

living planet symposium | BONN

23–27 May
2022

TAKING THE PULSE
OF OUR PLANET FROM SPACE



Exploring SSU & ML on fused multi- and hyper-spectral data for plastic marine litter detection – the REACT project



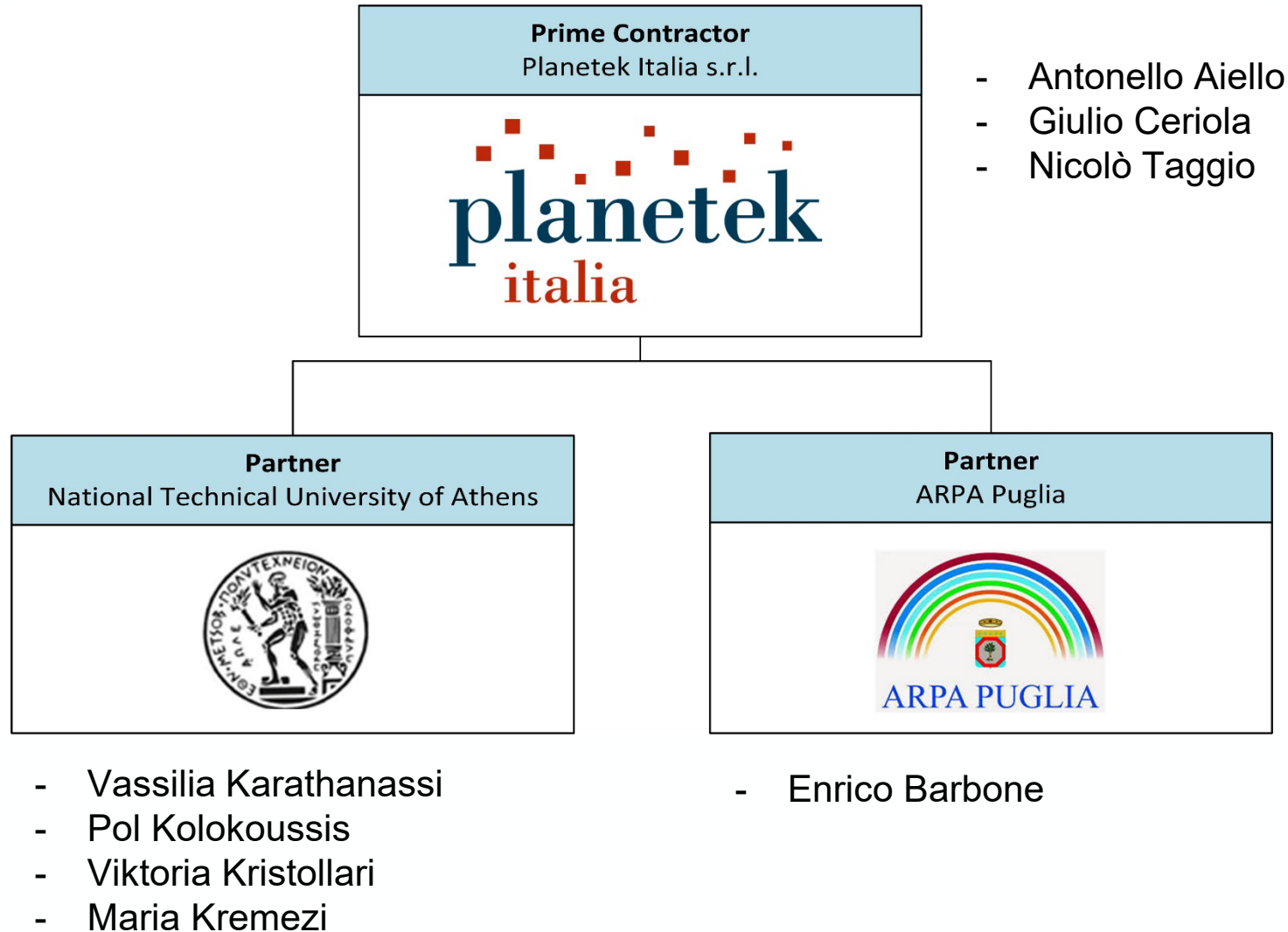
Antonello Aiello (Planetek Italia), Vassilia Karathanassi (NTUA), Enrico Barbone (ARPA Puglia), Paolo Corradi (ESA)

