One Integrated Marine Debris Observing System for a Clean Ocean

Addressing the gap between in situ and remotely sensed observations

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Marine Litter from daily human activities

Total plastic pollution entering in the oceans

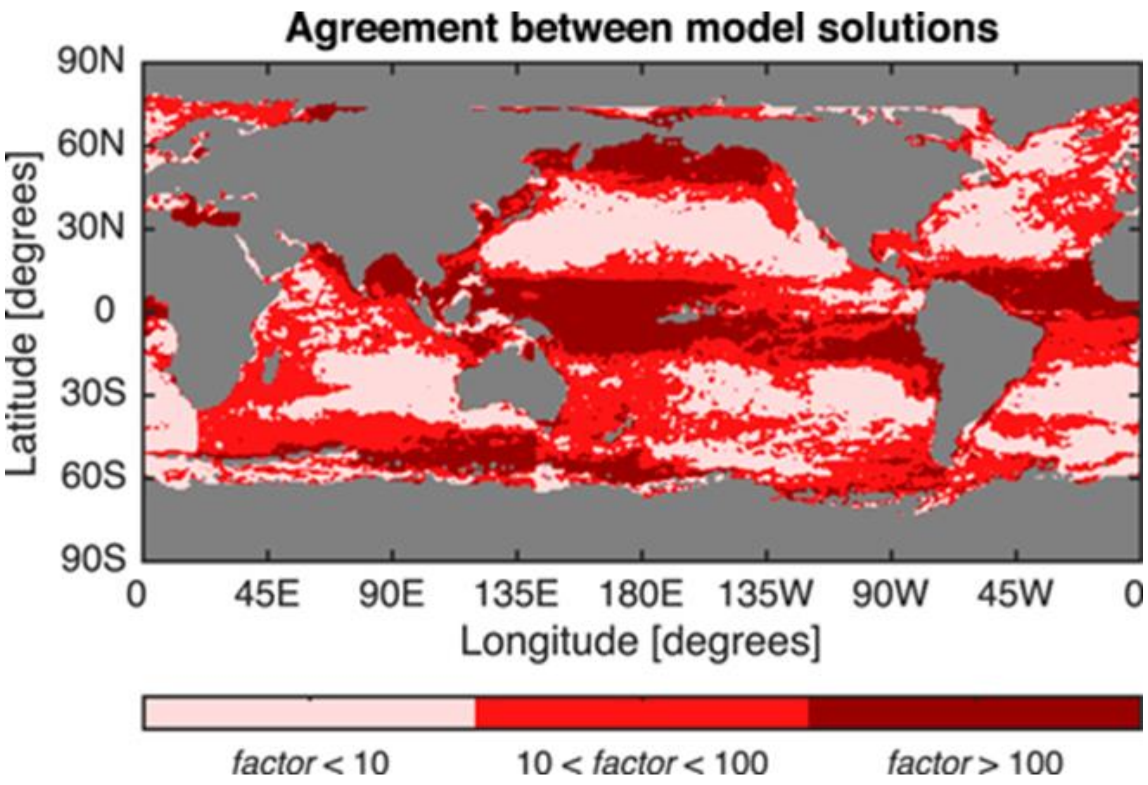
8 million metric tons / year

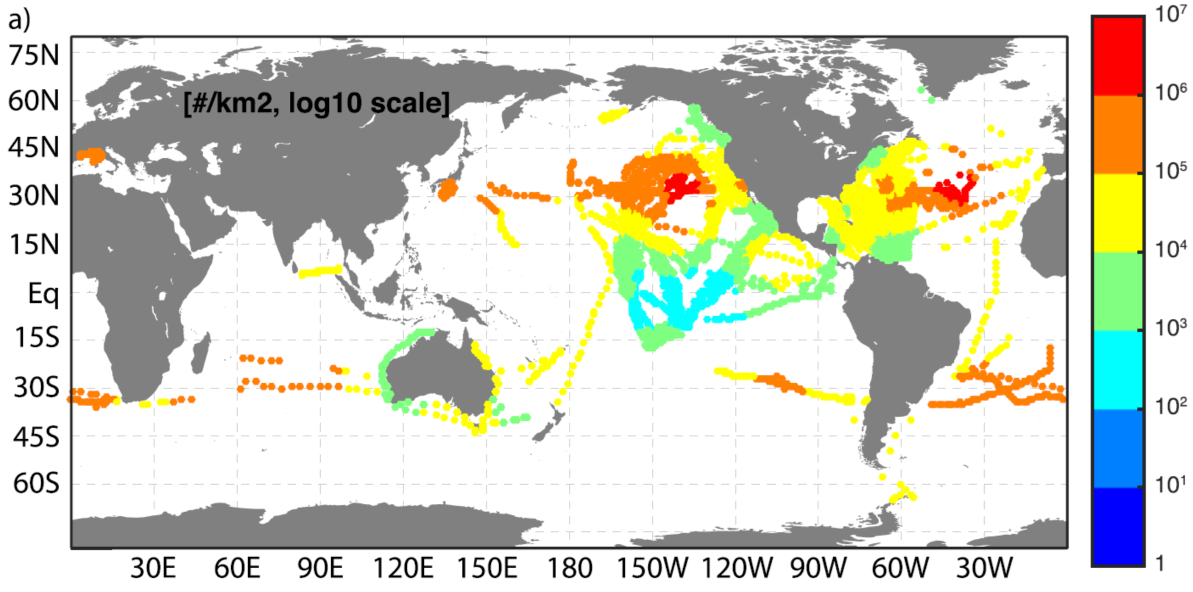
Total floating plastic pollution measurable by **aereal remote sensing**

6,350-245,000 metric tons / year

Why we need remote sensing to monitor marine debris?

