→ ATLANTIC FROM SPACE WORKSHOP

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National Oceanography Centre
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Observational limitations for marine litter monitoring: Earth Observation to the rescue

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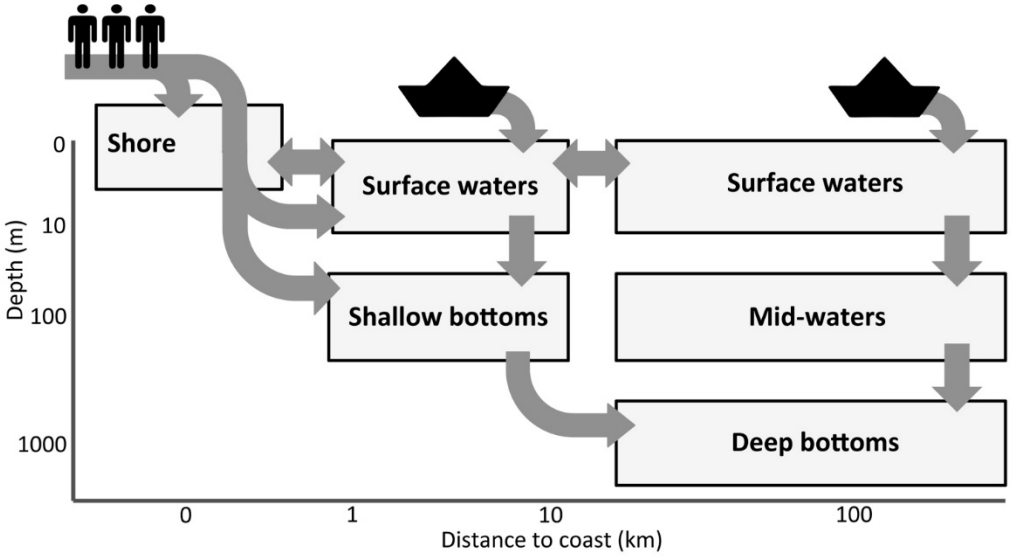
The issue of marine litter

Source: European Environmental Agency

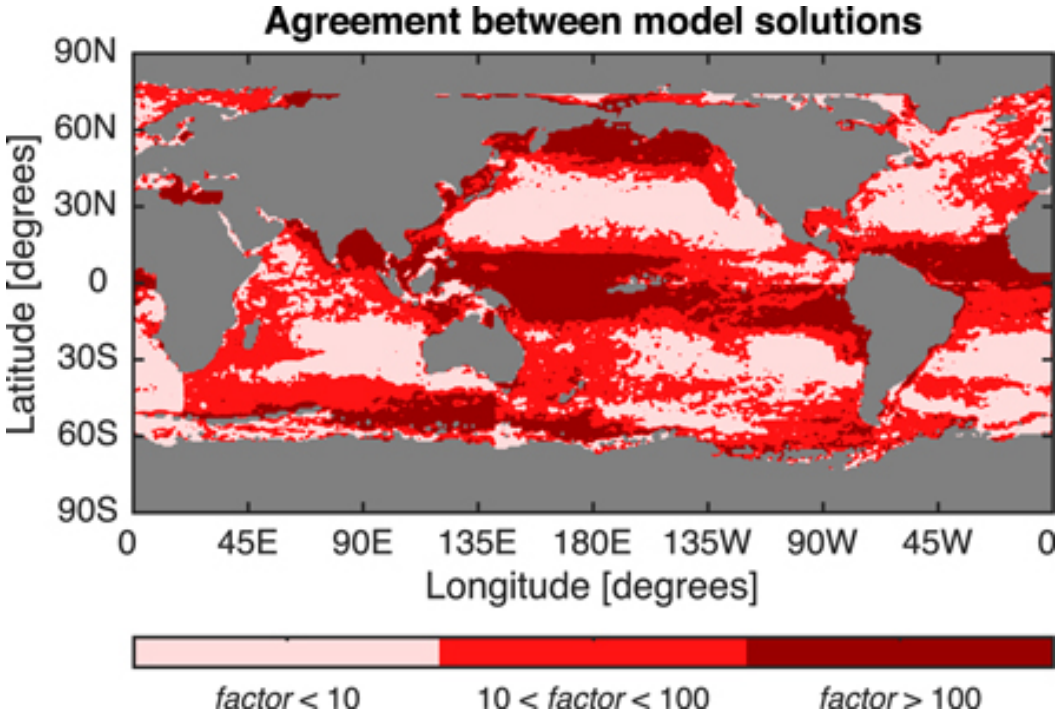
- Marine litter is one of the main challenges of marine pollution.
- ~ 10 million tonnes of litter end up in the ocean every year.
- ~ 80% comes from land-based activities.
- Floating litter ~15% of total litter (UNEP).
- With > 40% of the European population living at the coast, it is a pressing environmental problem.

The needs of the scientific community



- It is necessary to understand the **quantity of marine litter** present **in** various **marine domains**.
- Many fundamental questions about long-lived plastic remain with no answer.
- For example, an ~ 8 million tons of plastic debris are added to the ocean annually, but **at-sea and on-shore observations find only a tiny fraction of the expected accumulation** (Maximenko *et al,* 2016).

What the models can bring to the game



- Models provide information about marine litter distribution but **they differ in orders of magnitude**.
- Issue is the lack of observational data both in space and time.
- Currently *in-situ* data covers no more than a few km^2 of marine domains.

Source: Van Sebille *et al*, 2015

Characterization of the marine litter

- Based on the **marine domain** under consideration

Beaches

Shallow waters

Open Ocean

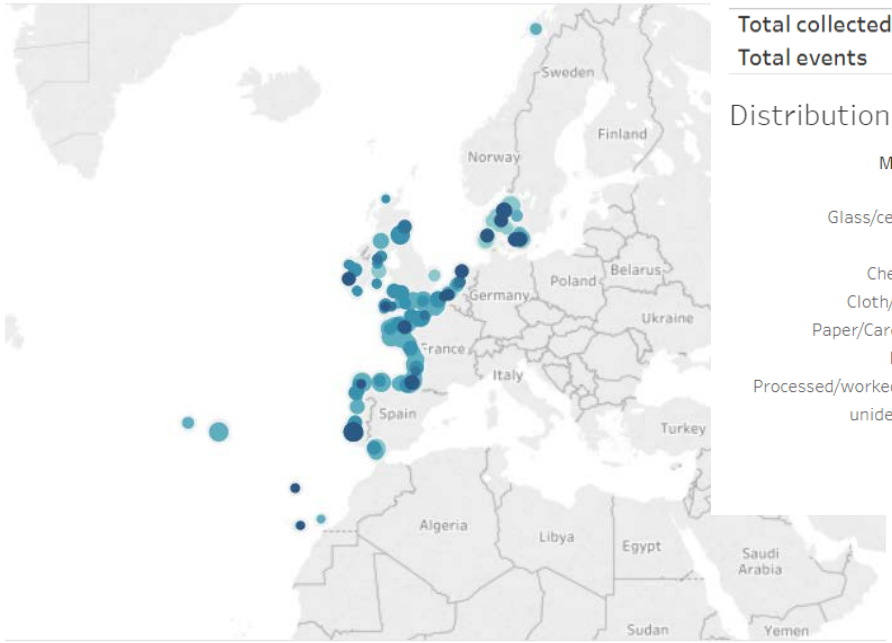
- Based on the **marine litter fraction** under observation

