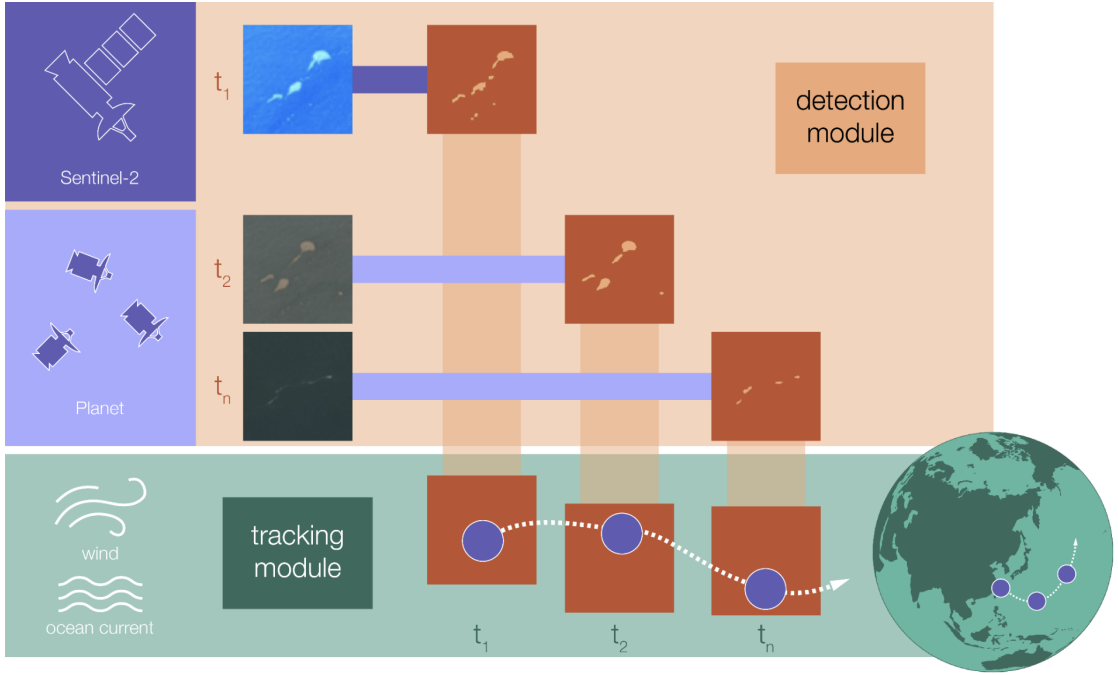
ADOPT:
AI for Detecting Ocean Plastic Pollution with Tracking

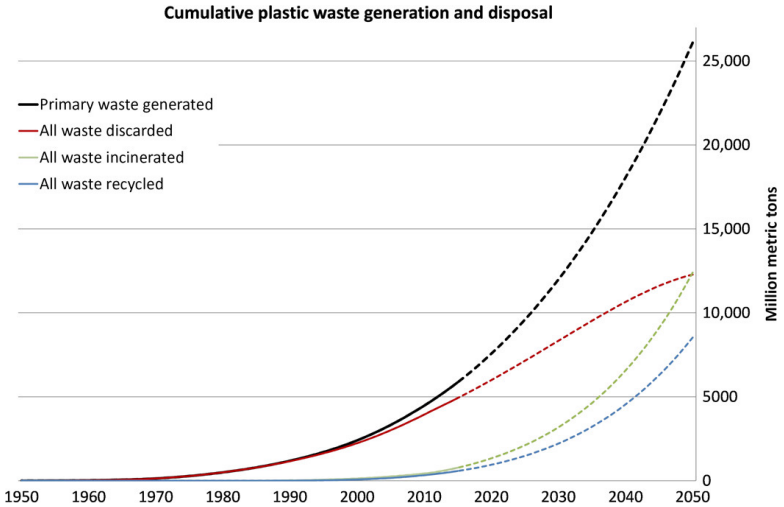


Context of the project

Cuttings Beach, Durban (South Africa) image credit: Lisa Guastella

Context of the project

- Plastic litter is an environmental hazard
  - Danger to animals
  - With unclear and potential harmful impact on human health
- Plastic waste is expected to increase



Geyer, R., Jambeck, J. R., & Law, K. L. (2017). Production, use, and fate of all plastics ever made. *Science advances*, *3*(7), e1700782.

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Marine Debris as Marine Litter Proxies

Photo twitter @oihanecb

Oceanic processes aggregate debris on the water surface:
Here **windrows, that can contain plastic litter.**

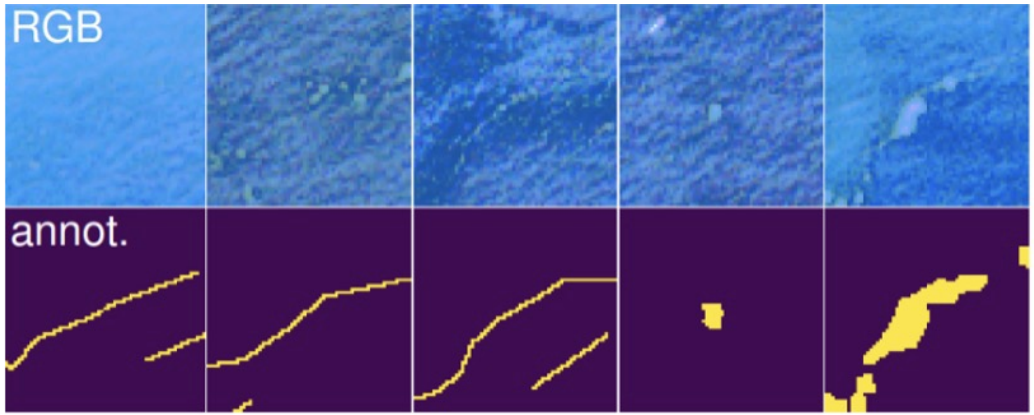
Example:
16.2 tons in 68 working days collected plastic litter in the Bay of Biscay in 2018 by Ruiz et al., 2020