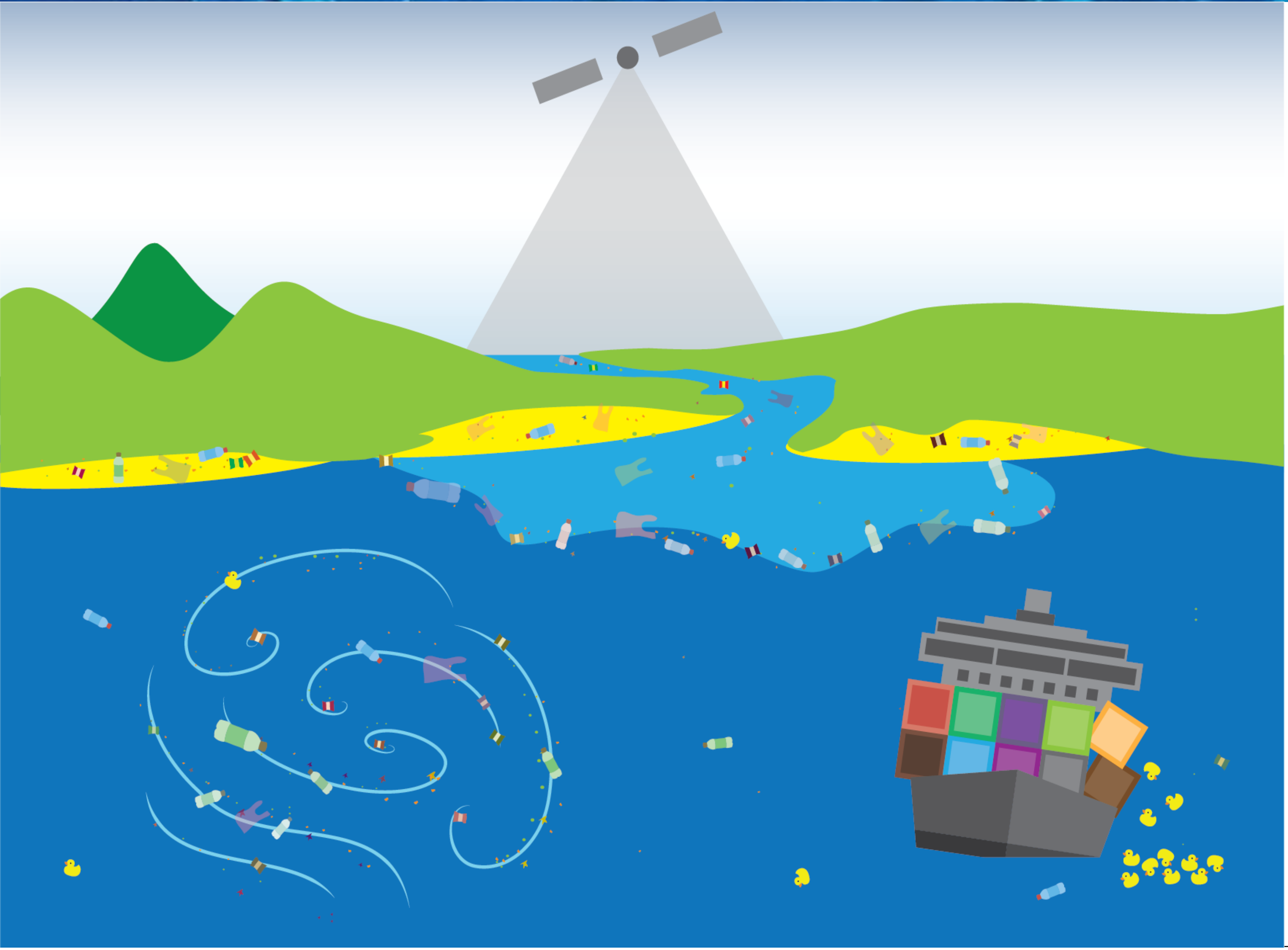
- Fate of only 1% plastic litter is known and 0.1% is cleaned up on shorelines.
- **Large uncertainties** in plastic distribution models, need more **validation** data.
- Sparse in-situ dataset, limited **spatial** and **temporal** resolutions.
- **Cost and difficulty of in situ observations** which lack of synopticity

