Exploring plastic detectability on riverbanks using remote sensing

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1. Background

- **Rivers** play a key role in transporting **plastic debris**
- Plastics **accumulate on riverbanks** and in floodplains
- **Remote sensing** offers an opportunity to upscale riverine plastic monitoring
- We designed a comprehensive **field experiment** to test detectability of river plastics from space

2. Objective

To explore the detectability of plastics on riverbanks from space

3. Controlled field experiment

- **Location:** Wageningen, the Netherlands (Figure 1)
- **Large plastic targets** with different sizes made of white polyester sheets or transparent PET bottles at different surface concentrations (Table 1)
- Data were collected with several different **remote sensing sensors**, covering a range of spatial, spectral, and temporal resolutions:
  - **ASD Handheld 2 Spectroradiometer** (HSR)
  - Multispectral camera **MAIA S2**
  - Multispectral satellite imagery:
    - **Sentinel-2**
    - **PlanetScope SuperDove**
  - Hyperspectral satellite imagery:
    - **EnMAP**

Table 1. Plastic target characteristics.

Plastic type	Target size	Density
Polyester	0.5x30 m², 1x30 m², 2x30 m², 3x30 m²	-
Polyethylene terephthalate (PET)	3x15 m², 3x30 m²	8 bottles/m², 4 bottles/m²

Fig. 1. Study area and plastic targets.

4. Methodology

- **Differences** between the **spectral signatures** of the riverbank materials and the plastics were analyzed by using the hyperspectral HSR and multispectral MAIA S2 measurements
- Plastic reflectance signals from the **satellite** imagery were compared for the different targets
- Ten **spectral indices** were analyzed to determine their suitability for plastic detection
- Two spectral indices were used to determine detectability of the plastics across different cover sizes, by training a **Naïve Bayes** model

5. Results

Sentinel-2 images were successfully used to detect the **three largest polyester targets.** The PET targets were not detected.

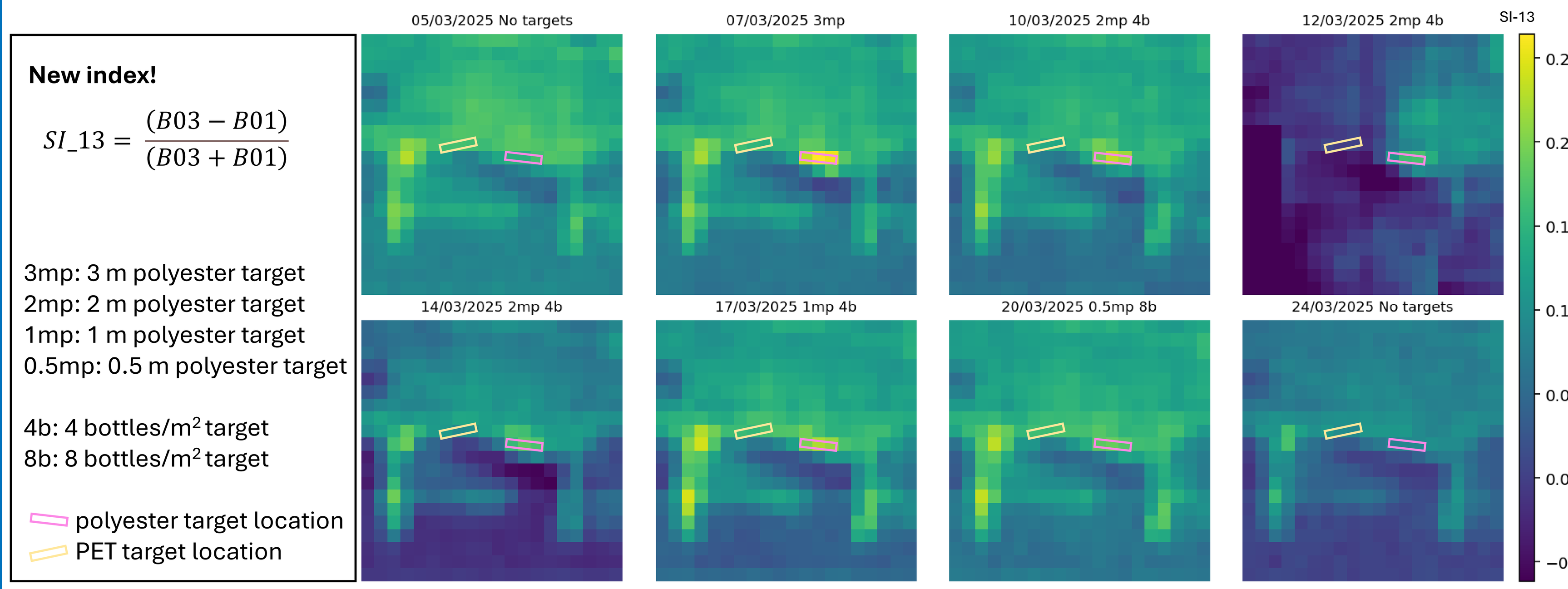

Fig. 2. SI-13 for the Sentinel-2 images, mapped over the study area in chronological order to compare values for different targets. In the image of the 3 m target, SI-13 is highest at the polyester target. When target size decreases, SI-13 at the target location decreases as well. The PET target did not influence the SI-13 values.