Large Items

Small pieces and fragments

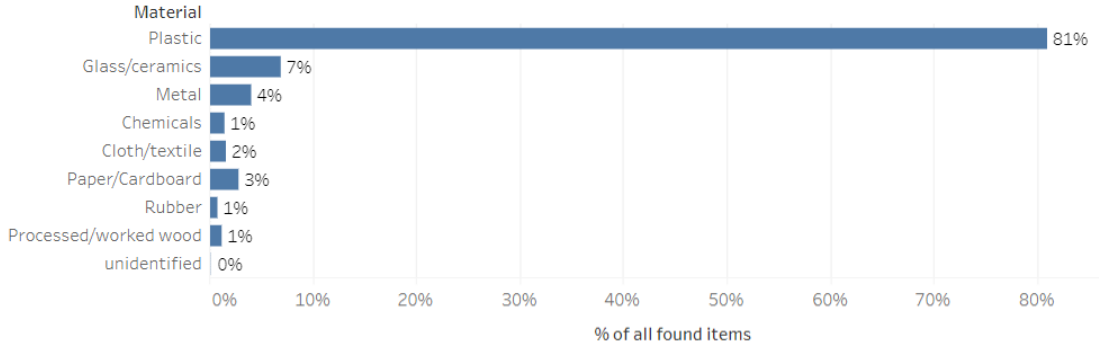
Microplastics

Characterization of the marine litter



Total collected items	956,680
Total events	2,267

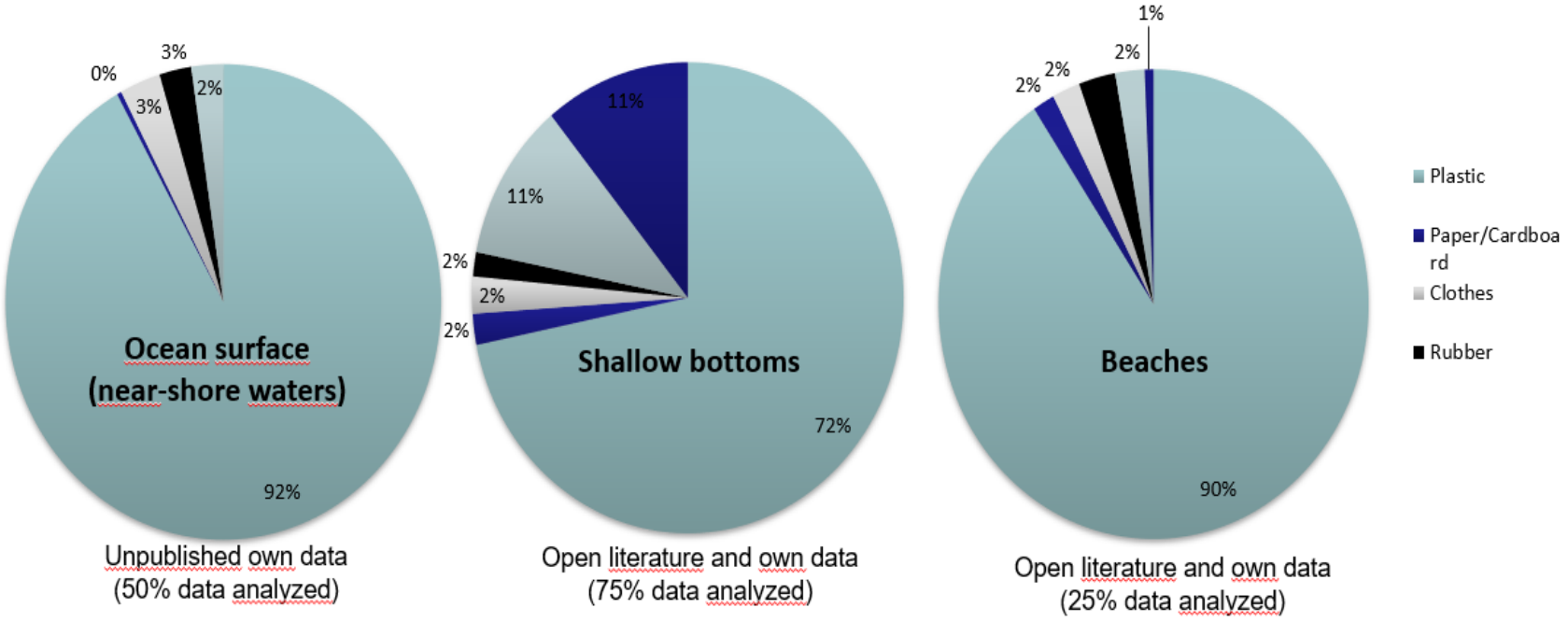
Distribution by material



Plastic represents **>80%** of total items found in European Atlantic beaches.

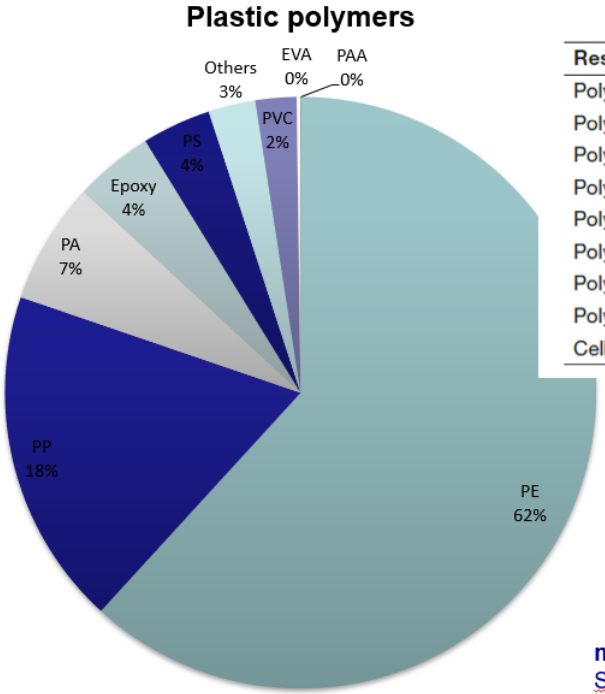
Source: European Environmental Agency

Characterization of marine litter



Courtesy: Cozar *et al* (2018)