within this scope

Windrows are **generic marine debris** that **may contain marine litter**

Ruiz, I., Basurko, O. C., Rubio, A., Delpey, M., Granado, I., Cózar, A. (2020). Litter windrows in the south-east coast of the Bay of Biscay: an ocean process enabling effective active fishing for litter. Frontiers in Marine Science, 7, 308.

Marine Debris as Marine Litter Proxies



Examples of **windrows** seen from Sentinel-2 (10m of resolution) and their corresponding binary annotation

Windrows are **visible** from remote sensing **satellites**: from local to **global** scale

Rußwurm, M., Sushen J. V., and Tuia D. "Large-scale detection of marine debris in coastal areas with Sentinel-2." Iscience 26, no. 12, 2023

From small scale to large scale

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Single campaigns collect marine litter at small scale,
e.g. [Ruiz et al., 2020]

Bay of Biscay, France
Image: Oihane Basurko

Lack of large-scale satellite-based detection methods limits collection efforts

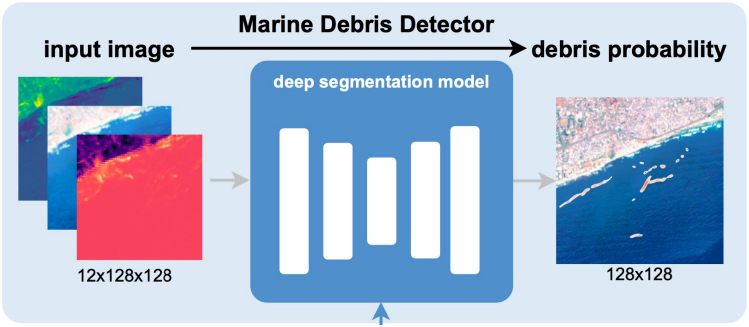
even though

an abundance of satellite data is freely available:

Sentinel-2, PlanetScope

ADOPT: AI for Detection of Ocean Plastic Pollution with Tracking

Current research



Large-scale Detection of Marine Debris in Coastal Areas with Sentinel-2

Marc Rußwurm, Sushen Jilla Venkatesa, Devis Tuia

Datasets overview

combination of available datasets

FloatingObjects Dataset [1]

- 26 regions
- 3297 line annotations of
- “other” objects randomly sampled

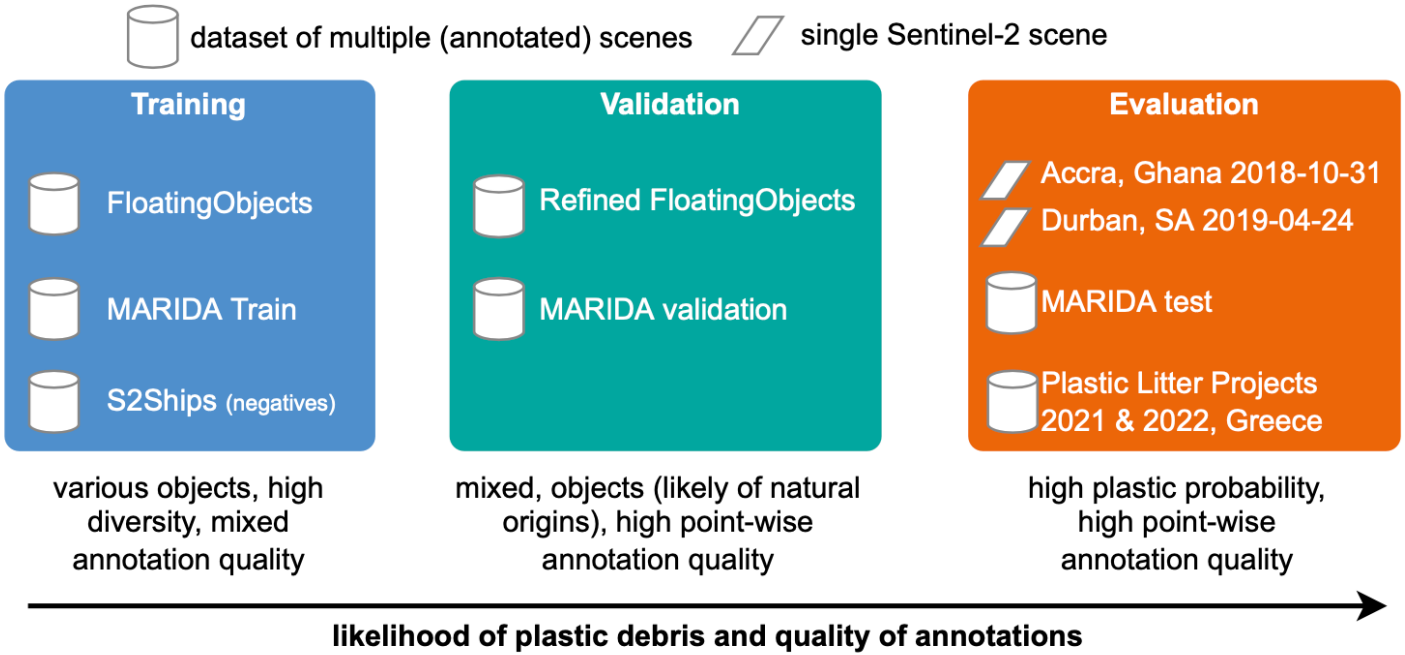
Marine Debris Archive [2]