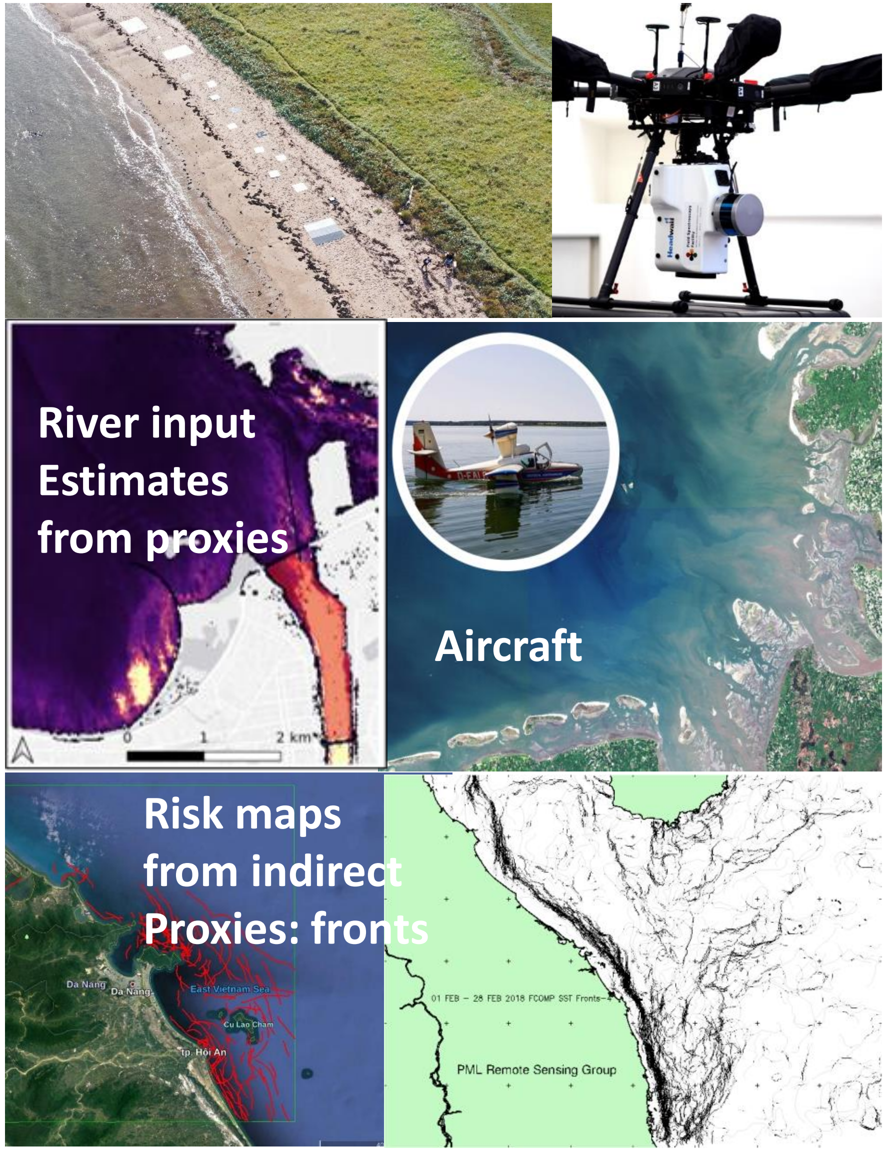




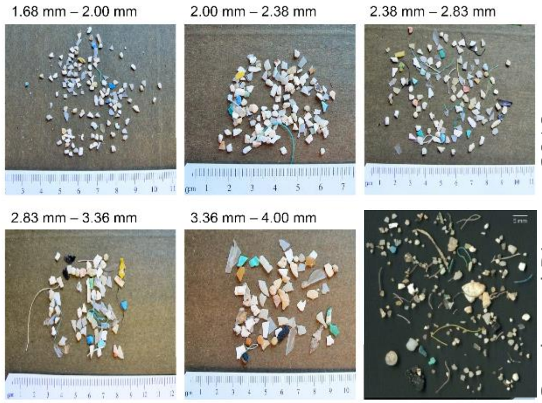
van Sebille et al., 2015

Why we need remote sensing to monitor marine debris?



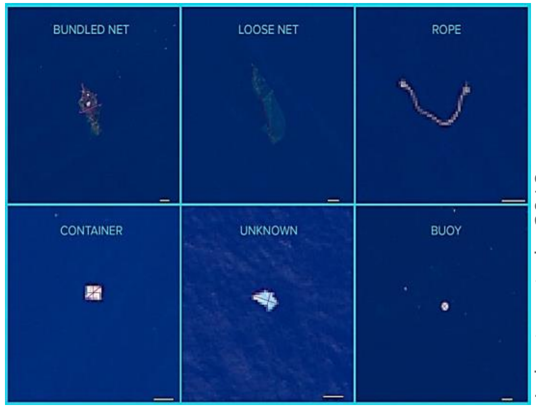


Challenges for Remote Sensing for Marine Litter



Garaba and Dierssen 2018
Jessica Donohue SEA Education

Microplastics



Lebreton et al., 2018

Large single debris
(e.g. ghost nets, ship ropes)

