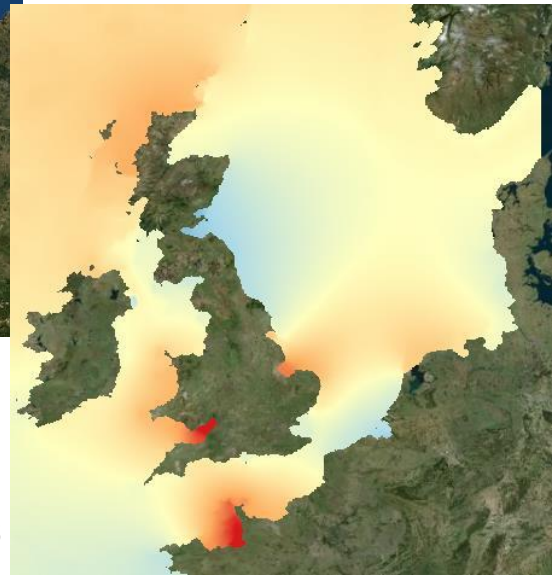
Waves[2] +



Wind speed[3] +



Sea surface height[1] =



Landing & refloating model

Sources: Copernicus Marine Service

1. NORTHWESTSHELF_ANALYSIS_FORECAST_PHYS_004_013
2. NORTHWESTSHELF_ANALYSIS_FORECAST_WAV_004_014
3. WIND_GLO_WIND_L4_NRT_OBSERVATIONS_012_004

Service: model configuration

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- The Copernicus Marine service information are re-sampling at 1km before merging, allowing us to have density per square km
- 5% of Litter sink every day
- After 60 days of presence into the sea, the floating litter status becomes SUNK or could also be disintegrating into marine micro-litter

  For the landed litter, after 60 days, we consider them as collected
- The floating litter is assumed to have a velocity equal to the vectoral sum of the water currents and the wind drift velocities, with a wind drift coefficient of 3%
- The service is processed under the Coastal-TEP
- Different mathematical methods can be used to integrate numerically give rise to various particle-tracking schemes.
  - ✓ The one used to simulate Lagrangian tracking here is the method of Parada et al., 2003; Guizien et al., 2006; Lett et al., 2007

Service: presentation

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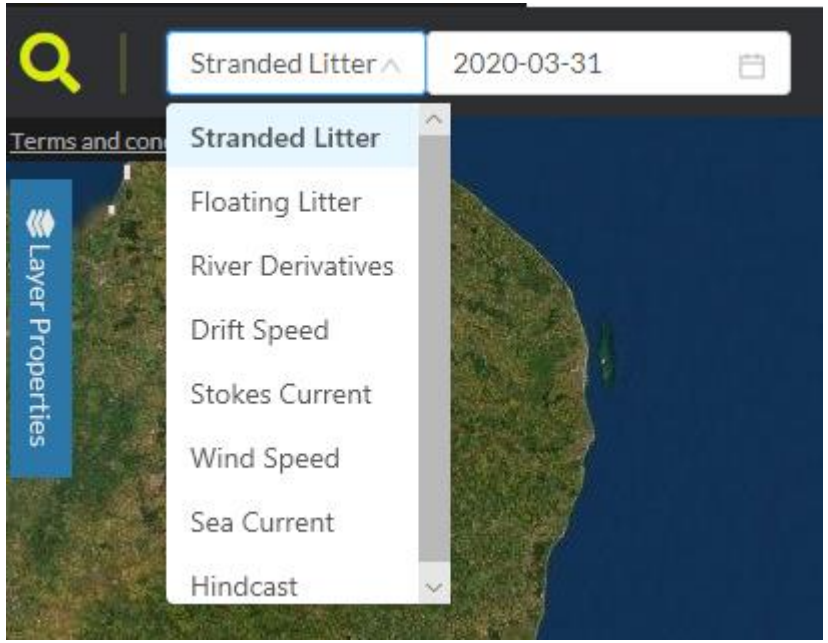
Service accessible to registered people