- 12 distinct regions
- 1882 marine debris polygons
- 2447 marine water polygons
- originally multi-class but vast majority is “marine debris”

[1] Kikaki K, et al., (2022) MARIDA: A benchmark for Marine Debris detection from Sentinel-2 remote sensing data. PLoS ONE

[2] Mifdal, J., et al.: TOWARDS DETECTING FLOATING OBJECTS ON A GLOBAL SCALE WITH LEARNED SPATIAL FEATURES USING SENTINEL 2, ISPRS, 2021.

Datasets overview



Rußwurm, Marc, et al. "Large-scale Detection of Marine Debris in Coastal Areas with Sentinel-2." *arXiv preprint arXiv:2307.02465* (2023).

Marine Debris Detector

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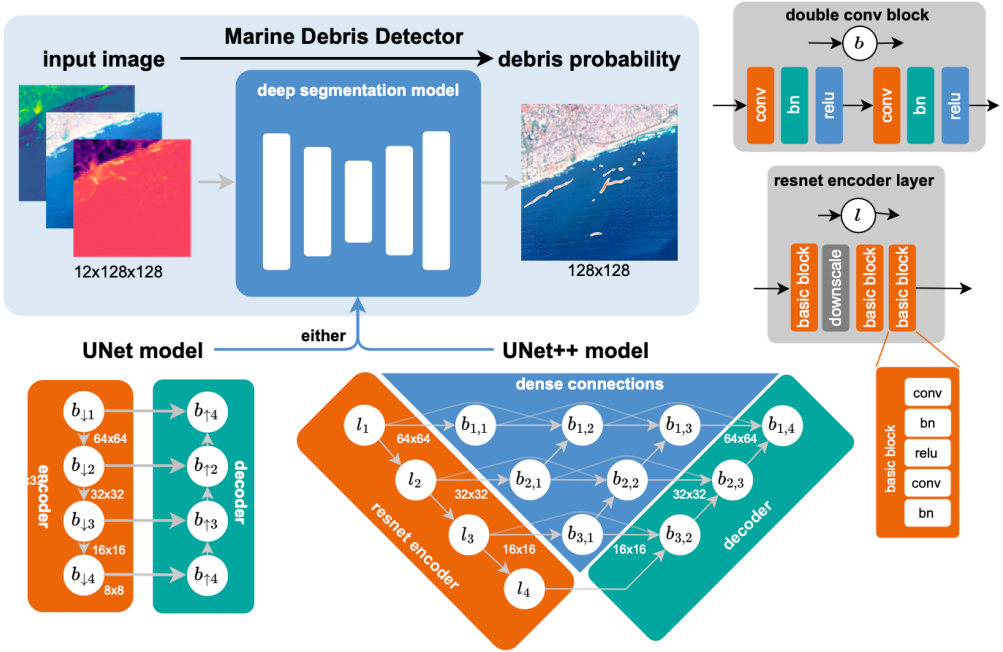
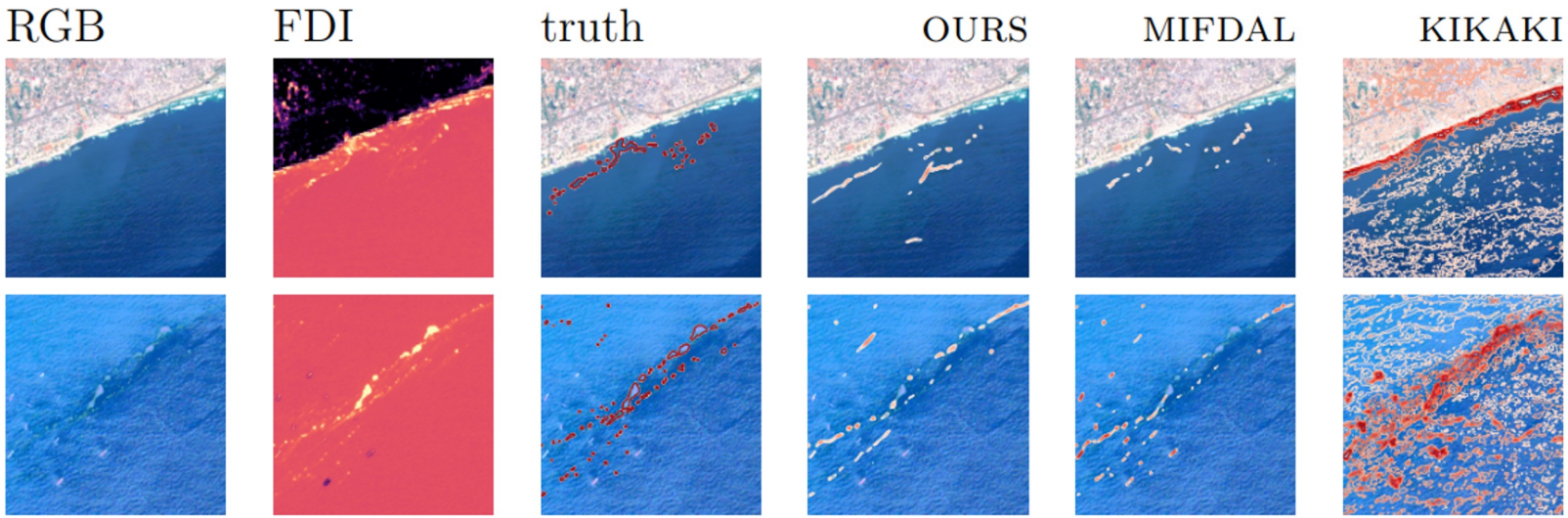
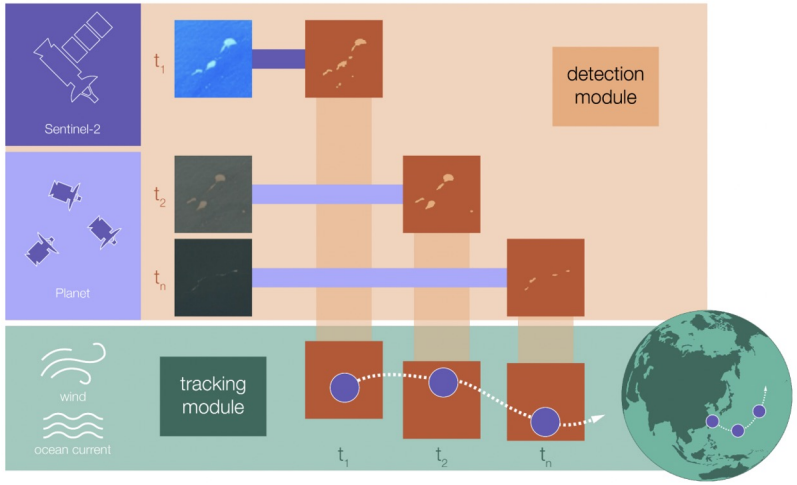