Caroline Power Photography

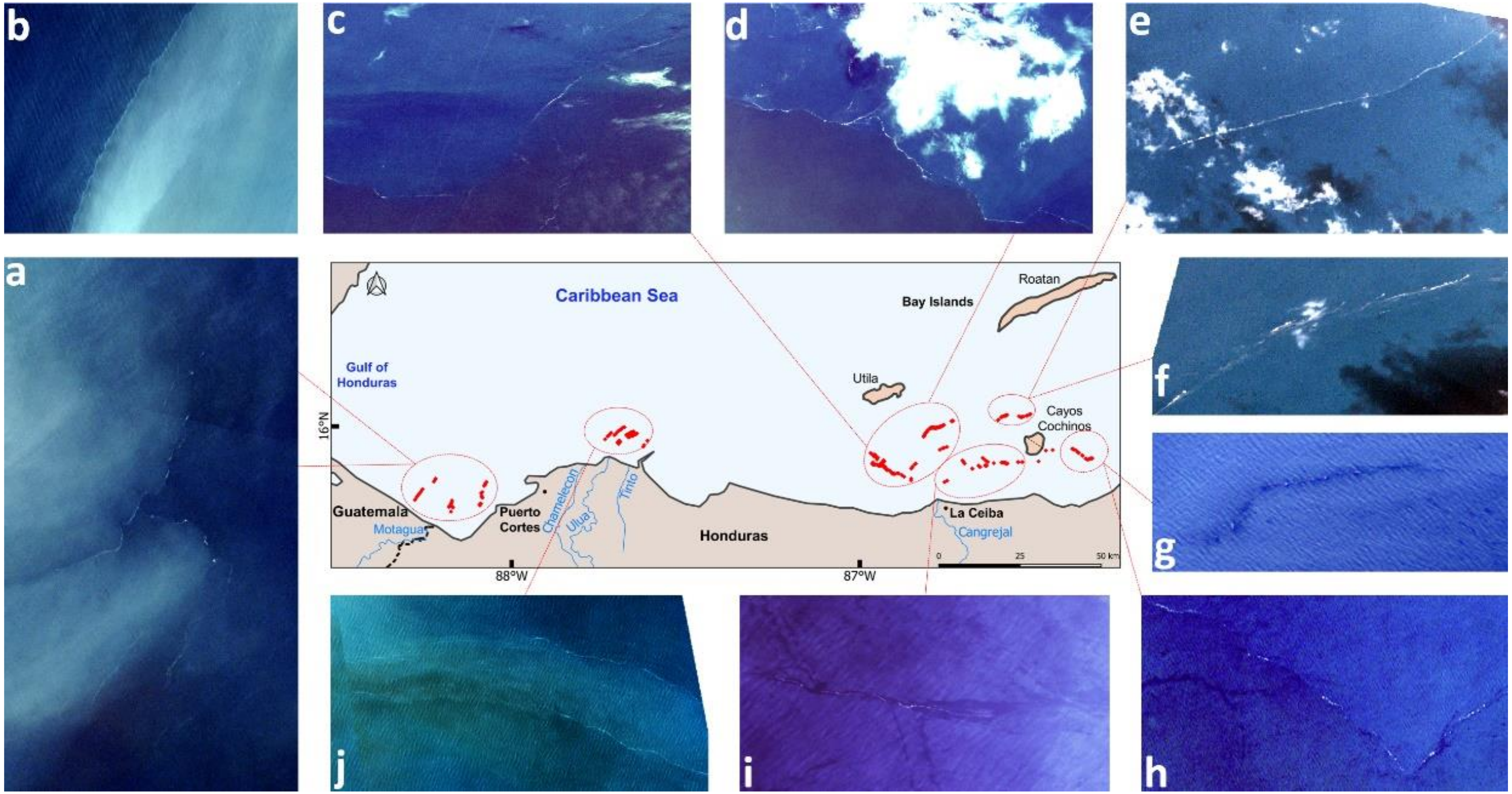
Large accumulations

µm mm m km

- Optical spectral techniques (Visible/Infra-red)
- LASER-based techniques

- High spatial resolution imaging
- Microwave-based techniques (RADAR and passive radiometers)

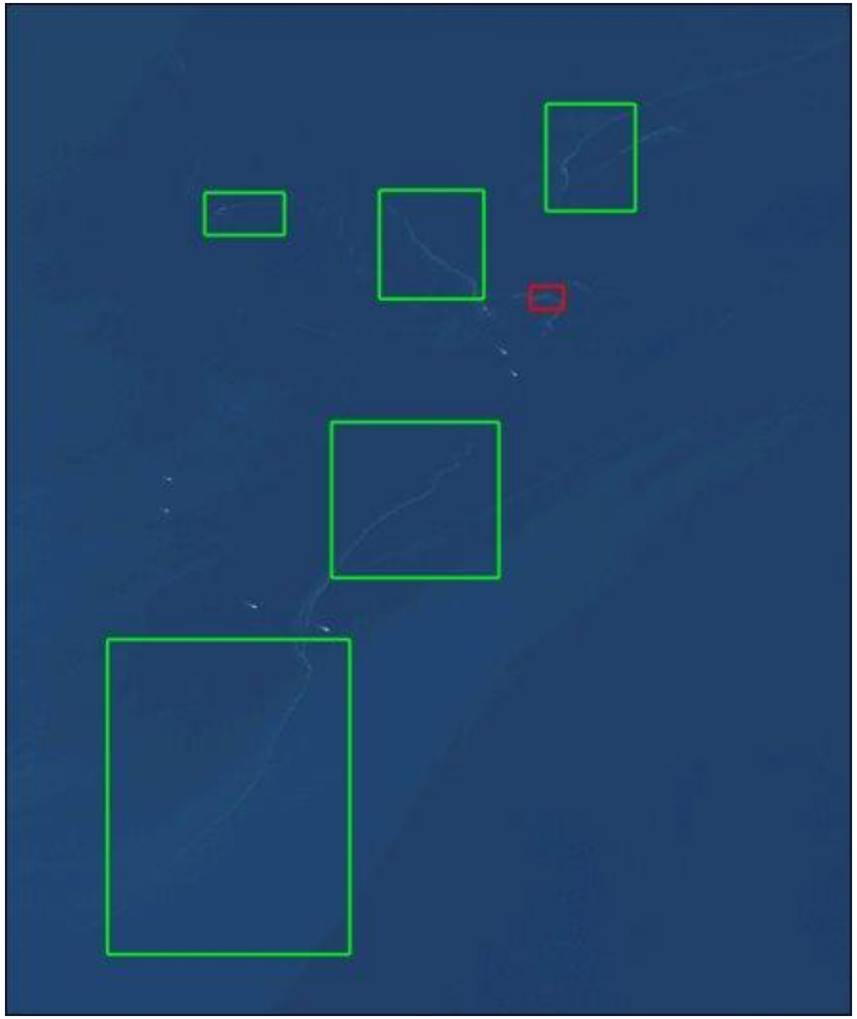
Current capabilities and efforts: Optical remote sensing



Use of spectral data acquired with satellites like Sentinel-2 can prove useful to monitor recurrent floating macro marine plastic debris at 10 metres scales, taking advantage of the reflected sun light.