+ a menu to select what you want to see

+ a date to select a moment

⇨ if the chosen date is tomorrow = a forecast

⇨5 days forecast

Service: drifting litter

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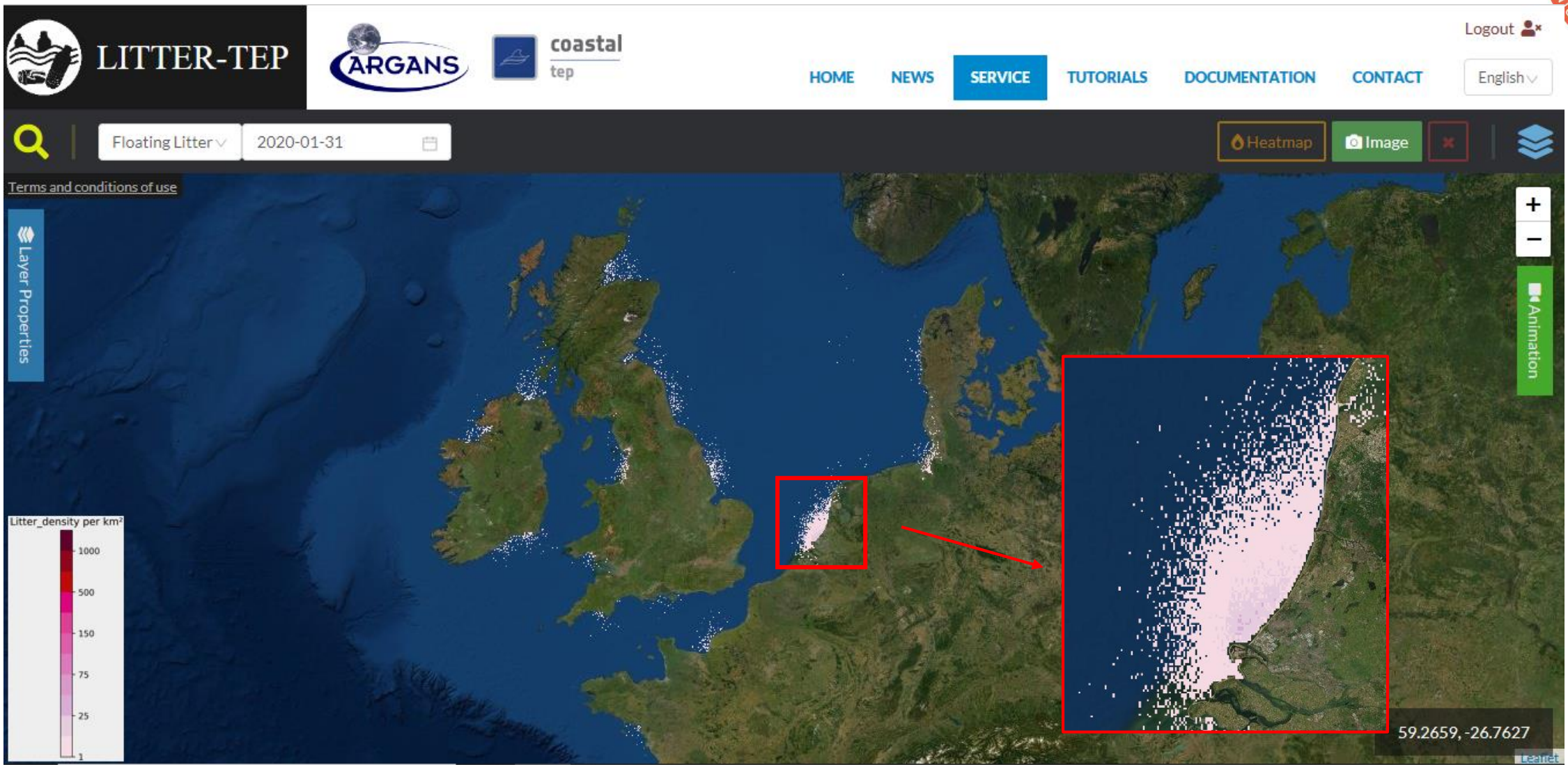