Results



- Interactive results on https://marcrusswurm.users.earthengine.app/view/marinedebrisexplorer

ADOPT Project (2023-2025)



AI for Detecting Ocean Plastic Pollution with Tracking

SDSC Michele Volpi

EPFL Emanuele Dalsasso, D. Tuia

WUR Marc Rußwurm

TOC Robin de Vries

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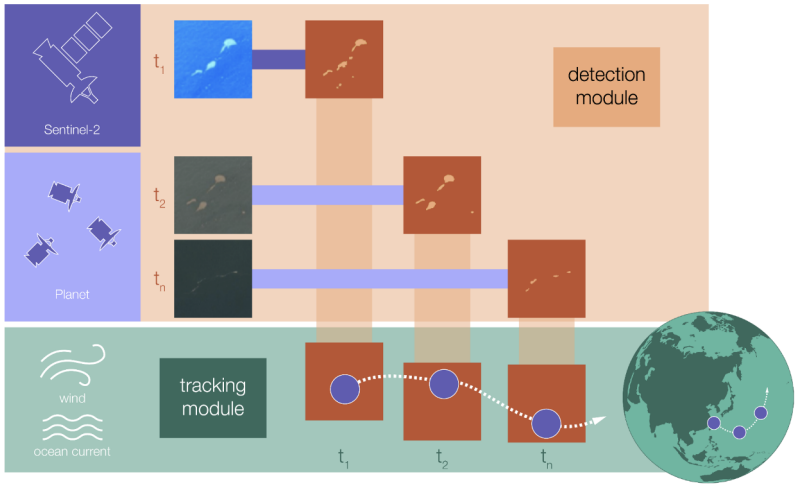
Objectives

- Address the growing ecological concern related to marine litter by enabling continuous global monitoring:
  - Detect litter objects with high accuracy
  - Provide timely estimates of future locations

- ADOPT is a hybrid model having two main components:
  - A deep learning-based detection module
  - A physical drift estimation module
  - A third hybridization step combines the first two steps into a unique deep learning-based physics informed module



ADOPT: Core Model Components

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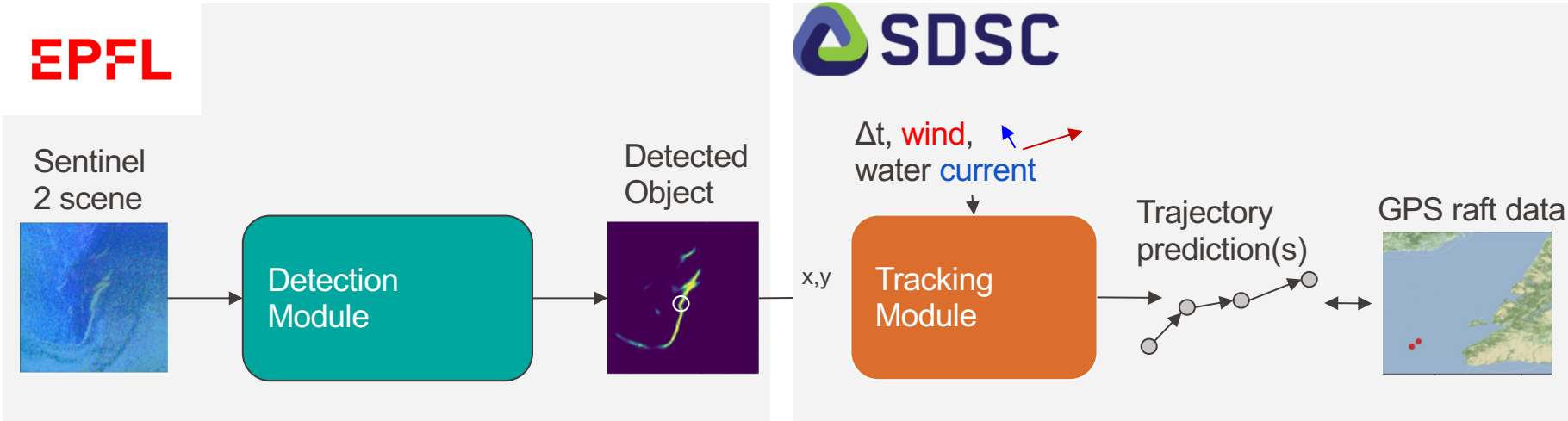
WP1: Detection Module