Characterization of marine litter



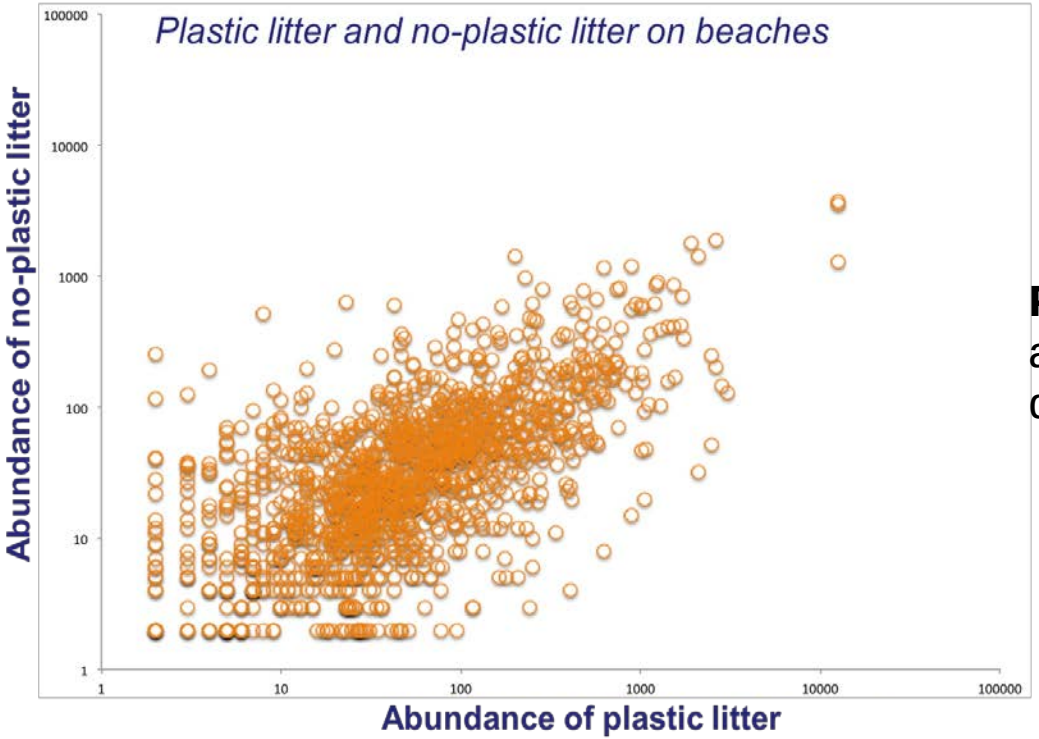
Resin type	Common applications	Specific gravity
Polyethylene	Plastic bags, storage containers	0.91–0.95
Polypropylene	Rope, bottle caps, gear, strapping	0.90–0.92
Polystyrene (expanded)	Cool boxes, floats, cups	0.01–1.05
Polystyrene	Utensils, containers	1.04–1.09
Polyvinyl chloride	Film, pipe, containers	1.16–1.30
Polyamide or Nylon	Fishing nets, rope	1.13–1.15
Poly(ethylene terephthalate)	Bottles, strapping	1.34–1.39
Polyester resin + glass fibre	Textiles, boats	>1.35
Cellulose Acetate	Cigarette filters	1.22–1.24

At open waters, **PE**, **PP** and **PS** mean **84%** of the **total floating plastic litter**

n = 4,704 items
Source: Open literature and unpublished data

Courtesy: Cozar et al (2018)

Characterization of marine litter

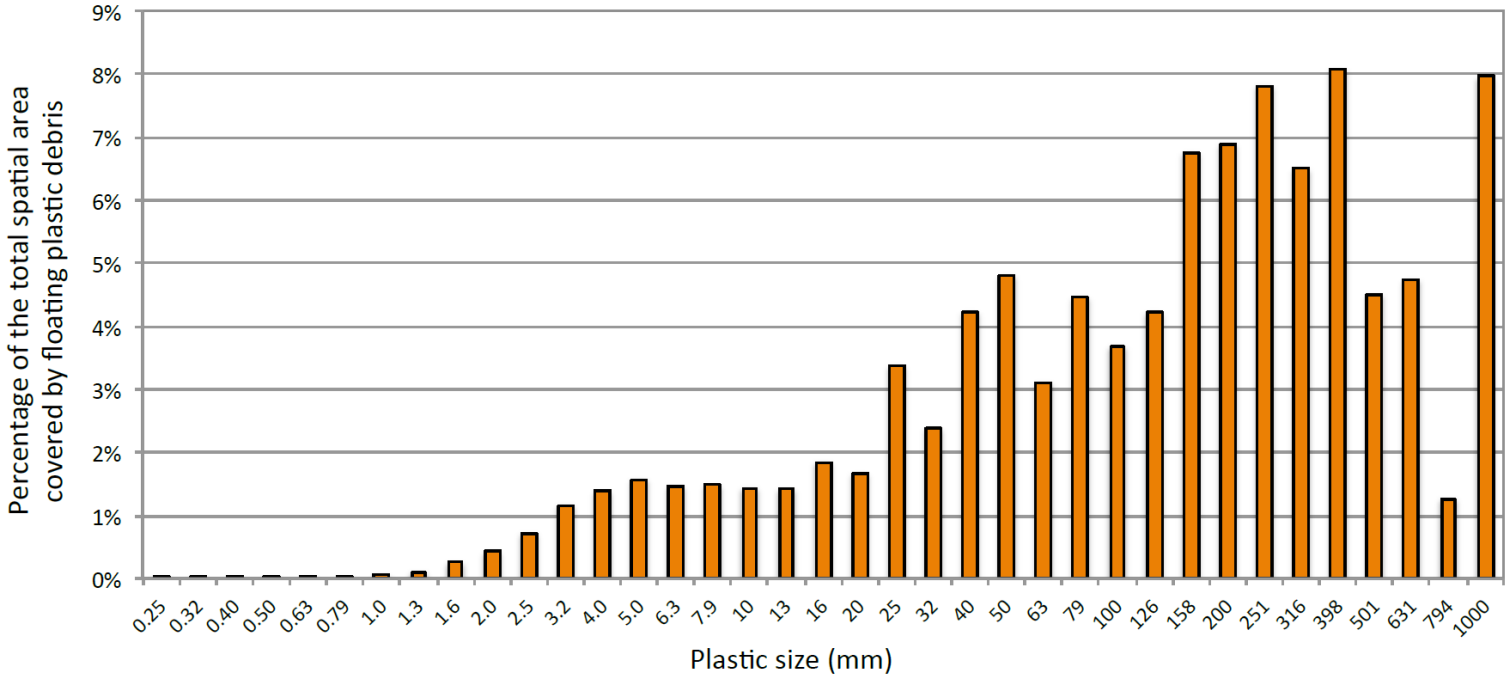


Plastic marine litter can be used as a **proxy for total litter** at the different domains.

Courtesy: Cozar *et al* (2018)

Characterization of marine litter

Plastic macro-litter is an opportunity for remote sensing monitoring of marine litter



Courtesy: Cozar *et al* (2018)

Options for Remote Sensing of Marine Litter

1. Macro-litter cover larger areas of the surface than smaller fractions.

2. Larger items are also representing a vast majority of the total mass of plastic.

3. Ocean dynamics play a key role as an accumulation factor, so better understanding is critical for successful in marine litter monitoring and modelling.

4. Plastic litter monitoring can be a very good proxy for the presence of total litter at different ocean domains.

5. Plastic litter composes a significant part of the floating marine litter hence, remote sensing observation.

Remote sesing solutions at global scale are critical to support monitoring and management of marine litter (Maximenko *et al,* OceanObs 2019)

What can do EO for marine litter?