Service: Stranded litter

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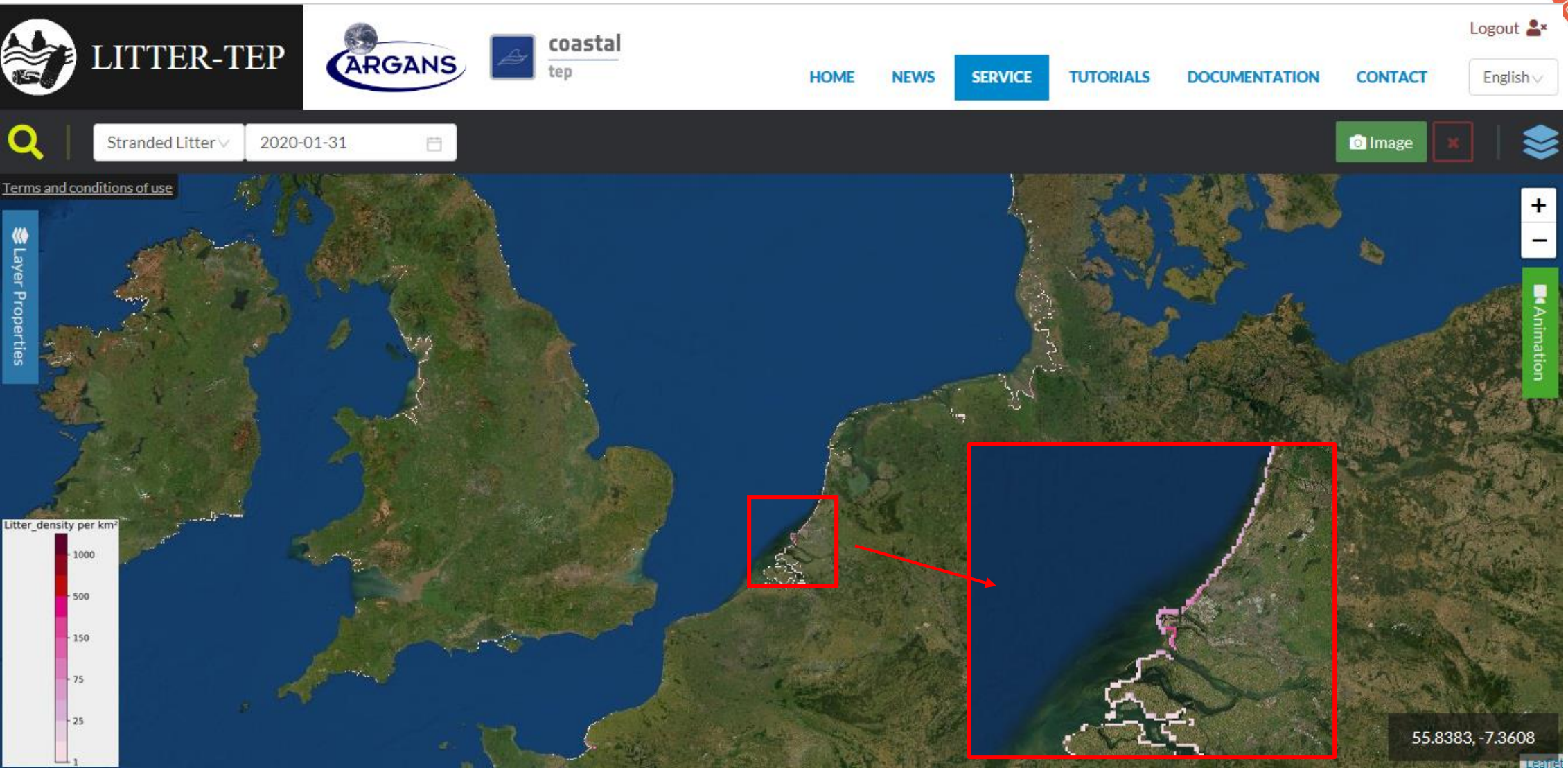