WP2: Tracking Module



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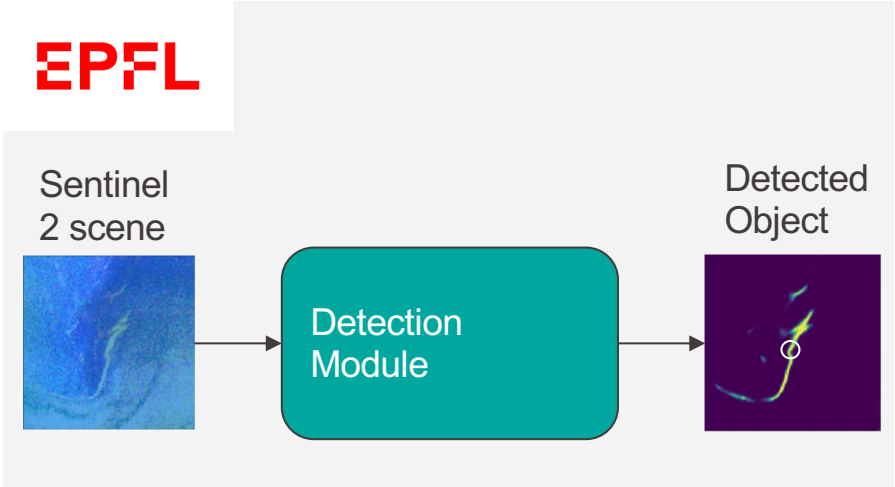
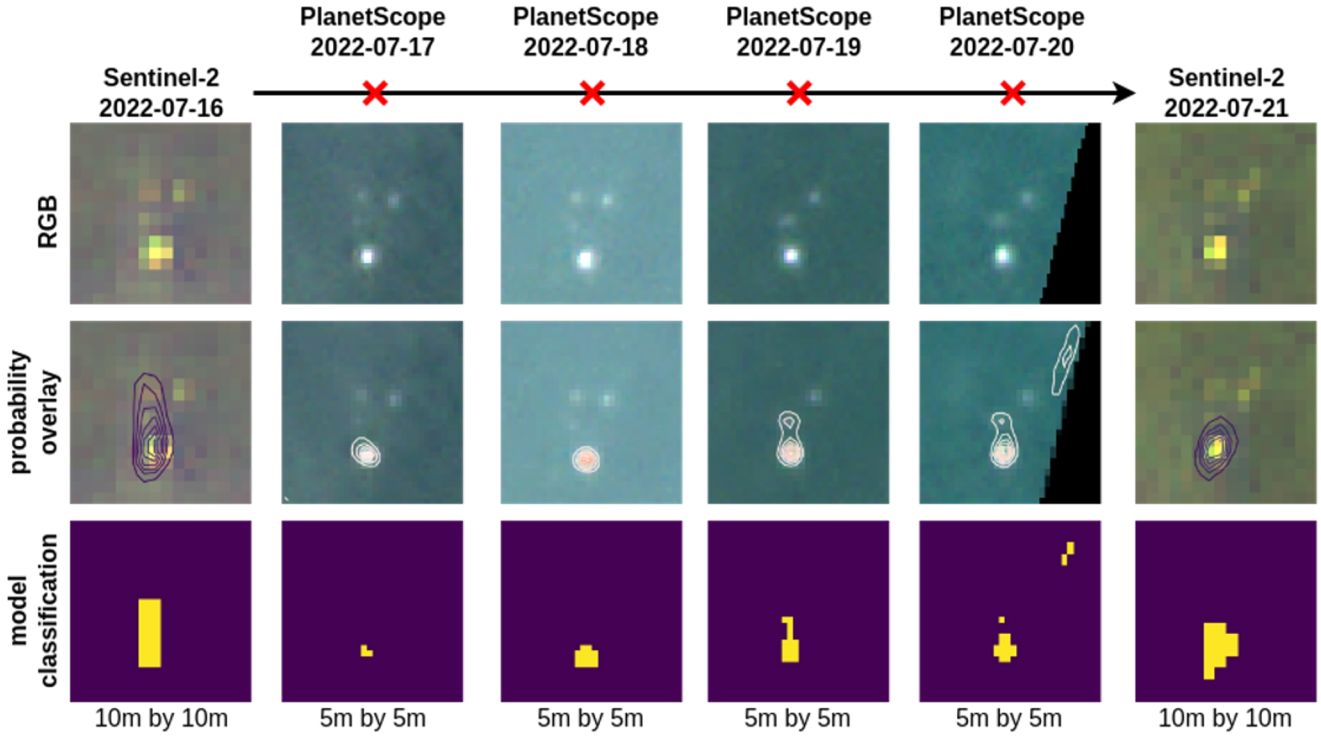
Detection Module