25/05/2022

ESA UNCLASSIFIED – For ESA Official Use Only



- ❑ Team and expertise
- ❑ Project's aims and objectives
- ❑ Controlled experiments
- ❑ Image Fusion
- ❑ Spectral Signature Unmixing
- ❑ Machine Learning
- ❑ Output
- ❑ Findings



REACT in numbers

3 Partners:
1 SME
1 University
1 Public Institution

2 Countries
Italy (2)
Greece (1)

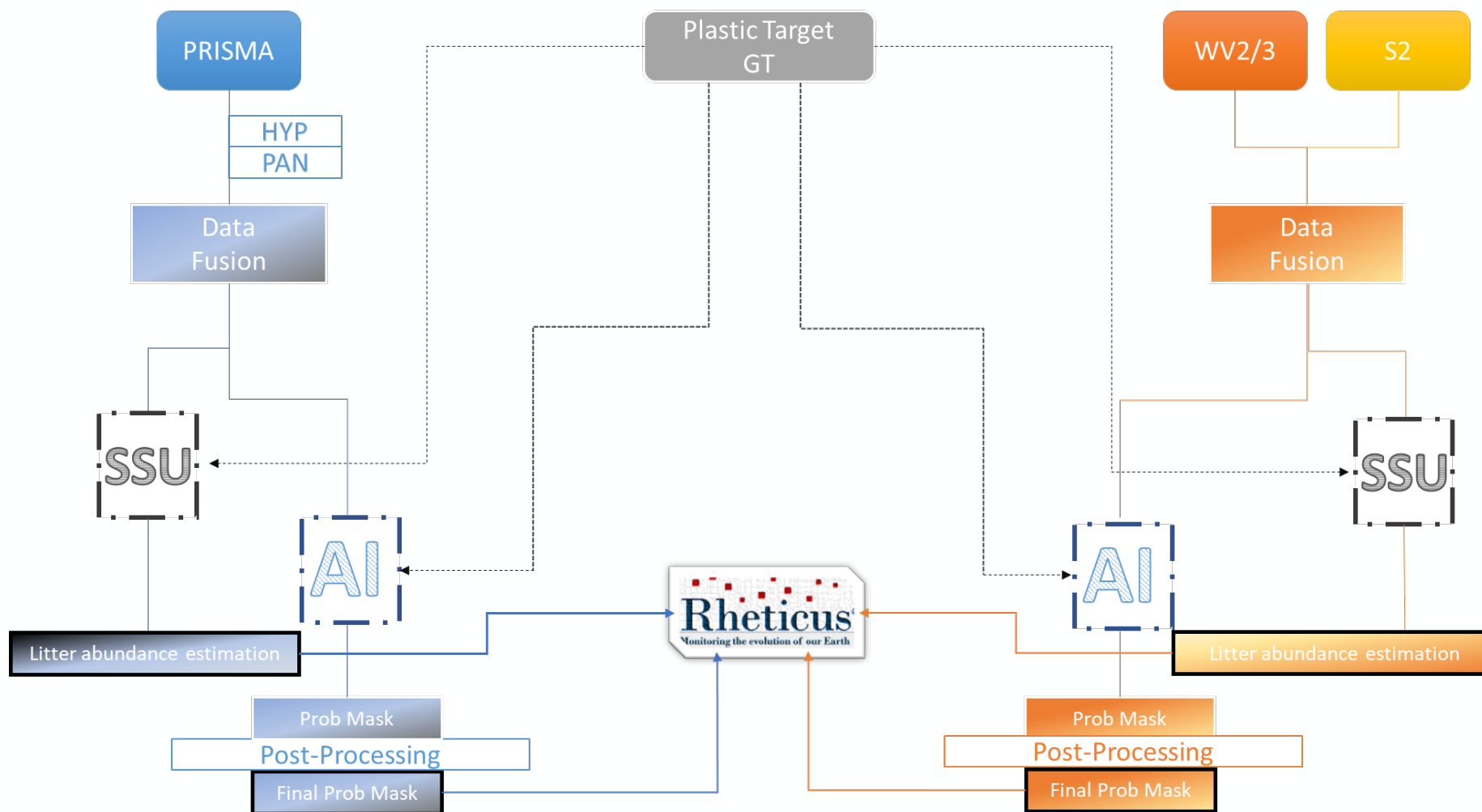
Duration
12 months

Start Date
June 2020

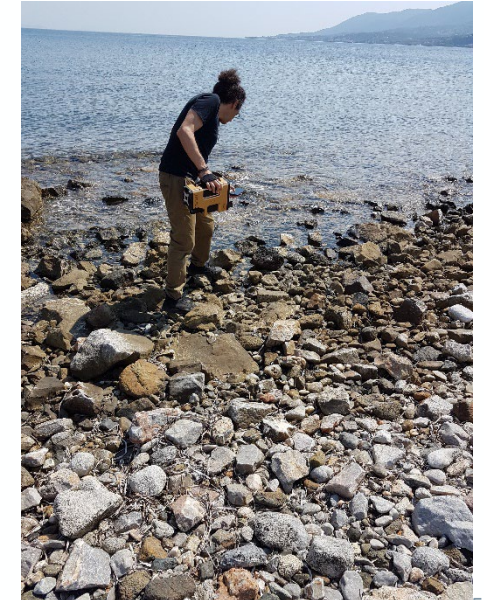
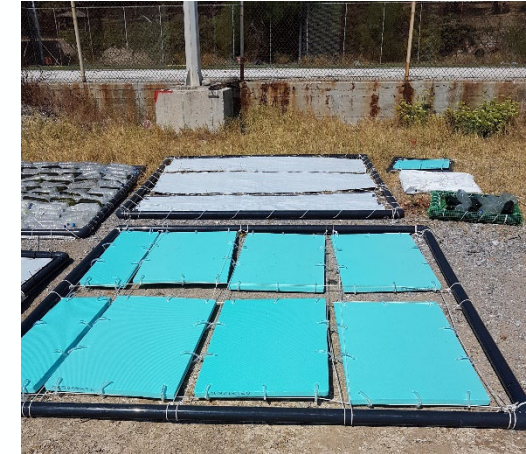
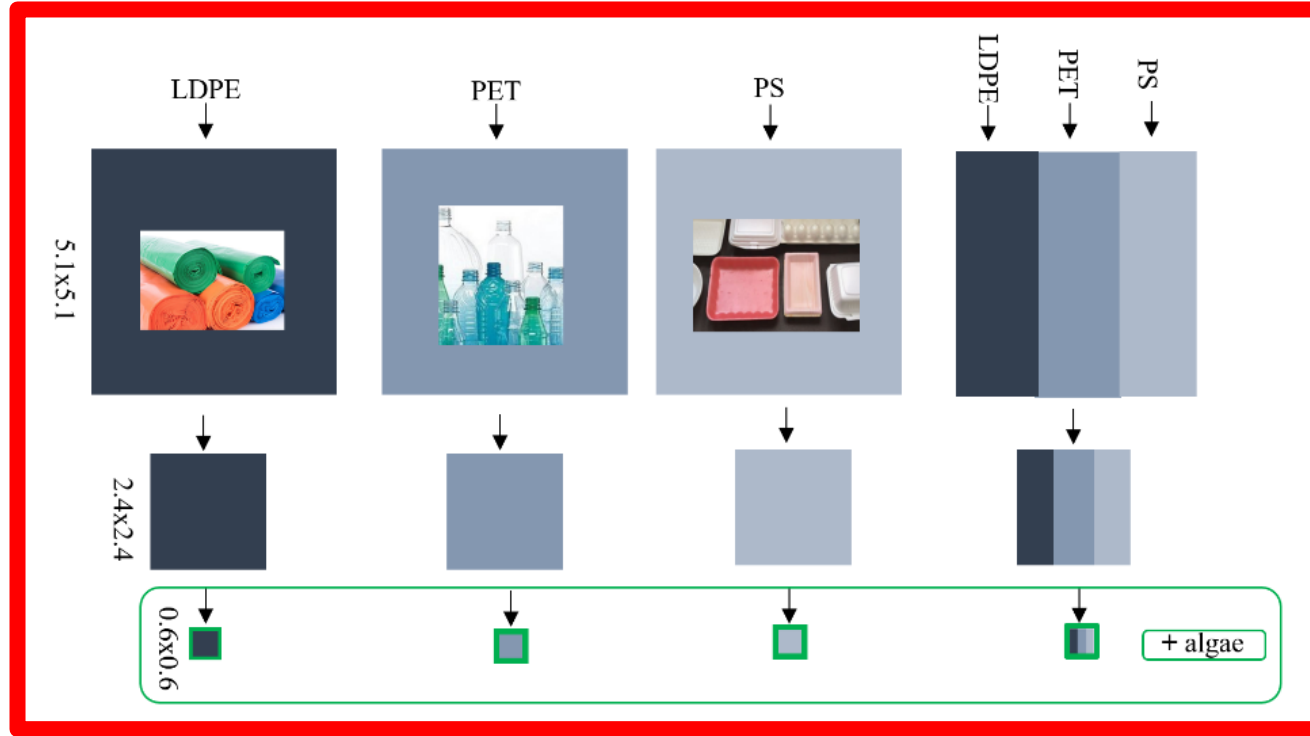
End Date
September 2021