Kikaki, A., Karantzalos, K., Power, C. A., & Raitsos, D. E. (2020). Remotely sensing the source and transport of marine plastic debris in bay islands of honduras (Caribbean Sea). Remote Sensing, 12(11), 1727.

Current capabilities and efforts: Use of proxies and AI



Remote sensing can report on proxies of marine plastic pollution and hotspots with high accuracy

In this case, detection of windrows (filaments of floating debris and materials) are a useful environmental indicator of plastic pollution

Use of Artificial Intelligence complements spectral detection with contextual identification

Arias, M., Sumerot, R., Delaney, J., Coulibaly, F., Cozar, A., Aliani, S., ... & Corradi, P. (2021, July). Advances on Remote Sensing of Windrows as Proxies for Marine Litter Based on Sentinel-2/MSI Datasets. In 2021 IEEE International Geoscience and Remote Sensing Symposium IGARSS (pp. 1126-1129). IEEE.

Current capabilities and efforts: Thermal Infra-red signature

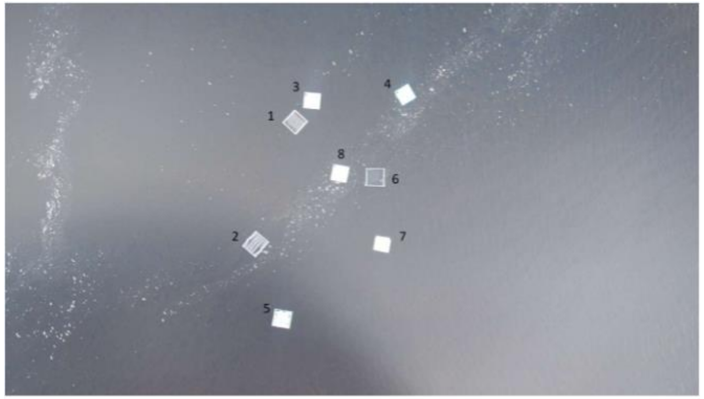


Figure 4. Snapshot image in VIS at 20 m, Survey 1

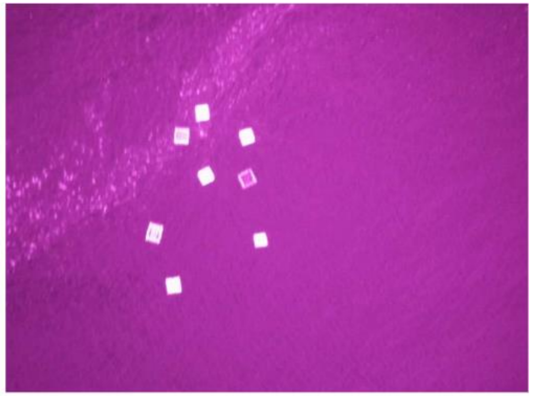


Figure 5. Snapshot image in NIR at 30m, Survey 1

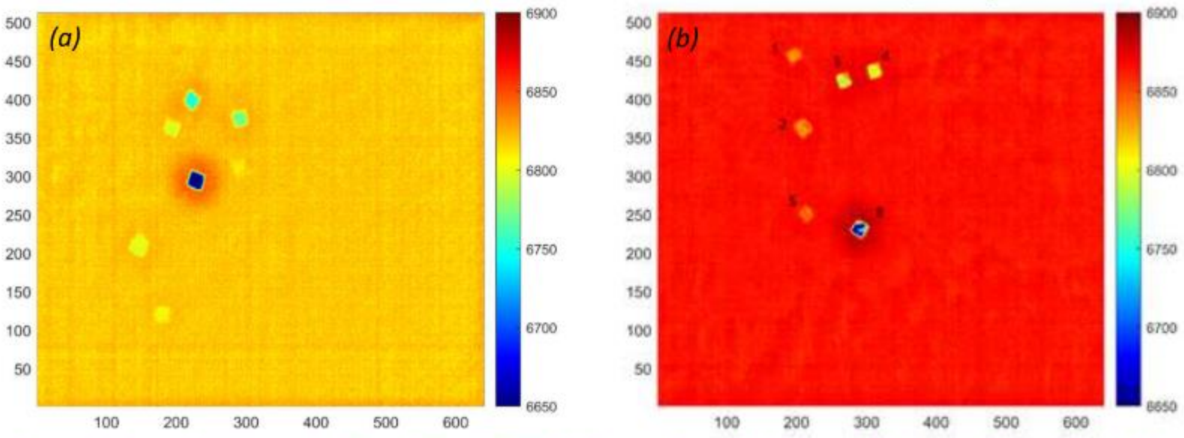


Figure 6. Snapshot image in TIR at 30 m in DN, (a) Survey 1, and (b) Survey 2, targets 6 and 7 invisible