The use of Sentinel-2 and PlanetScope images



Sentinel-2 + PlanetScope on PLP2022



Need to increase the temporal resolution of Sentinel-2

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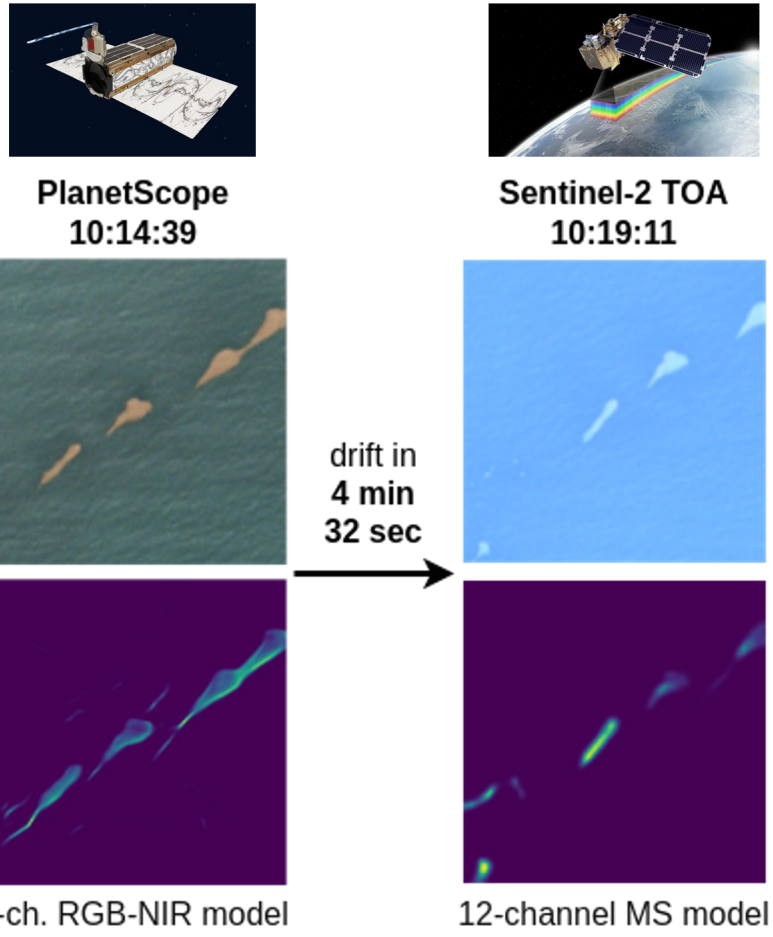
Transfer of Marine Debris Detector on PlanetScope

- Daily PlantScope imagery can augment the weekly Sentinel-2 scenes
- The Marine Debris Detector is re-trained the model on a 4-channel RGB+NIR version of the Sentinel-2 training dataset
- Tested on PlanetScope imagery (downsampled to 5m)

relatively good results given that no fine-tuning is involved

A step towards tracking objects through time



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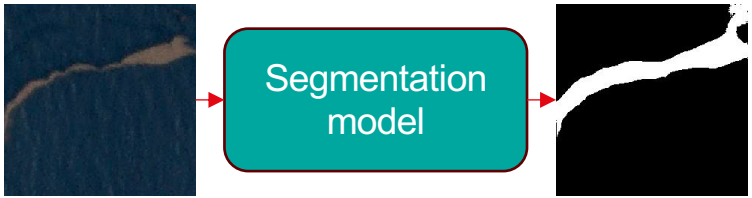
Cross-sensor marine debris detection from optical satellites

A domain generalization approach



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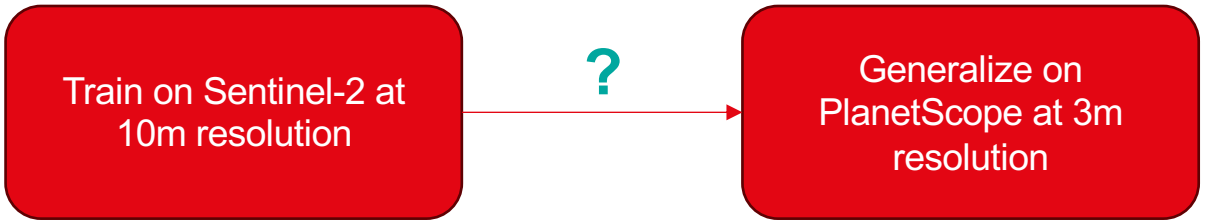
A domain generalization problem

