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Litter detection from Super-Resolved Remote Sensing data

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"The REACT project (Crowdsourcing, Copernicus, and Hyperspectral Satellite Data for Marine Plastic Litter Detection, Quantification, and Tracking) aimed to develop a proof-of-concept for remote sensing of marine plastic litter. The project utilized image fusion techniques with multispectral (i.e., Sentinel-2, WorldView 2/3) and hyperspectral (i.e., PRISMA) satellite data, combined with in situ data collection, employing two different approaches: one based on spectral signature unmixing (SSU) and the other on machine learning (ML) methodologies.

The primary objectives of the project were to assess the detection capabilities of current and future remote sensing tools for plastic litter, understand the impact of atmospheric and illumination conditions on the spectral properties of marine plastics, develop adaptive indices insensitive to biases induced by sunglint, explore data fusion methods to increase the detectability of marine plastic litter and investigate SSU and ML algorithms for plastic litter detection. The project aimed to generate abundance maps and probability maps of marine plastic litter, representing the fraction and probability of plastic presence in each pixel.

The key user of the REACT project was the Environmental Prevention and Protection Agency of the Puglia Region in Italy, which is responsible for monitoring marine litter in compliance with European legislation.

Controlled experiments were conducted, utilizing 12 floating plastic targets of varying sizes and materials. Spectroradiometer measurements were taken during these experiments, and the targets were placed both offshore and onshore during satellite data collection campaigns in Mytilini and Geras Gulf, on the Greek island of Lesvos.

In the project, different methods of pansharpening hyperspectral (HS) images were evaluated, with component substitution methods yielding the best results. By fusing Sentinel-2 (S2) and WorldView (WV) images using the CNMF method, the capability of S2 imagery to detect marine plastic targets was enhanced. The endmember spectra of plastic materials showed high abundance values, while water endmembers exhibited low abundance values. SSU applied on HS detected offshore plastic targets, with certain limitations due to spectral inseparability between plastic targets and swallow waters. Land and swallow water pixels were masked, and SSU and pansharpening effectively detected floating plastic accumulations.

The study proposed three plastic indexes based on radiance differences in the VNIR region to discriminate plastic targets from water. These indexes were successfully applied to the pan-sharpened image, resulting in the detection of offshore plastic targets.

A combination of unsupervised (K-Means) and supervised (Light Gradient Boosting Model) methodologies was employed for ML-based detection. Despite the limited dataset, ML algorithms showed promising results in detecting floating objects offshore, reducing false positives and improving accuracy with increased training data.

Two probability maps were produced based on available data: one from pan-sharpened PRISMA data using supervised and unsupervised methods and the other from the fusion of S2 and WV data using the K-means method. These probability maps provided valuable information for monitoring plans, determining optimal monitoring station locations, and modelling dispersion.

However, the spatial resolutions achieved through image fusion were insufficient to detect common litter accumulations onshore, indicating the need for further studies in this area.

In conclusion, the REACT project successfully developed a methodology for remote sensing of marine plastic litter, utilizing image fusion techniques, SSU, and ML algorithms. Abundance maps and probability maps were

generated, providing valuable insights for monitoring, evaluation, and modelling purposes. Further research is required to enhance onshore detection capabilities and refine the methodologies employed in the project."

Authors: AIELLO, Antonello (Planetek Italia); TAGGIO, Niccolo' (Planetek Italia)

Presenters: AIELLO, Antonello (Planetek Italia); TAGGIO, Niccolo' (Planetek Italia)