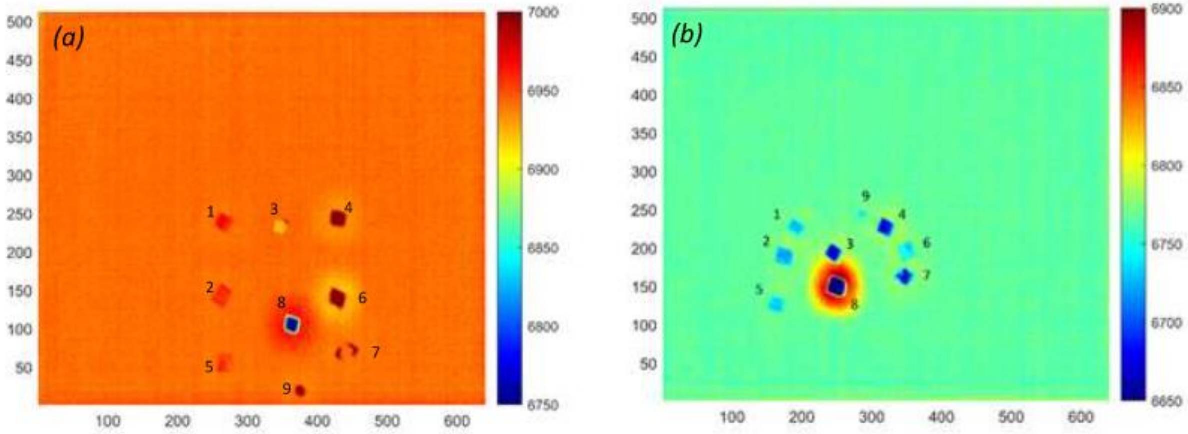
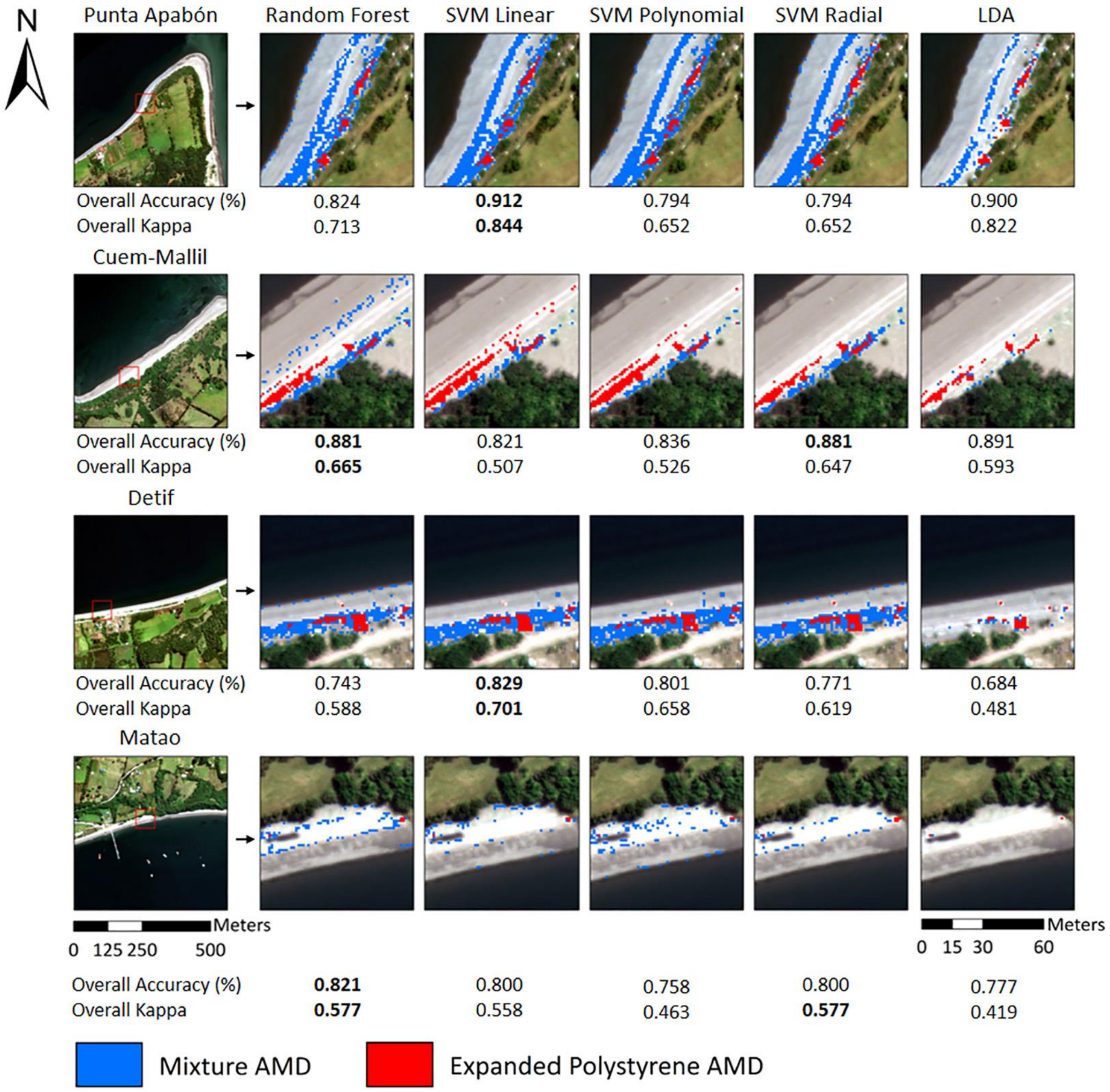


Figure 7. Snapshot image in TIR at 30 m in DN, (a) Survey 3, and (b) Survey 4

The differences in heat transfer between water and air, when plastic is present, are a promising technique already tested on artificial targets, with the advantage of operating during the day and the night.