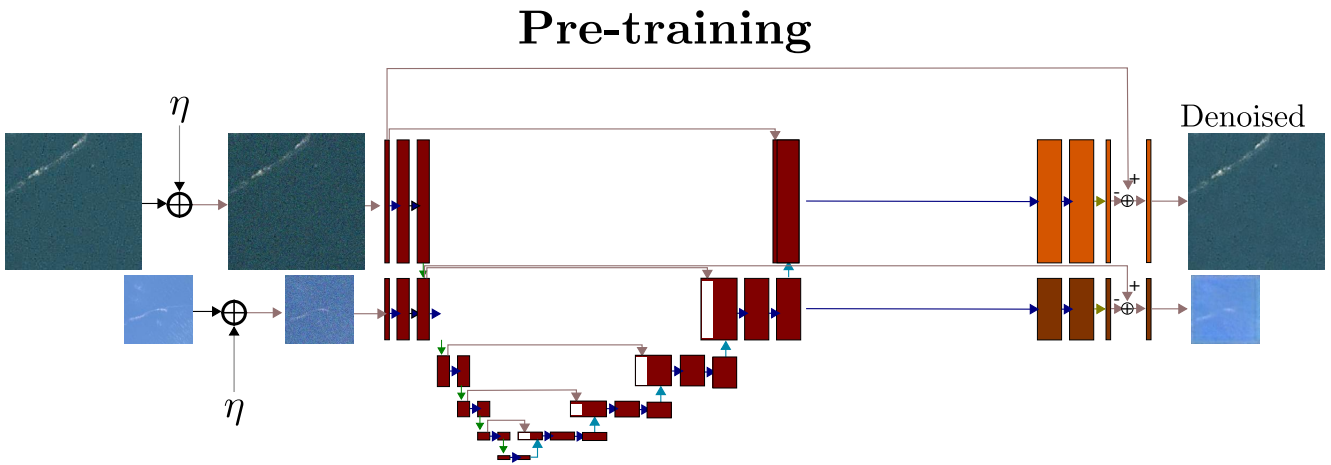
- **Sentinel-2 data available for marine debris detection**
  - RefinedFLOBS
  - MARIDA
  - S2Ships
- **Missing annotated Planet data**

