Simulating Marine Litter observations from space to support Operations Research

Stephen Emsley, Manuel Arias, Théodora Papadopoulou, and François-Régis Martin-Lauzer
ARGANS Ltd, Plymouth, UK (enquiries@argans.co.uk)

An breadboard for end-to-end (E2E) Marine Litter Optical Performance Simulations (ML-OPSI) is being designed in the frame of the ESA Open Space Innovation Platform (OSIP) Campaign to support Earth Observation (EO) scientists with the design of computational experiments for Operations Research. The ML-OPSI breadboard will estimate Marine Litter signal at Top-Of-Atmosphere (TOA) from a set of Bottom-Of-Atmosphere (BOA) scenarios representing the various case studies by the community (e.g., windrows, frontal areas, river mouths, sub-tropical gyres), coming from synthetic data (computer-simulated) or from real observations. It is a modular, pluggable and extensible framework, promoting re-use and be adapted for different missions, sensors and scenarios.

The breadboard consists of (a) the OPSI components for the simulation i.e. the process of using a model to study the characteristics of the system by manipulating variables and by studying the properties of the model allowing an evaluation to optimise performance and make predictions about the real system; and (b) the Marine Litter model components for the detection of marine litter. It shall consider the changes caused in the water reflectance and properties due to marine litter, exploiting gathered information of plastic polymers, different viewing geometries, and atmospheric conditions as naturally occurring. The modules of the breadboard include a Scenario Builder Module (SB) with maximum spatial resolution and best modelling as possible of the relevant physical properties, which for spectral sensors could include high spatial resolution and high spectral density/resolution BOA radiance simulations in the optical to SWIR bands; a Radiative Transfer Module (RTM) transforming water-leaving to TOA reflectance for varying atmospheric conditions and observational geometries; a Scene Generator Module (SGM) which could use Sentinel-2, Landsat, or PRISMA data as reference or any other instrument as pertinent; a Performance Assessment Module (PAM) for ML detection that takes into account the variability of the atmosphere, the sunlight & skylight at BOA, the sea-surface roughness with trains of wind waves & swells, sea-spray (whitecaps), air bubbles in the mixed layer, marine litter dynamics as well as instrumental noise to assess marine litter detection feasibility.

Marine Litter scenarios of reference shall be built based on in-situ campaigns, to reflect the true littering conditions at each case, both in spatial distribution and composition. The breadboard shall be validated over artificial targets at sea in field campaigns as relevant. This might include spectral measurements from ASD, on-field radiometers, and cameras on UAVs, concomitant with
Copernicus Sentinel-2 acquisitions. Combined, they can be used to estimate atmospheric contribution and assess performance of the testes processing chain.

This activity collaborates on the “Remote Sensing of Marine Litter and Debris” IOCCG taskforce.