Thermal infra-red sensing of floating plastic litter. L. Goddijn-Murphy, B. Williamson, J. McIlvenny, B, Bremner, P. Corradi, 2021.

Current capabilities and efforts: Very High Resolution sensors

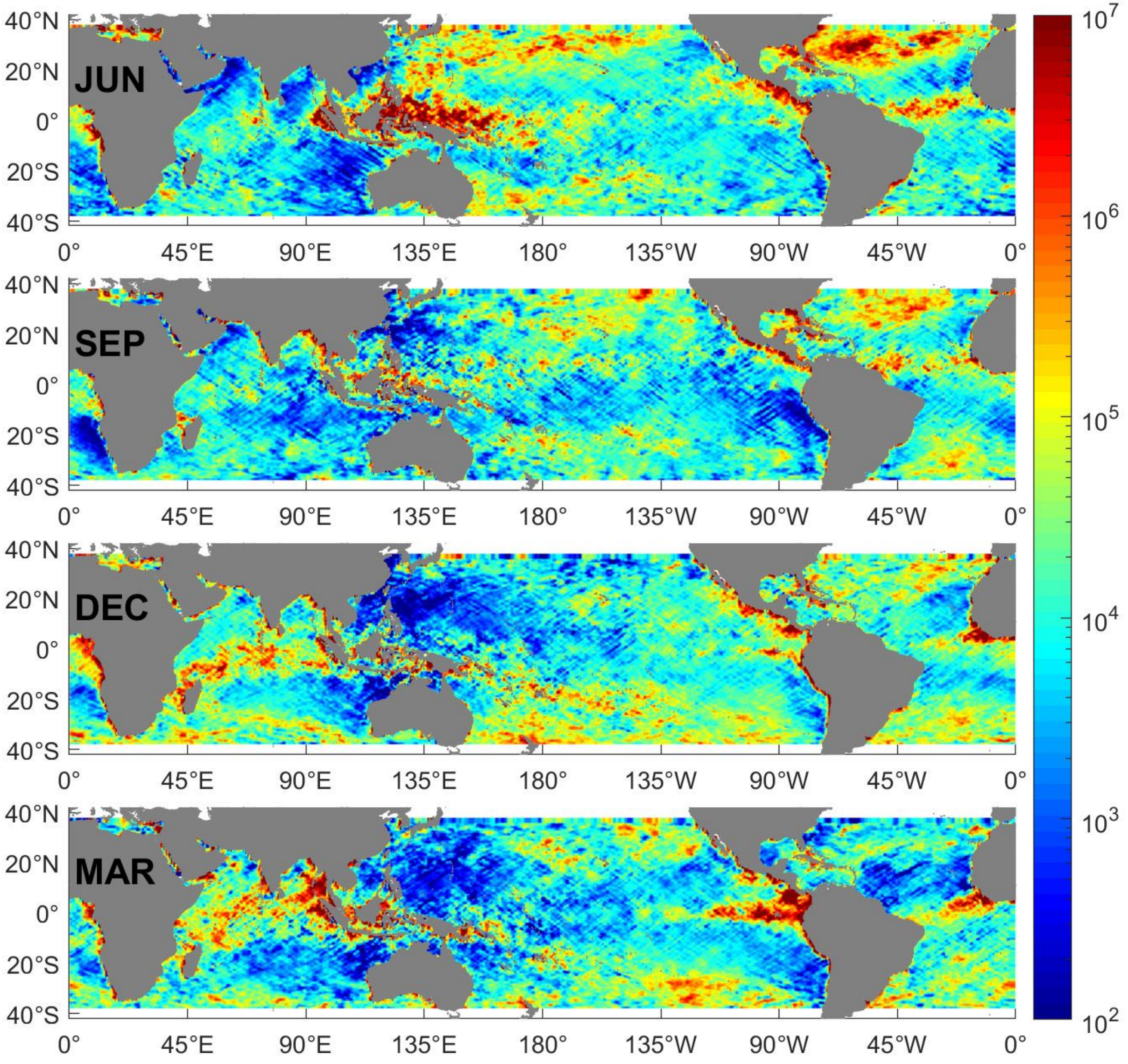


Low orbit satellites providing images with pixels of 30 cm or better can be used to detect patches of plastic litter on beaches and coastal areas.

As the spectral data, only operates during the day, and in this case, size of the images and cost of the acquisitions can make of this solution an expensive one.

Acuña-Ruz, T., Uribe, D., Taylor, R., Amézquita, L., Guzmán, M. C., Merrill, J., ... & Mattar, C. (2018). Anthropogenic marine debris over beaches: Spectral characterization for remote sensing applications. Remote Sensing of Environment, 217, 309-322.

Current capabilities and efforts: GPS reflected signal (GNSSR)



