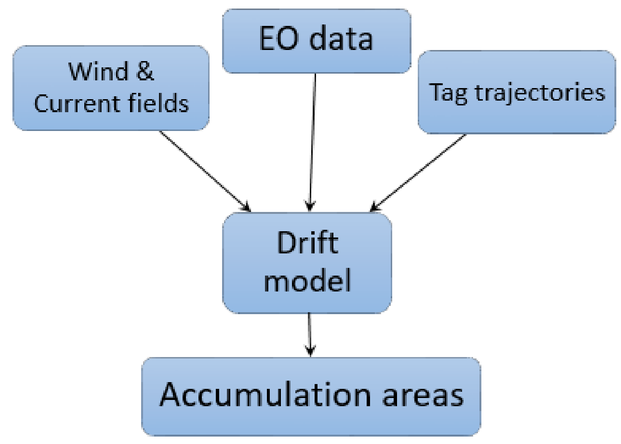
Detection of Marine Plastic Source Locations using Machine Learning Applied to Satellite Earth Observation Data

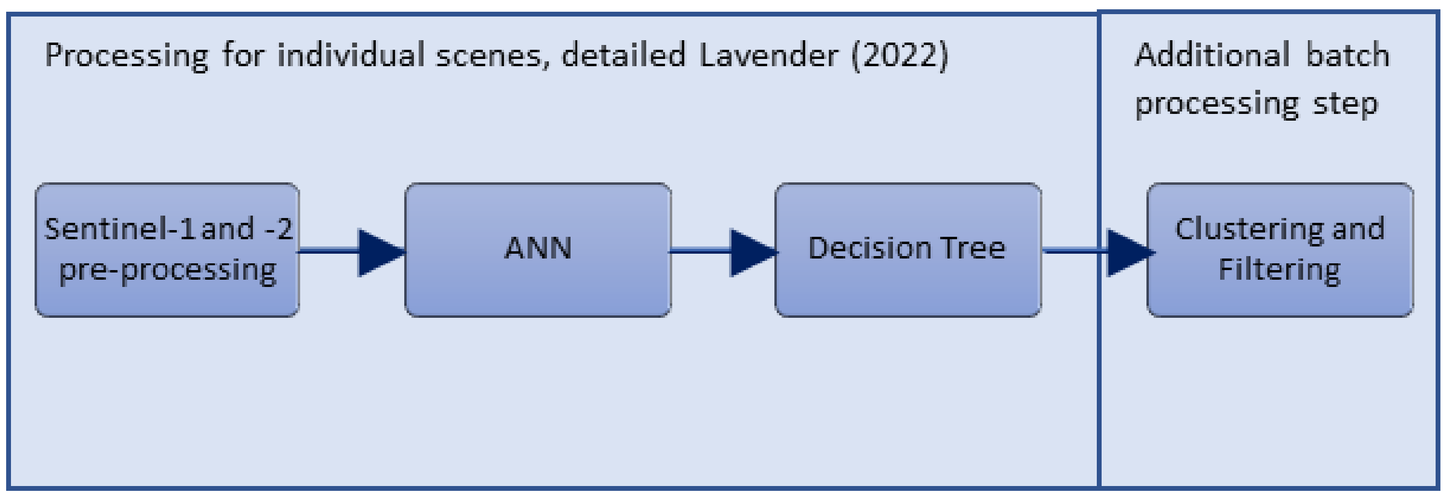
Dr Samantha Lavender [1] and Marc Lucas [2]