Service: hindcast data

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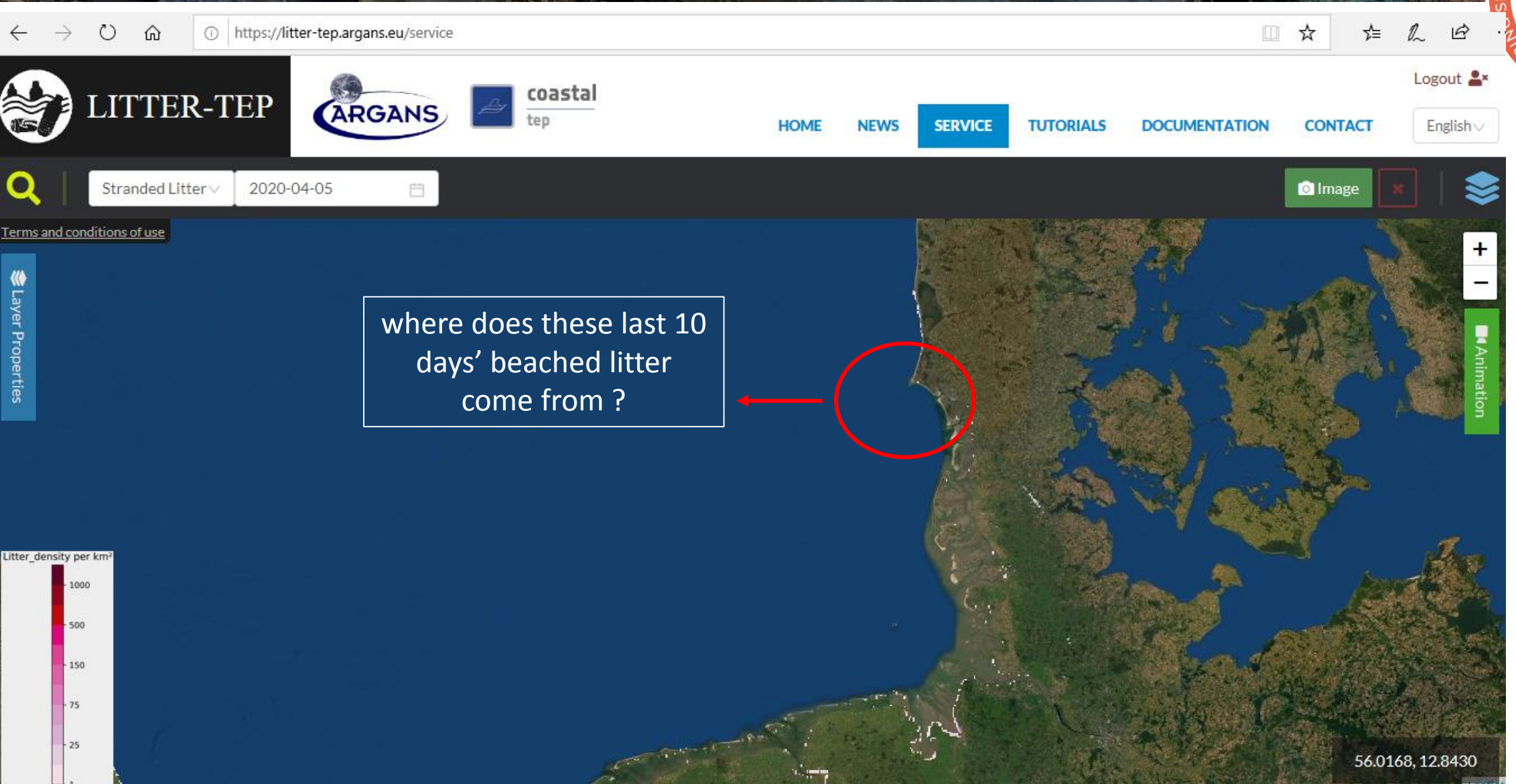