Client
ESA

Poof of concept on remote sensing of marine plastic litter



Controlled experiments 1/2



Controlled experiments 2/2





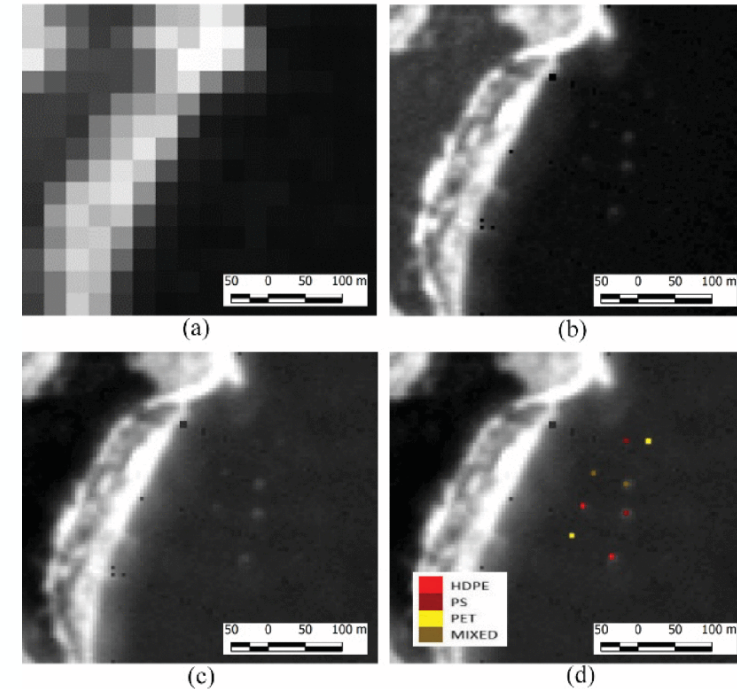
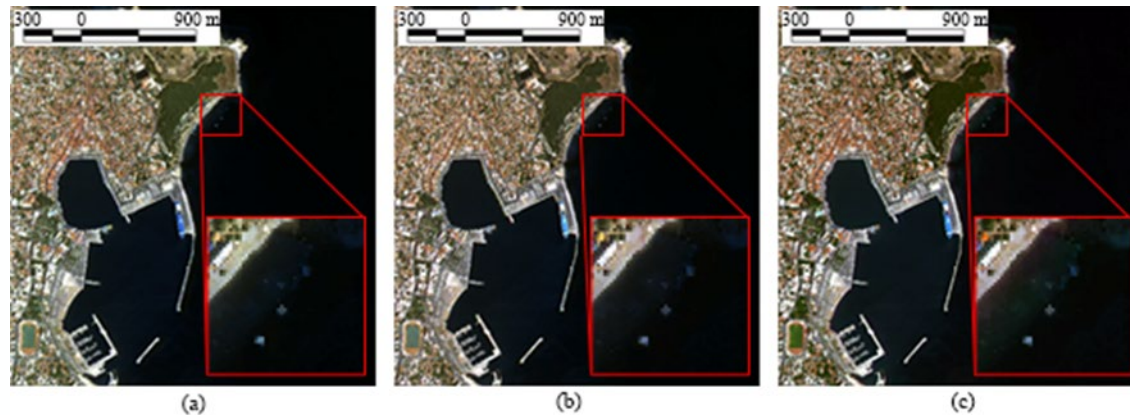
sentinel-2