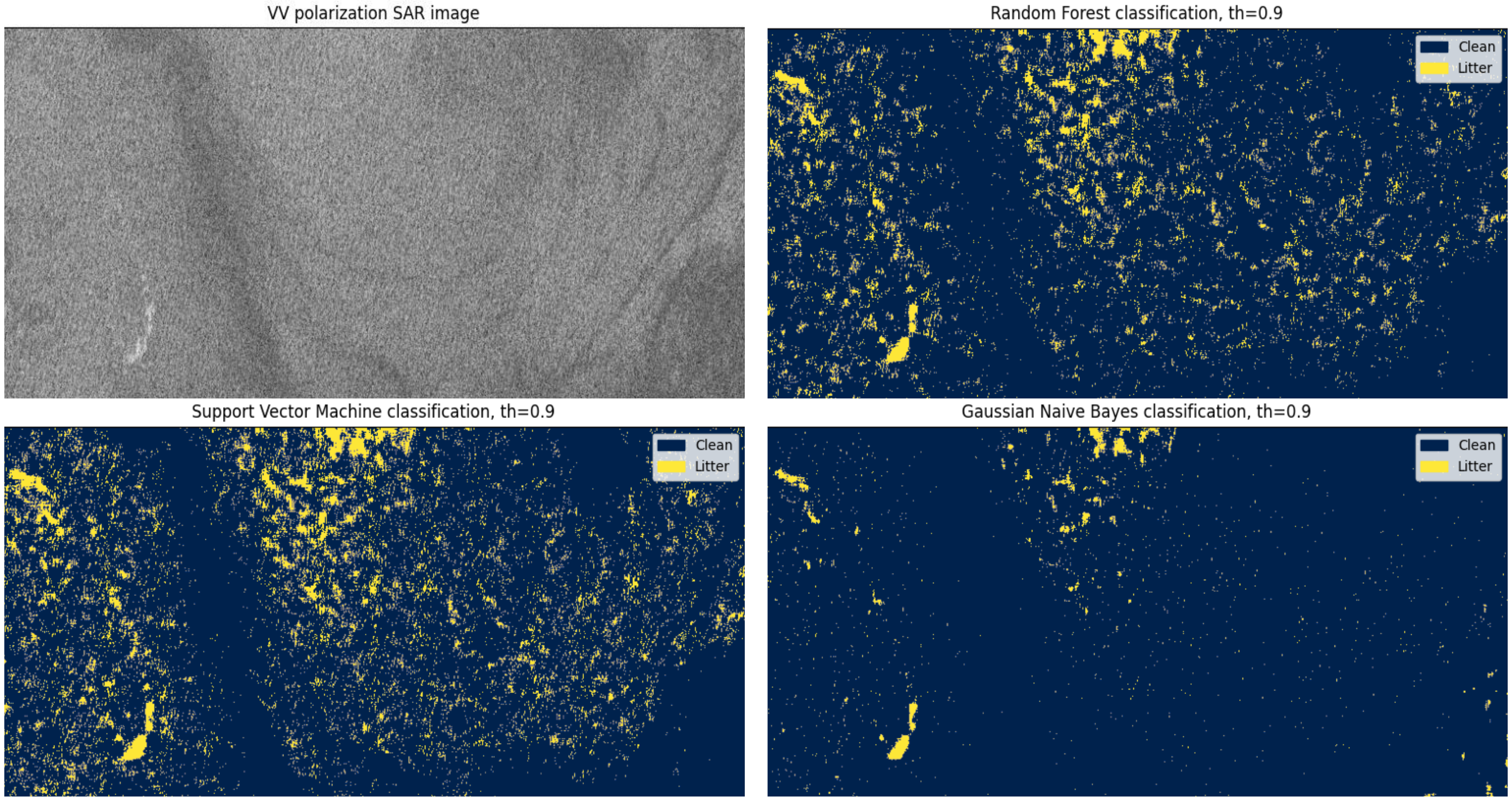
Evans, M. C., & Ruf, C. S. (2021). Toward the Detection and Imaging of Ocean Microplastics With a Spaceborne Radar. IEEE Transactions on Geoscience and Remote Sensing.

The signals emitted by the global GPS constellation of satellites have potential to inform on accumulation hotspots.

The signals reflected by the surface of the ocean change with the presence of surfactants and near-surface substances.

This method, if achieved, could measure the small fraction of floating plastic pollution but a low spatial resolution, operating day and night and with great global coverage.

Current capabilities and efforts: SAR and Artificial Intelligence



"A first approach to the automatic detection of marine litter in SAR images using artificial intelligence", Salvatore Savastano, Ivan Cester, Marti Perpinya, Laia Romero, Proceedings of IGARSS 2021, Brussels

Synthetic Aperture Radar (SAR) is a medium to high spatial resolution technology that can inform on presence of plastic marine debris.

Use of Artificial Intelligence enables advance signal processing to extract marine litter information out of complex and noisy data.

Summary

NEED

- Remote sensing technologies are the solely affordable tools able to provide systematic observations of marine plastic litter at global scale and in viable time scales.
- It complements in-situ observations, which are always necessary, and bridges the gaps in data supporting the modelling effort.

CAPABILITIES

- Remote Sensing could inform of plastic litter using sensors from kilometric spatial resolution to centimetric spatial resolution (e.g. from satellite to drones).
- Similarly, remote sensing could prove able to inform in multiple plastic fractions and accumulations, but having in mind that satellite-based solutions are unlikely to report on individual items, rather than "densities" or "concentrations".

LIMITATIONS

- No sensor/technology is perfect, with some being particularly challenging or having specific limitations (e.g. optical remote sensing operating only in the day and with no clouds).
- Current results for satellites are still not mature for operational purposes; there is need of significant R&D effort.

Taskforce – Remote Sensing of Marine Litter and Debris

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*The Task Force on Remote Sensing of Marine Litter has as an overarching goal to **coordinate the advancement** of current and future **remote sensing** technologies and techniques that have **potential** to provide observations of **plastic litter over all aquatic environments**.*

1. **Assessing the most suitable technologies.**
2. **Studying the best retrieval procedures.**
3. **Establishing open datasets for the community.**
4. **Addressing interdisciplinary questions.**

https://ioccg.org/group/marine-litter-debris/


Thank you!