Service: hindcast data

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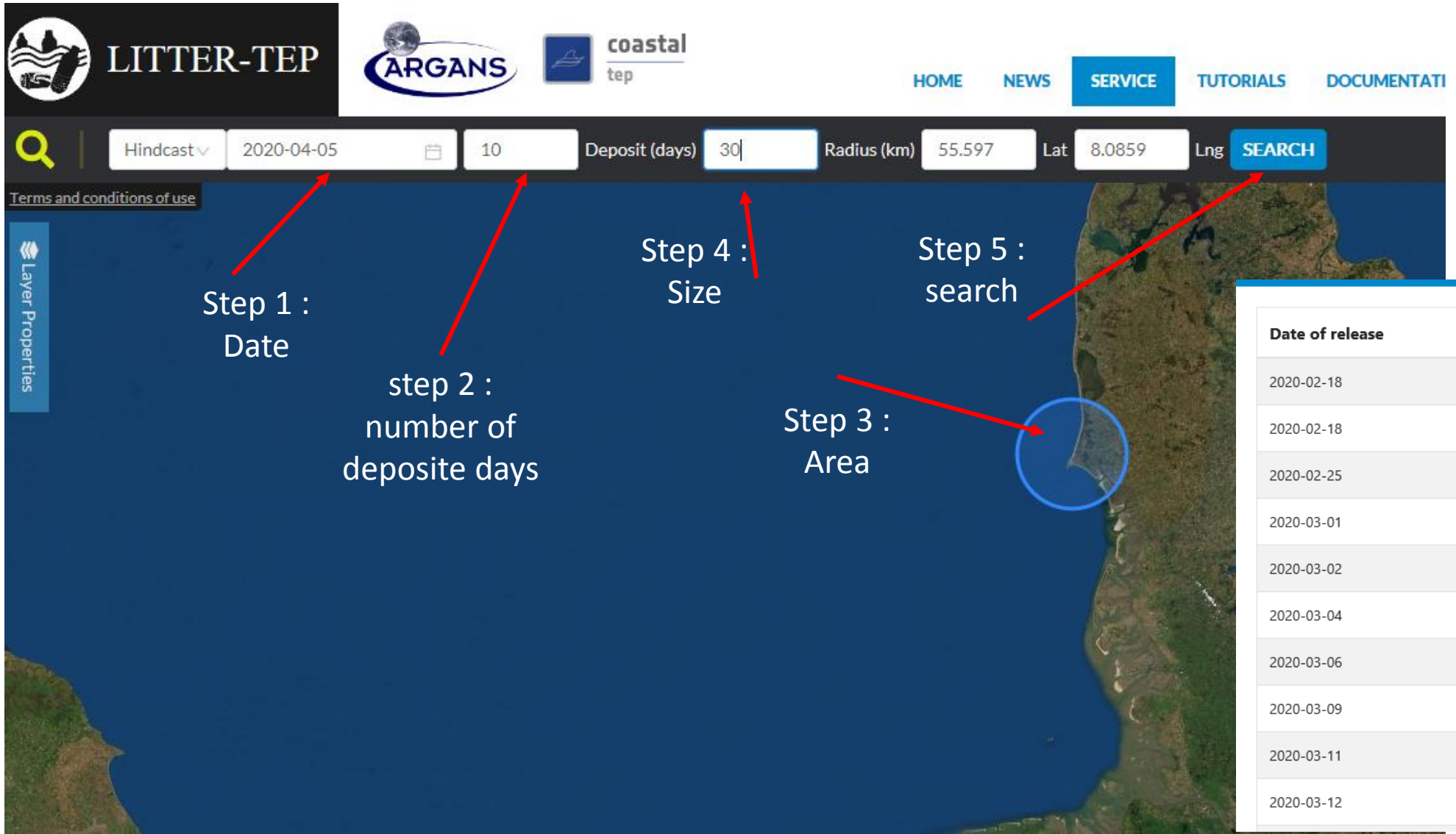

Step 6 : see the result

Date of release	Issue	Number Of Litter
2020-02-18	Bann	4
2020-02-18	Forth	5
2020-02-25	Moy	2
2020-03-01	Weser	2
2020-03-02	Tweed	1
2020-03-04	Forth	4
2020-03-06	Ringkobing_Fjord	1
2020-03-09	Ringkobing_Fjord	5
2020-03-11	Forth	3
2020-03-12	Ringkobing_Fjord	7

Conclusion

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We expect the LITTER-TEP to be a useful service

i. to forecast the position of Litter from rivers, and
ii. to track back the Litter.

However, it is essentially based on ocean currents, winds and waves and there are a number of other factors that will change the distribution of marine litter on the beach: factors such as

- prevailing wind directions nearshore[5] (e.g. katabatic winds => topography and HR met models),
- bathymetry and coastal offshore currents,
- sedimentology & nearshore currents such as the rip currents,
- runoff on the beach, etc.

⇨ **necessity to evolve modelled scales of the litter dynamics** (local scales)

to offer a more reliable service to local authorities

= R&D needed

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Thank you for your attention

https://litter-tep.argans.eu/

If you want to contact us :

Email littertep@argans.eu

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