Marine Litter Programme

- esa — **Remote Sensing for Marine Litter -RESMALI-** → Future of EO for Marine Litter
- UK SPACE AGENCY — **GeoInt Service for Marine Litter -SSGP Project-**
- esa — **EO Tracking of Marine Litter in the Mediterranean Sea**

→ Exploitation of Copernicus Sentinel-2 data

- Copernicus — **Copernicus Service for Marine Litter (LitterTEP)** → Numerical modelling for Marine Litter flows

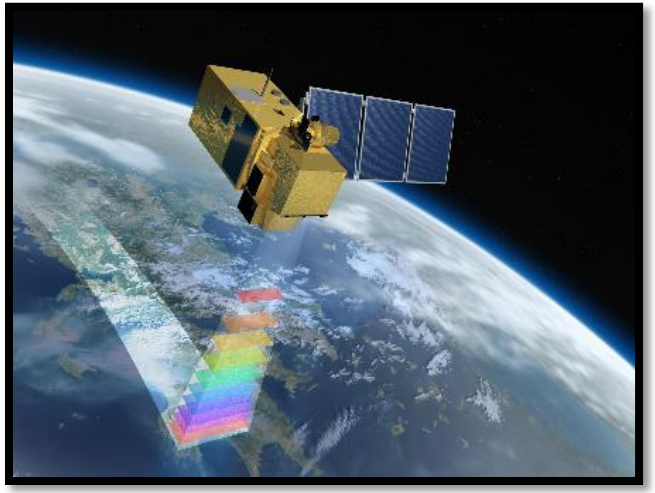
What can do EO for marine litter?

ML Characteristic	Domain			
	Open Ocean	Continental Shelf	Coastal Area	Shores & Beaches
Variability	Low (months to years)	Medium (months to weeks)	Medium to High (weeks to days)	Very high (days to hours)
Residence time	Long	Medium to short	Short	Long to short
Origin	Plastics (PP, PE)	Plastics (PP, PE, PS, PET) Organic	Plastics (PP, PE, PS, PET) Organic, Rubber, Paper	Plastics (PP, PE, PS, PET) Organic, Rubber, Paper, Metal
Accumulation factor	Global currents	Wind/currents transport, human activity	River mouths, run-offs, dumping, human activity	Tidal/storm stranding, dumping, human activity

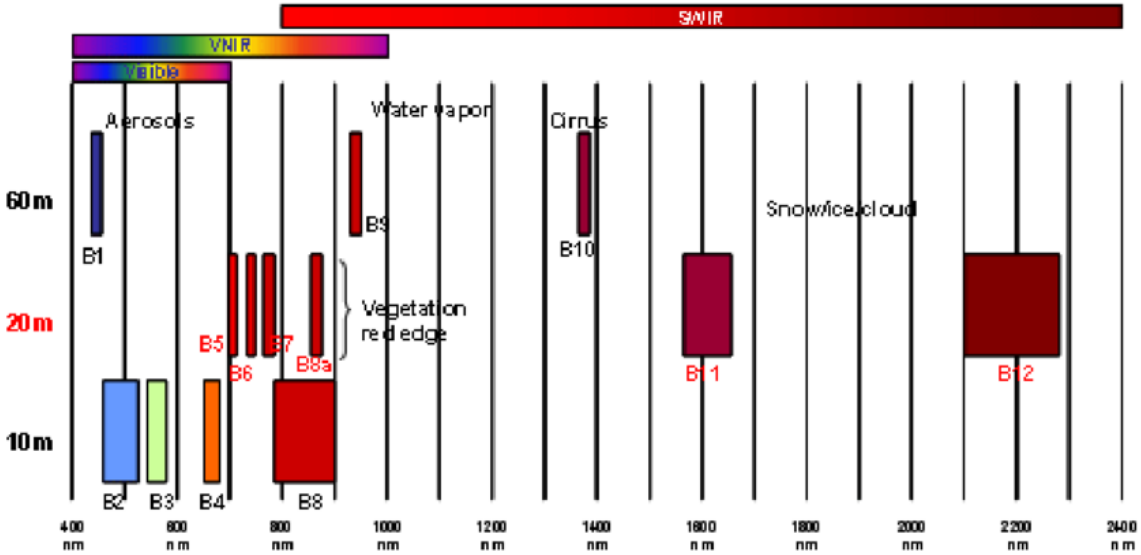
Complexity

Source: Arias *et al* (2019, in prep.)

What can do EO for marine litter?

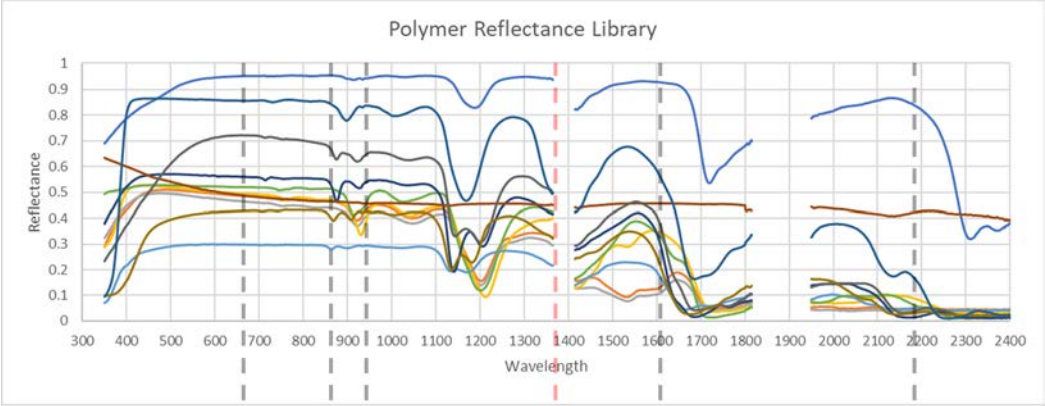


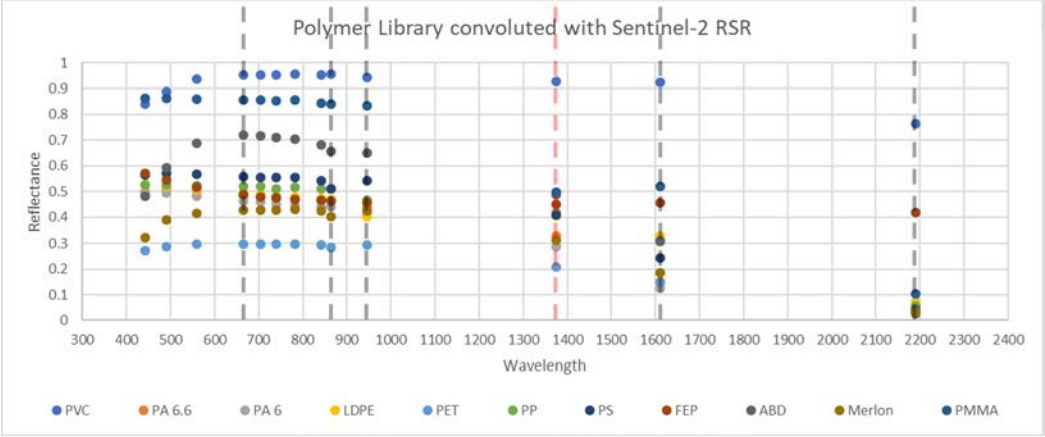
Copernicus Sentinel-2



- 2 satellites in operation: S-2A (June 2015) and S-2B (March 2017)
- 10-20-60m band-dependent resolutions (13 bands)
- Acquisition frequencies for tandem mission: 5 days (Equator) 2-3 days (mid-latitudes)
- Spectral error tolerance: < 5% TOA Reflectance

What can do EO for marine litter?