Targets Offshore: 6 images
Targets Onshore: 3 images

PRISMA (HS + PAN) → COMPONENT SUBSTITUTION → PCA

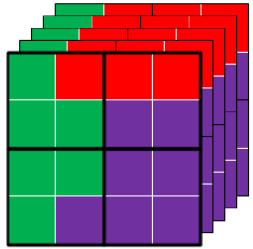
S2/WV → CNMF



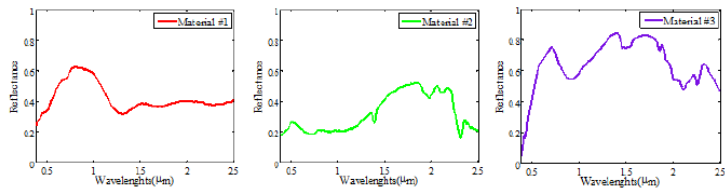
Kremezi, M., Kristollari, V., Karathanassi, V., Topouzellis, K., Kolokoussi, P., Taggio, N., Aiello, A., Ceriola, G., Barbone, E., Corradi, P., 2021. **Pansharpener PRISMA Data for Marine Plastic Litter Detection Using Plastic Indexes**. IEEE Access, 9, pp. 61955-61971

Spectral Signature Unmixing

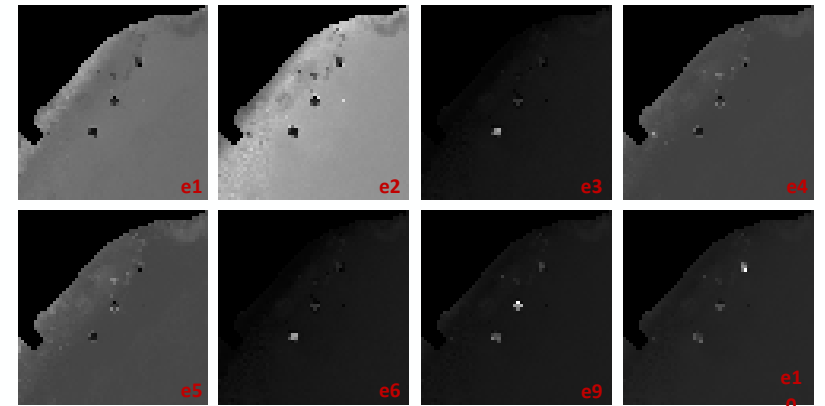
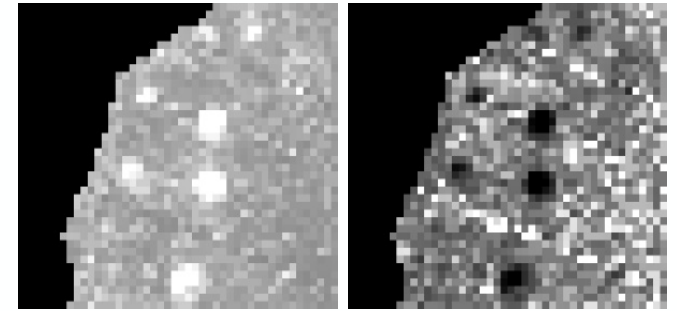
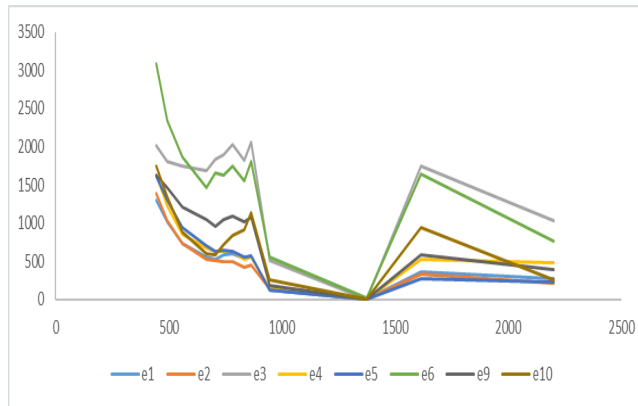
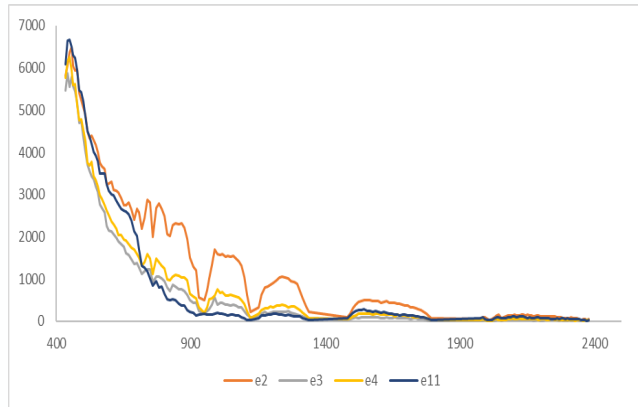
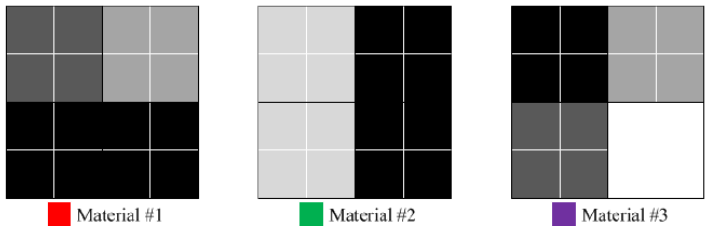
Hyperspectral cube containing four mixed pixels