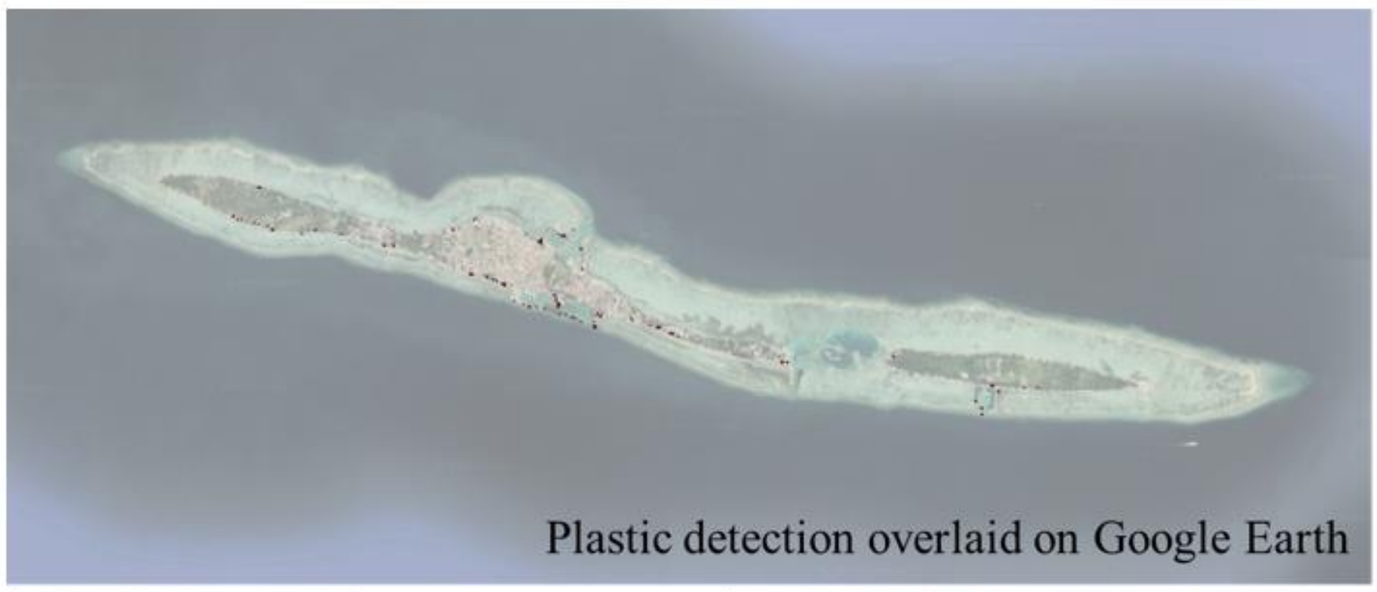
[1] *Pixalytics Ltd (UK)* , [2] *CLS (France) E-mail: slavender@pixalytics.com*

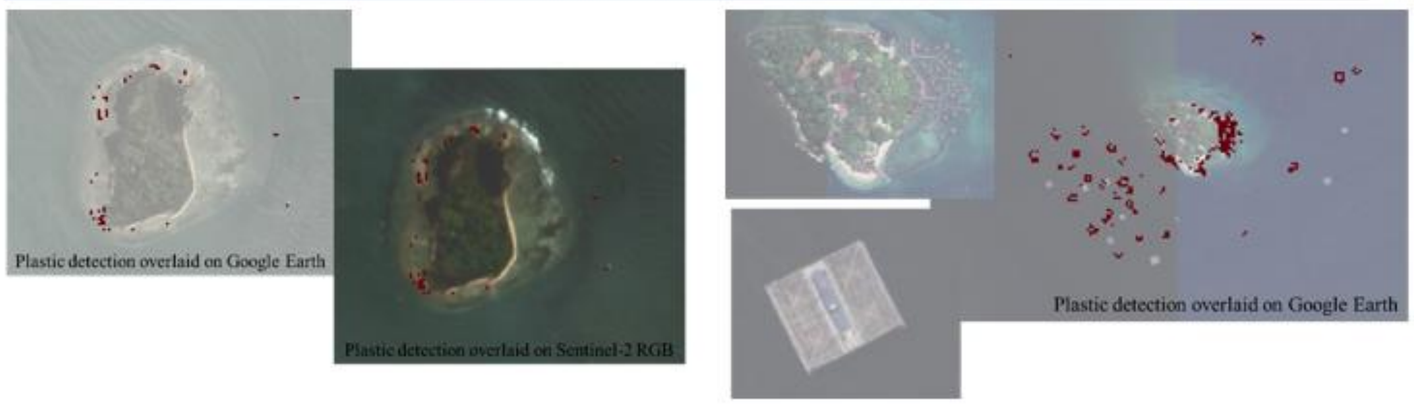
The MARLISAT project was funded through a Remote Sensing of Plastic Marine Litter competition on the European Space Agency (ESA) Open Space Innovation Platform.

The aim was for satellite Earth Observation (EO) to detect the source locations of marine plastics, then trajectory modelling is supplemented by information gained from developed floating tags (that act as a large piece/accumulations of plastic) to predict where the plastic will end up. If the plastic returns to the coast as marine litter, then the EO data can be further used to confirm the presence of accumulations.









Zoomed-in regions showing plastic detection for the (top) Tidung Barat (bottom left) Pulau Laki and (bottom right) Pulau Opak Besar Timur islands.

The baseline detection was performed using a combination of Copernicus Sentinel-1 and -2, building on an approach originally developed by Page et al. (2020, https://doi.org/10.3390/rs12172824) for on-land detection of plastic and tyre waste sites.