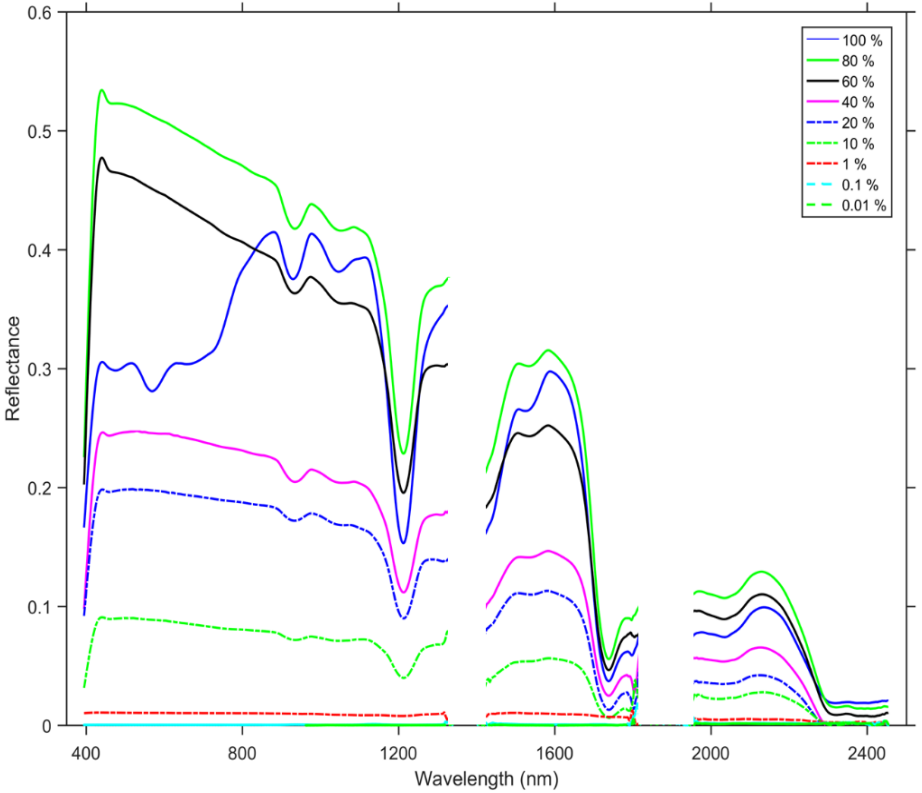


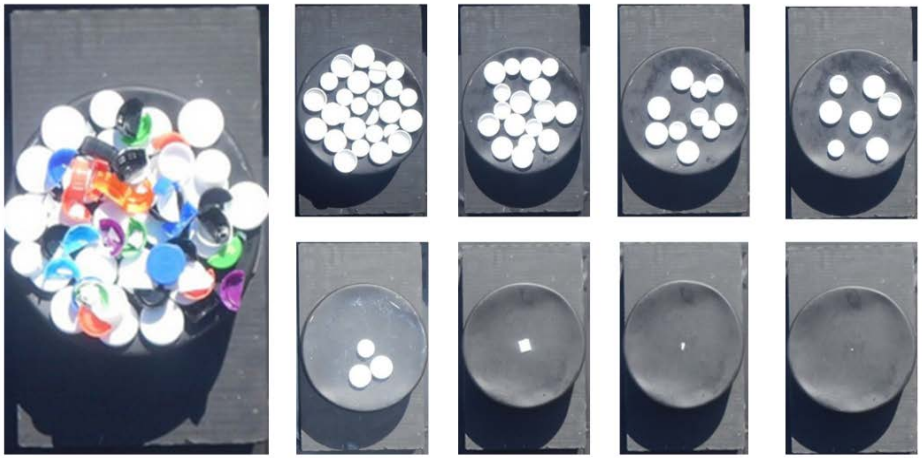


- **Plastic polymers** have different **spectral signatures** which offer opportunities for EO.
- **NIR/SWIR bands** have in principle **strong contrast** against a water target.
- Sentinel-2 has bands with **limited capability** for plastics observation from space.
- The question remains open about current **sensitivity to plastics.**

Source: Arias *et al* (2019, in prep.)

What can do EO for marine litter?





Detection of small fractions of plastic in a pixel is an **important challenge.**

Source: Arias *et al* (2019, in prep.)

What can do EO for marine litter?

	HDPE			LDPE			PP			PS		
	Dry	Wet	APD	Dry	Wet	APD	Dry	Wet	APD	Dry	Wet	APD
850 nm												
0°	0.408	0.237	-42	0.106	0.038	-64	0.368	0.232	-37	0.916	0.890	-3
15°	0.427	0.228	-47	0.080	0.049	-39	0.276	0.216	-22	0.883	0.871	-1
30°	0.506	0.225	-55	0.039	0.044	12	0.324	0.141	-57	0.861	0.870	1
45°	0.498	0.186	-63	0.028	0.051	78	0.256	0.107	-58	0.777	0.708	-9
1215 nm												
0°	0.154	0.036	-77	0.129	0.029	-77	0.233	0.020	-91	0.894	0.678	-24
15°	0.165	0.045	-73	0.081	0.039	-52	0.185	0.021	-88	0.861	0.651	-24
30°	0.199	0.023	-88	0.044	0.035	-21	0.203	0.012	-94	0.842	0.758	-10
45°	0.210	0.021	-90	0.034	0.044	27	0.166	0.010	-94	0.772	0.474	-39
1732 nm												
0°	0.039	0.015	-62	0.133	0.028	-79	0.070	0.013	-81	0.804	0.381	-53
15°	0.039	0.019	-52	0.073	0.035	-52	0.055	0.012	-79	0.769	0.345	-55
30°	0.043	0.014	-67	0.041	0.031	-25	0.061	0.008	-87	0.755	0.560	-26
45°	0.046	0.014	-70	0.033	0.041	21	0.053	0.008	-85	0.694	0.197	-72

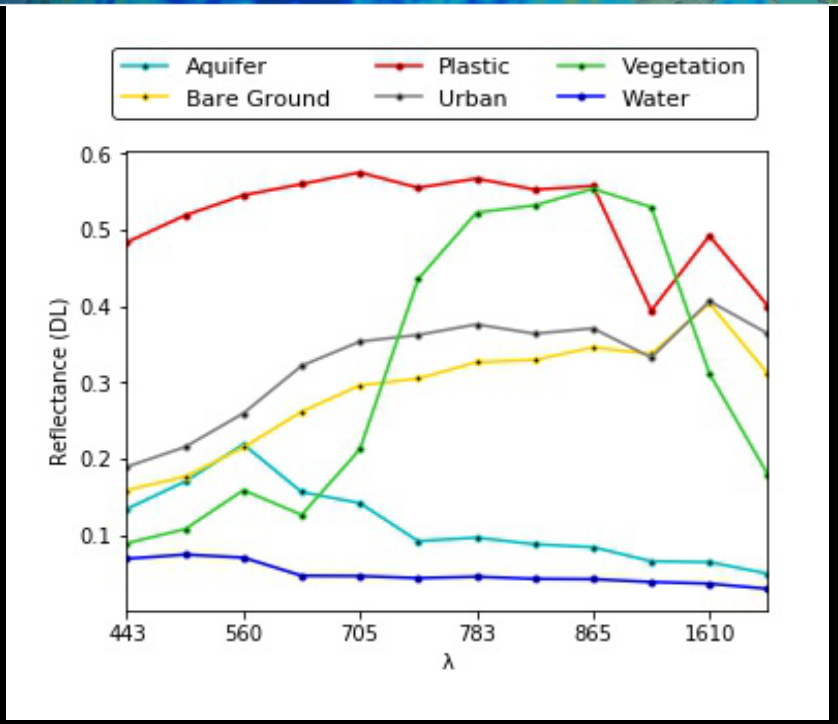
Absolute percentage differences (APD) showing the loss of reflectance due to water of each sample at different nadir angles at 100% pixel coverage.