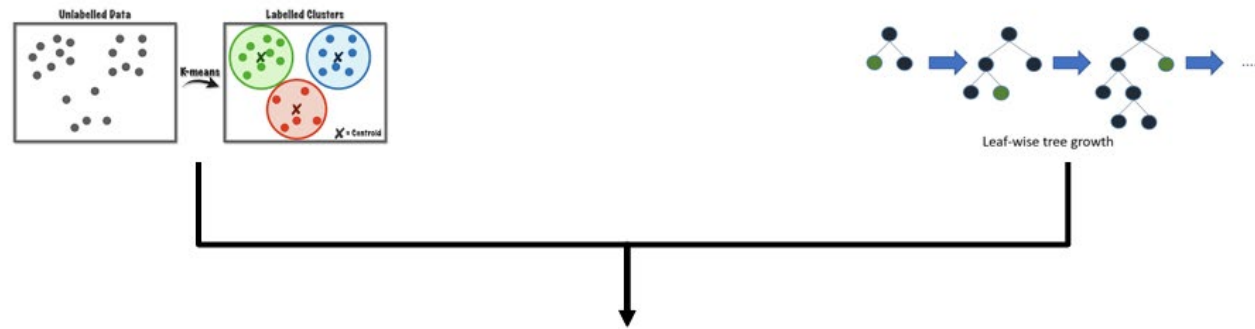
Endmembers



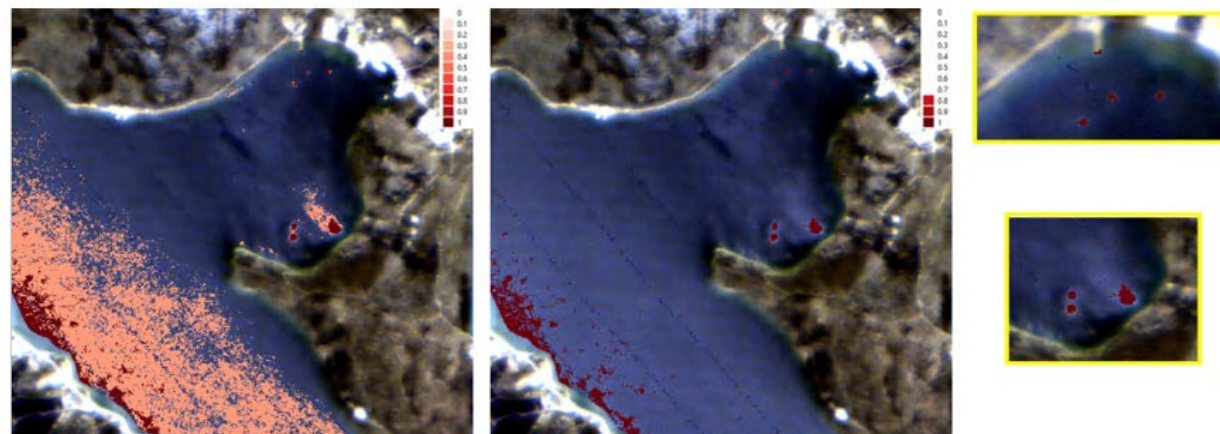
Abundance fraction maps



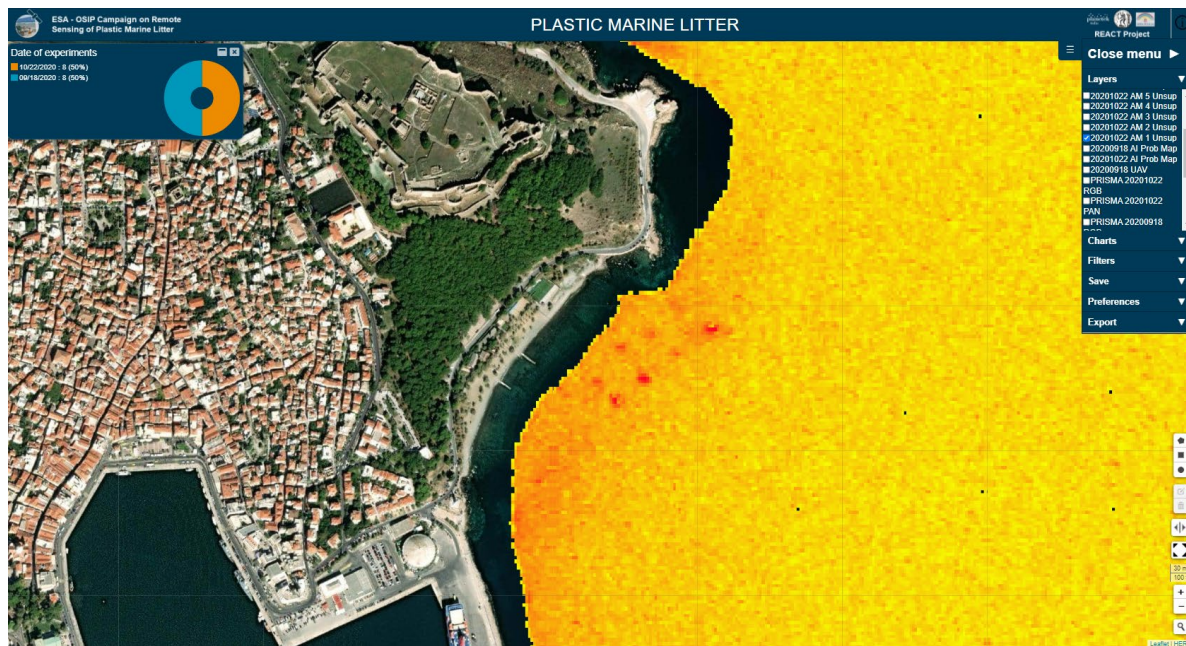
1. **Unsupervised learning:** algorithms that learn pattern from data, no ground truth data;
 2. **Clustering:** unsupervised method, is the task of grouping a set of objects in the same group (called a **cluster**) that are more similar (in some sense) to each other than to those in other groups (clusters);
 3. **K-means:** aims to partition n observations into k clusters in which each observation belongs to the cluster with the nearest mean (cluster centers or cluster **centroid**), serving as a prototype of the cluster
- **Supervised learning:** is the machine learning task of learning a function that maps an input to an output based on example input-output pairs;
 - **Multiclass classification task:** is the problem of classifying instances into one of three or more classes
 - **Light Gradient Boosting Model (LGBM):** It is based on decision tree algorithms and used for ranking, classification and other machine learning tasks.



Output of AI on PRISMA acquisition



Abundance Map



Probability Map



Spectral Signature Unmixing

- ❑ Targets offshore were detected
 - ❑ up to 2.4m dimension with pan-sharpened HS
 - ❑ up to 0,6m with fused MS
- ❑ No significant results were highlighted with the target onshore with both HS and MS
- ❑ Land and shallow waters had to be masked with pan-sharpened HS
- ❑ Land had to be masked with fused MS
- ❑ CNMF + SSU performed well with MS
- ❑ Tuning in labelling was required
- ❑ PS and LDPE were detectable, while PET was not on pan-sharpened HS
- ❑ All materials were detectable on fused MS

Machine Learning

- ❑ Linear combination of K-means + LGBM performed well with pan-sharpened HS
- ❑ K-means performed well with fused MS
- ❑ Land and shallow waters had to be masked, in both cases
- ❑ No significant results were highlighted with target onshore

End-User's assessment

- ❑ Abundance maps and probability maps represent valuable products:
 - ❑ For defining monitoring plans
 - ❑ For evaluating the best position for a monitoring station
 - ❑ For modelling dispersion



This work was **supported by the Discovery Element of the European Space Agency's Basic Activities** under ESA Contract 4000131235/20/NL/GLC (REACT Project: Crowdsourcing, Copernicus and Hyperspectral Satellite Data for Marine Plastic Litter Detection, Quantification and Tracking)