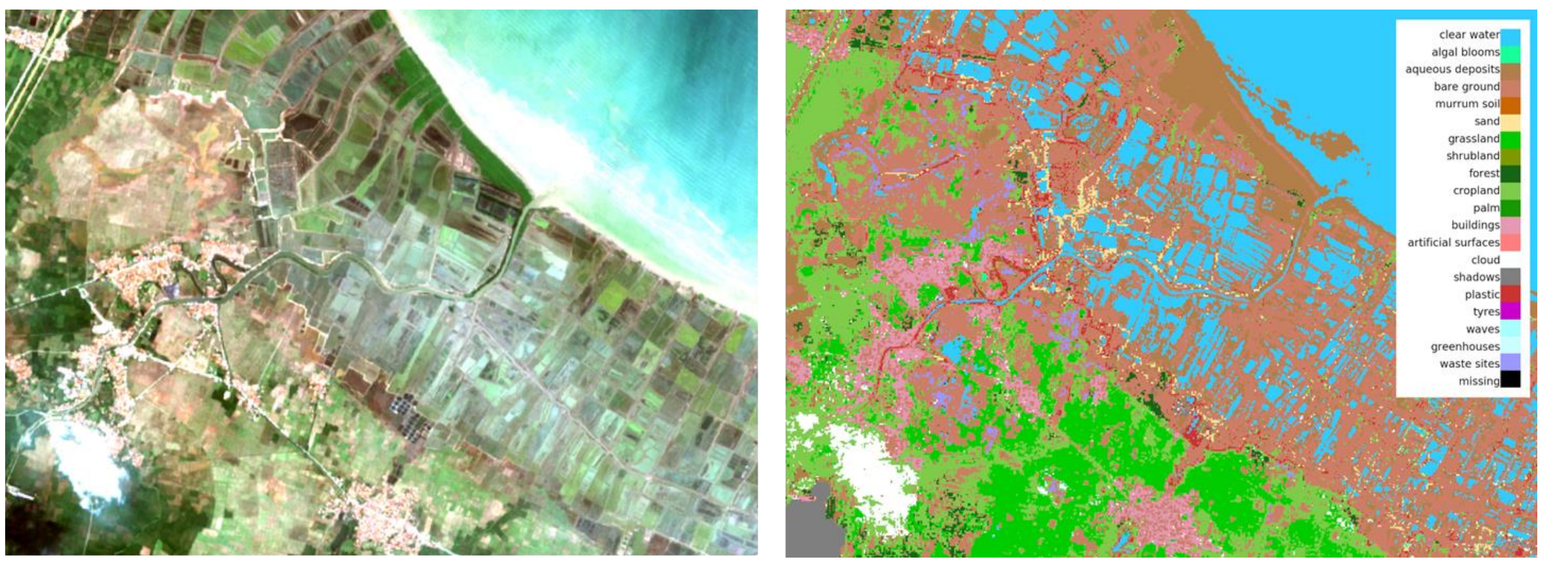
A training dataset was generated from sites around the planet, including legal and illegal waste sites alongside known sites of riverine/marine plastic accumulation. This dataset is being continually grown as new sites are identified through web articles or personal communication.

During Marlisat the Machine Learning (ML) approach was extended to utilise an Artificial Neural Network (ANN), with a Decision Tree then used to further refine the results (Lavender, 2022 https://doi.org/10.3390/rs14194772). The approach was run on Sentinel-1/-2 data from July and August 2021 around the coast of Indonesia with filtering used to reduce false detections.

Since the project finished, work has focused on improving the performance through transfer learning and supporting the development of standards by being a member of the Open Geospatial Consortium (OGC) Standards Working Group focused on a Training Data Markup Language for AI (OGC TrainingDML-AI Standard Part 1 defines a Conceptual Model, https://docs.ogc.org/is/23-008r3/23-008r3.html).

The ML model was designed to be generalist - ongoing work is looking at its extension to tackle difficult-to-detect cases by testing different ML setups, such as Transfer Learning and Generative Adversarial Networks, and fusing commercial higher spatial resolution imagery to support the detection of smaller accumulations.

One disadvantage of using both Sentinel-1 and -2 for floating marine targets is that the two satellites don't acquire imagery coincidently, so if the plastic debris moves, the expected combined radar/optical signal will not be present. Therefore, the testing is also looking at how to deal with this flexibly.



Comparison inland with a river showing up as contaminated by plastic

Acknowledgements: Satellite data access courtesy of Copernicus/ESA, activities funded by ESA (4000131481/20/NL/GLC), Singapore Government (2010JVVZ), and OGC (Tesbed-19 Machine Learning: Transfer Learning For Geospatial Applications)