- **Water** on top of the plastic litter **significantly reduces** the signature.
- Materials with **lower density** (by composition or shape) can be observed by remote sensing.
- However, even a **low signature** in a pixel could provide **contrast** with surrounding water.

Source: Arias *et al* (2019, in prep.)

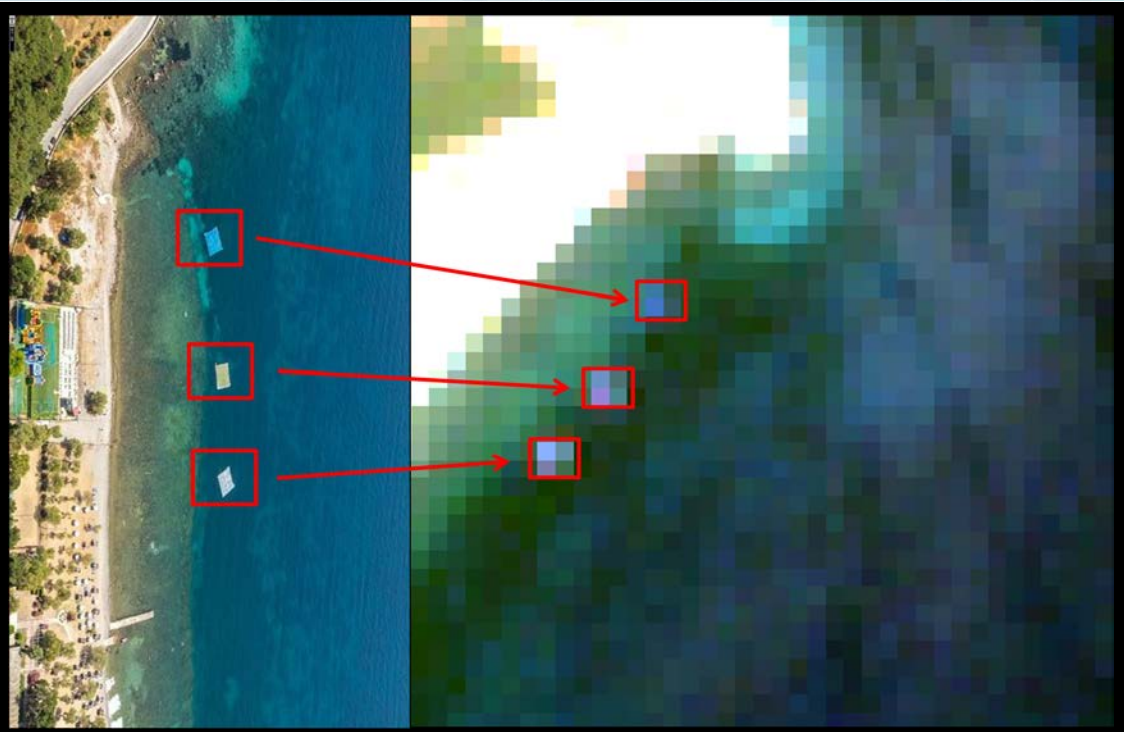
What can do EO for marine litter?

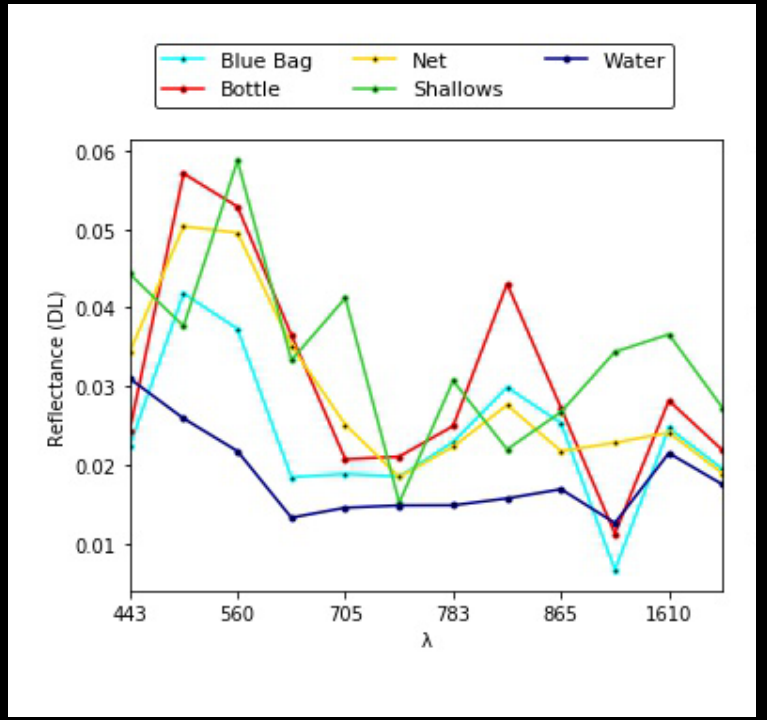
Sentinel-2/MSI Band 8 (835 nm - NIR) / Sea of Plastic - Almeria



Source: Arias *et al* (2019, in prep.)

What can do EO for marine litter?