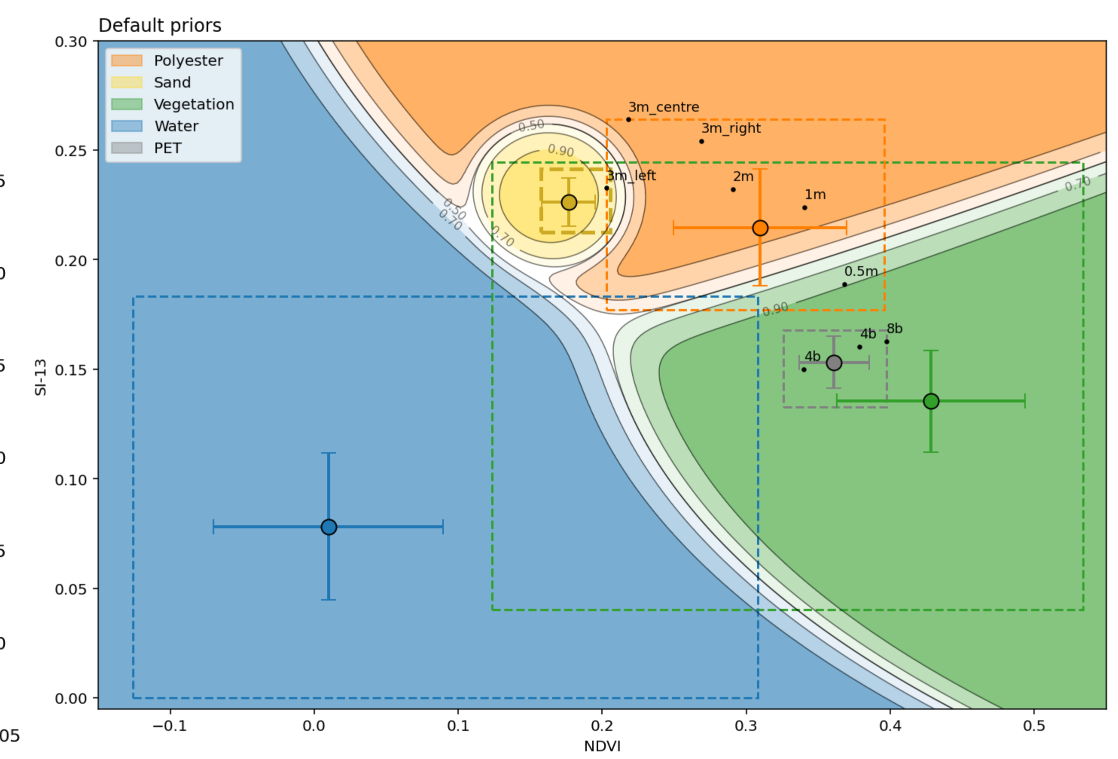

Fig. 3. Naïve Bayes class probabilities and distributions of the Sentinel-2 pixels. SI-13 and NDVI are combined to increase separability. For each land cover, the mean and standard deviation are shown. The bounding boxes delineate the ranges of the pixel values within each land cover.

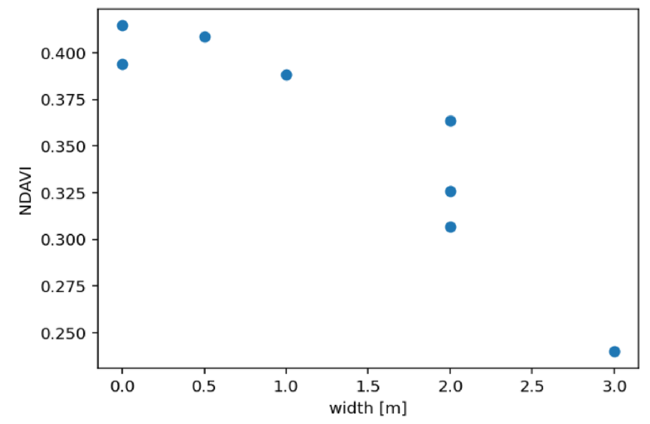

Fig. 4. The relationship between NDAVI and polyester target width. The 2 m and 3 m targets clearly show a difference from each other and the no target scenario.

High **spearman correlations** between polyester target size and several spectral indices

- Highest for NDAVI: -0.93

6. Recommendations

- More experiments with other plastic targets, increasing the **variation in plastic polymer and item types**, **concentrations**, and **mixing** with other materials
- Investigate spectra of existing plastic pollution accumulation zones
- Extend the experiments to **other river systems** that contain other land surface features, such as riverbank type and vegetation characteristics
- Use satellites for **global detection** (Sentinel-2 shows promise) ➡ Use cameras for **local detection**
- Collect more hyperspectral signatures of plastic types and riverbanks, over a higher spectral range
- Investigate other plastic detection algorithms

7. Conclusions

- Plastic detection on riverbanks from space is **feasible and should be investigated further**
- **Spectral signatures** of plastics can be distinguished visually from spectral signatures of riverbank and river water, but are influenced by the **background** below the plastics
- **Transparent PET** is hard to distinguish from the other land covers as its spectrum is similar to the spectrum of its background
- **White polyester sheets** can mainly be distinguished based on a high **overall reflectance** compared to the spectra of the other land covers. They also change the reflectance in the 400 nm and 680 nm range
- In this study, **Sentinel-2** imagery was found most suitable for plastic detection
- The **1 m, 2 m, and 3 m polyester targets were detected** by Sentinel-2 when using Naïve Bayes classification
- **Spectral indices** were found to be indicators of **plastic cover size** in Sentinel-2 imagery

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Paper

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