➢ **Challenge**



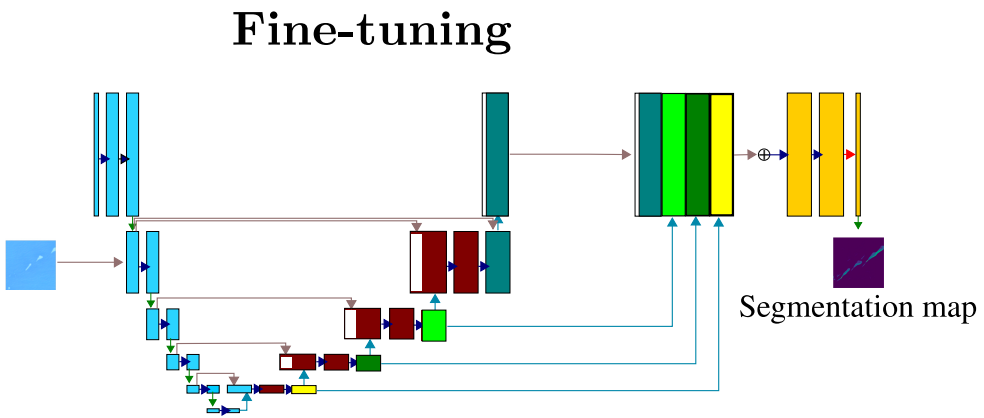
Method

- **1.** Learn a common representation on unannotated images



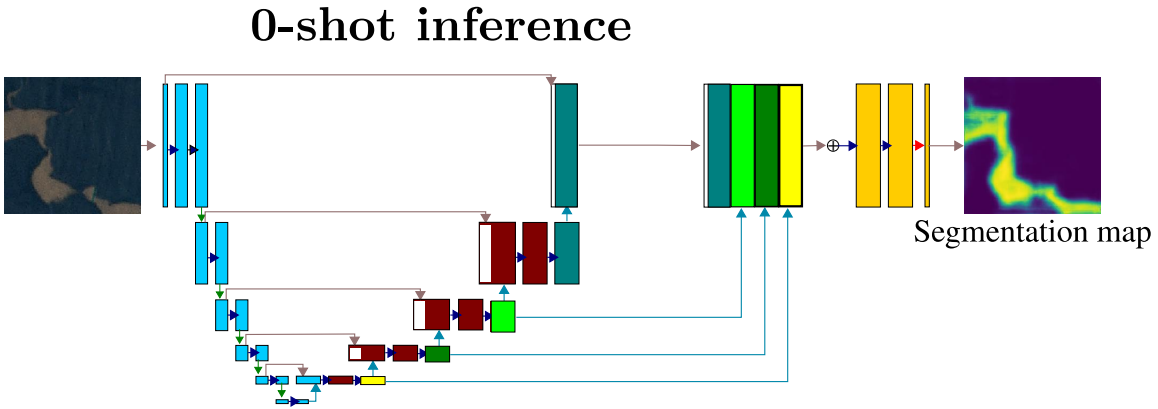
Method

- **2.** Fine-tune on available Sentinel-2 labeled images



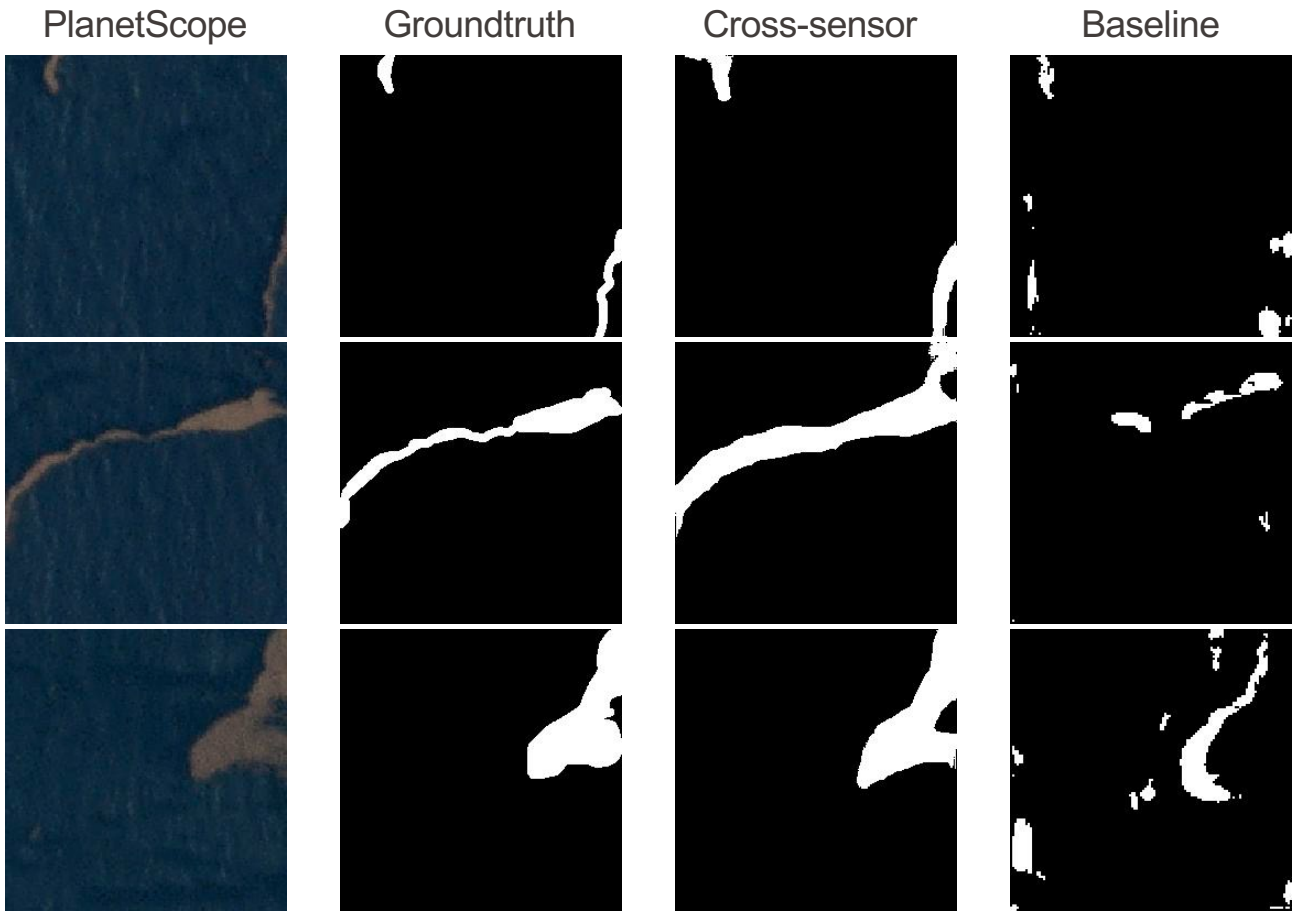
Method

- **3.** Run inference on PlanetScope images



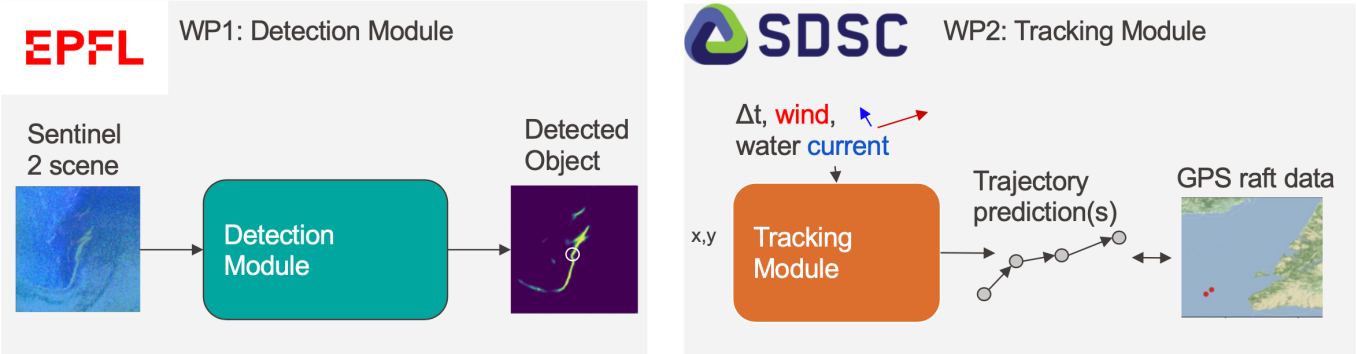
- While the network has learned to segment Sentinel-2 data, it co-learned to segment PlanetScope scenes

Results



Conclusions and perspectives

- ✓ Self-supervised pre-training allows generalizing to PlanetScope images without the need for annotated data
- ○ Currently working with RGB data: extend to other bands
- ○ Integrate uncertainty estimation (ongoing semester project + Master's thesis)
- ○ Long-term: development of a hybrid model for detection and tracking



Thank you for your attention! Questions?