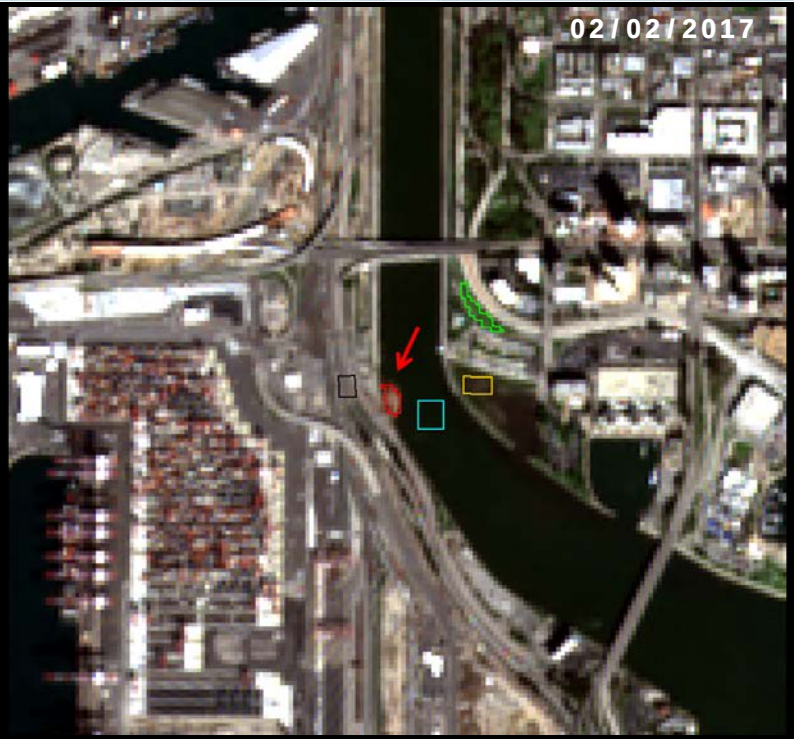


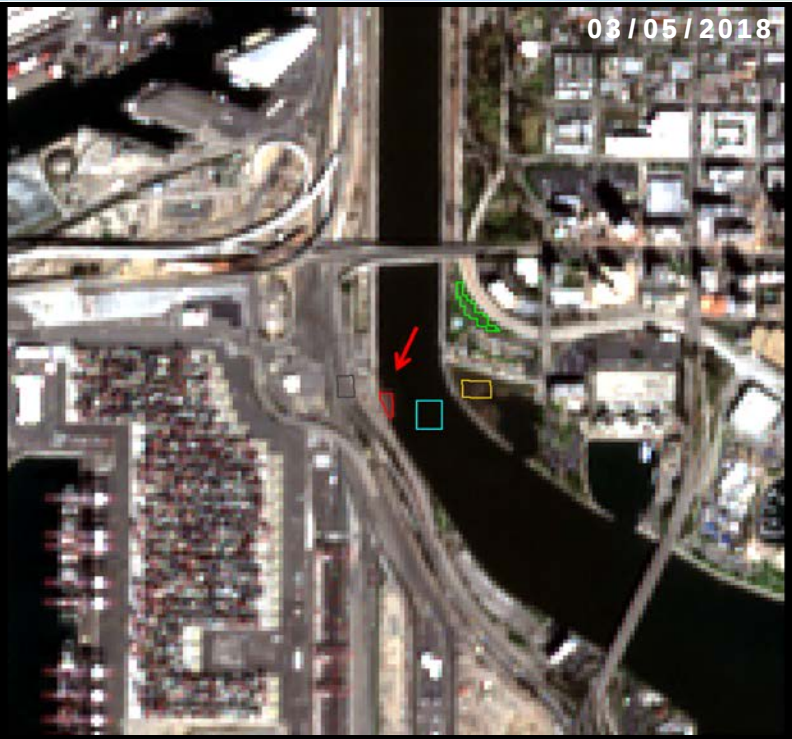


Courtesy: K. Topouzelis

Sentinel-2 data over artificial targets over water enables detection

What can do EO for marine litter?





Source: Arias *et al* (2019, in prep.)

Sentinel-2 litter detection in rivers (L.A., U.S.A.)

What can do EO for marine litter?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NEWS

Hidroelectrica loses money operating on lakes covered in plastic waste after the floods

Georgeta Gheorghe 07/08/2018 | 17:20

TWITTER FACEBOOK LINKEDIN GOOGLE

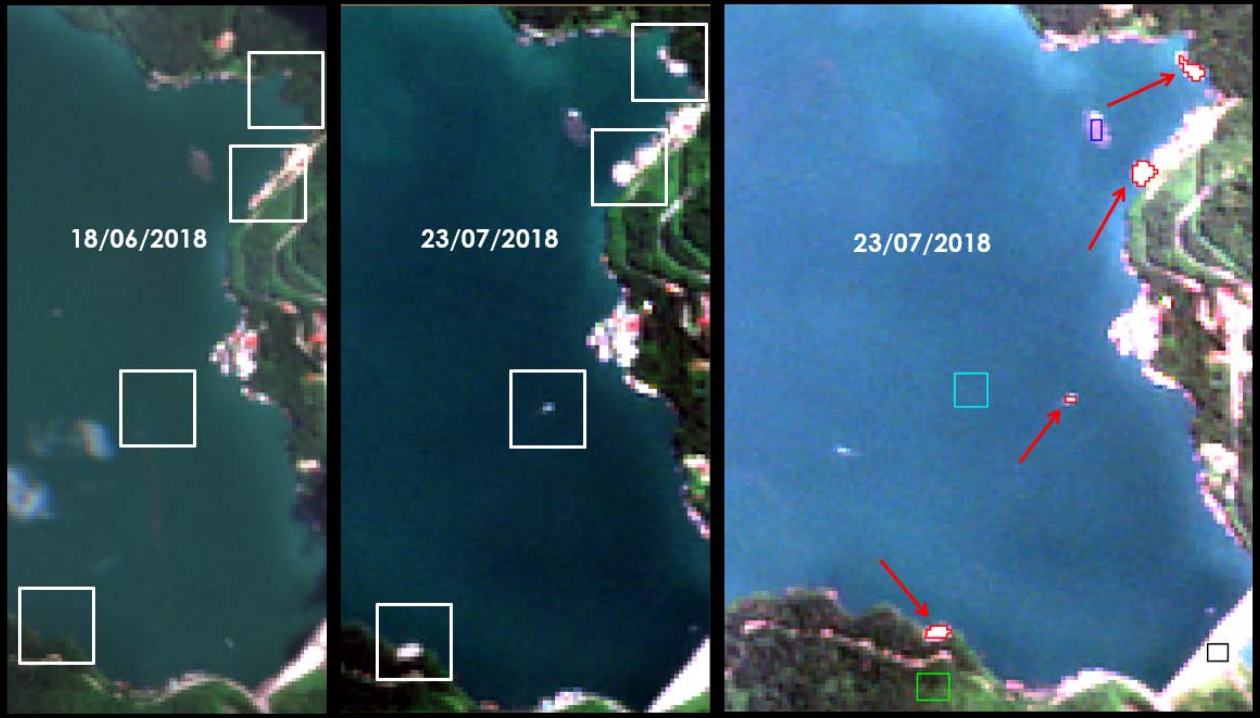
FEATURE ARTICLE

Hidroelectrica, Romania's biggest power producer, is losing money while cleaning the lakes that have been covered in plastic waste after the floods that hit several Romanian regions, the company's general director Bogdan Badea said.

Romania was hit by heavy rains and floods and the debris, including large

Source: Arias *et al* (2019, in prep.)

What can do EO for marine litter?



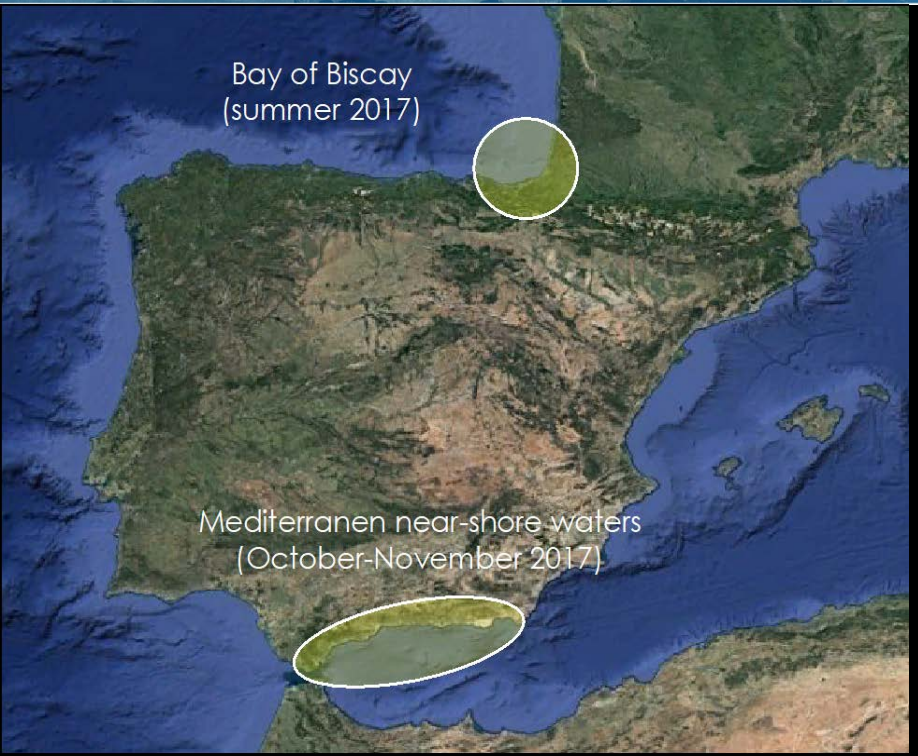
Sentinel-2 is able to detect hotspots of litter in rivers and lakes before it reaches the ocean under certain conditions.

Machine learning could be very important for the monitoring of litter from space.

Source: Arias *et al* (2019, in prep.)

Sentinel-2 litter detection in rivers (L.A., U.S.A.)

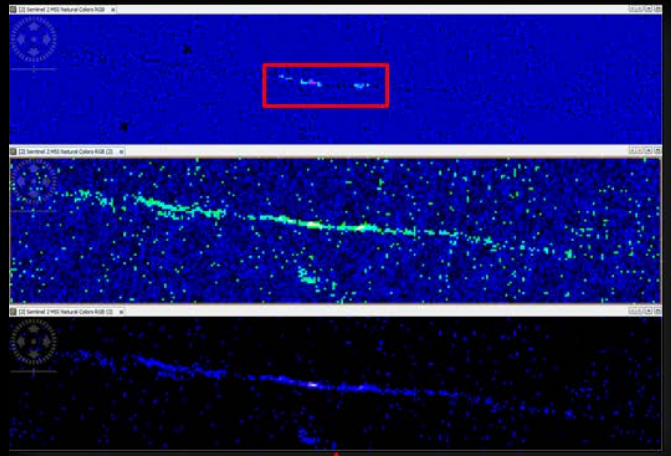
What can do EO for marine litter?

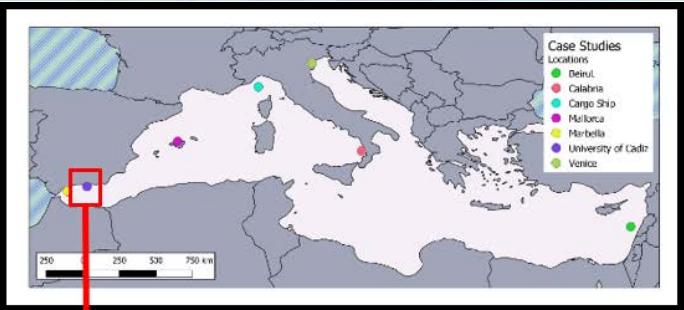


Courtesy: A. Cozar / Azti

Regional efforts to better understand marine litter present in coastal areas.

What can do EO for marine litter?





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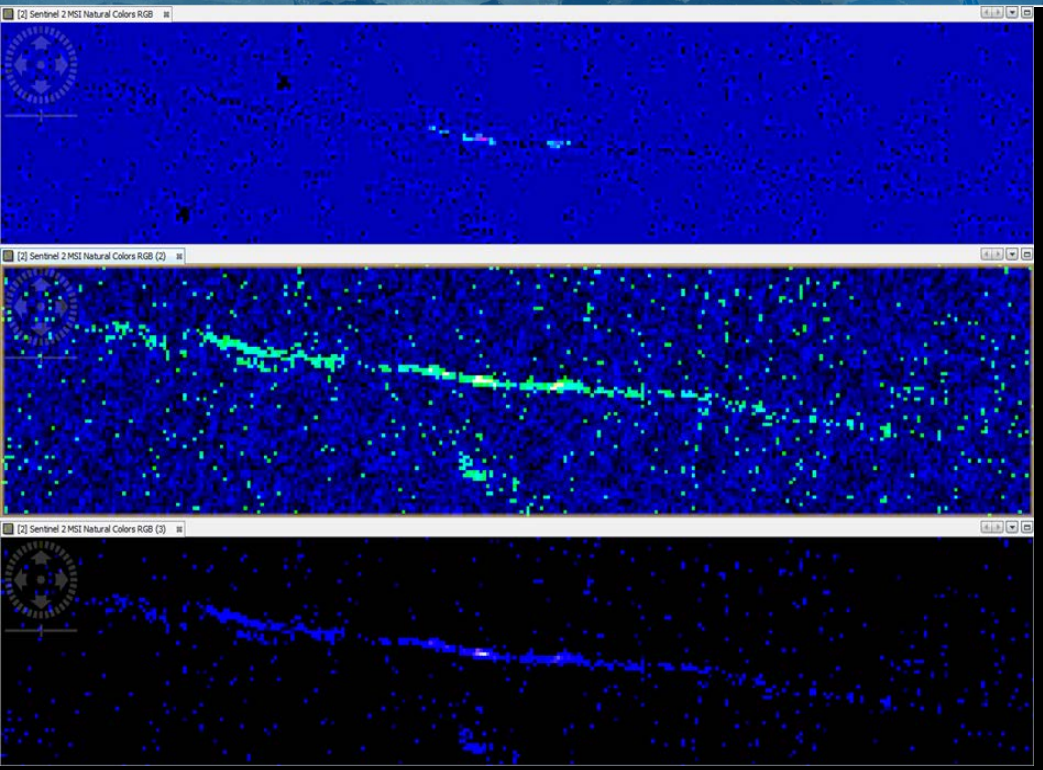

Source: Arias *et al* (2019, in prep.)

Sentinel-2 can capture microscale accumulations of litter that cannot be resolved by models.

Algorithms for image processors and automatic detection are in early stages.

Detection and monitoring could be significanty improved with the right spectral bands and optimal spatial resolution.

What are our needs in terms of EO for ML?

1. Current sensors onborad satellites are not fit for purpose. Significant improvements could be done for observation of marine litter with the right sensor.

2. Numerical models supporting marine litter distribution and behaviour at sea need to signficiantly increase spatial resolution of variables, including ocean current velocities derived from altimetry.

3. Additional parameters controlling dynamics of marine litter are needed, both for numerical models and support for future developments, including Stokes drift estimation, upper-layer ocean velocity, wind speed, and scales relevant for marine litter.

4. We need further support access to existing limits of current technologies and available data, including field campaigns for R&D.

Thank you!

Any questions?