Automated system for ship detection from medium resolution satellite imagery

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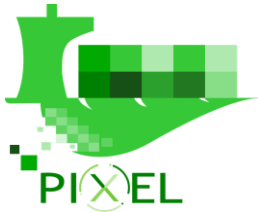
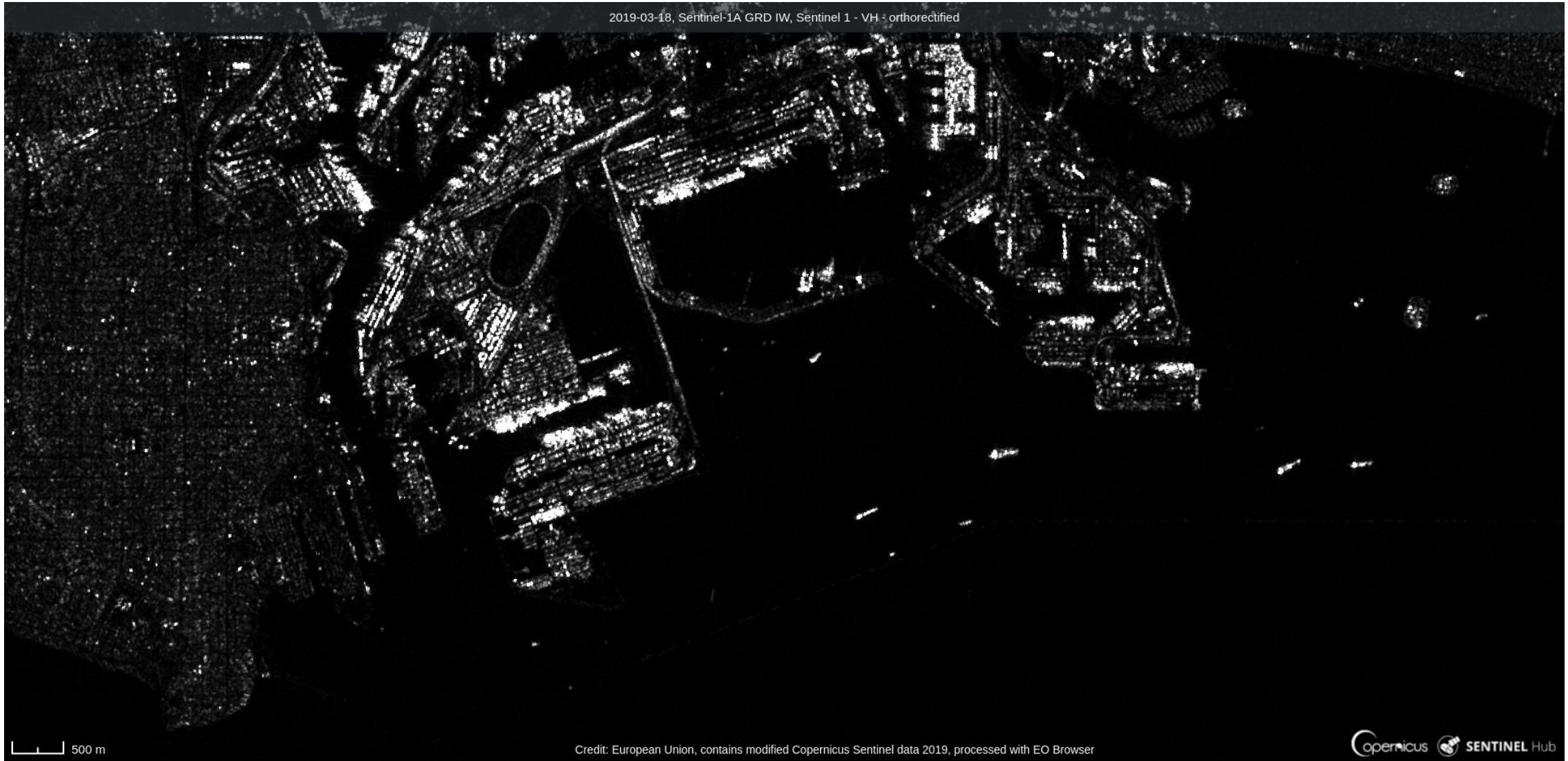
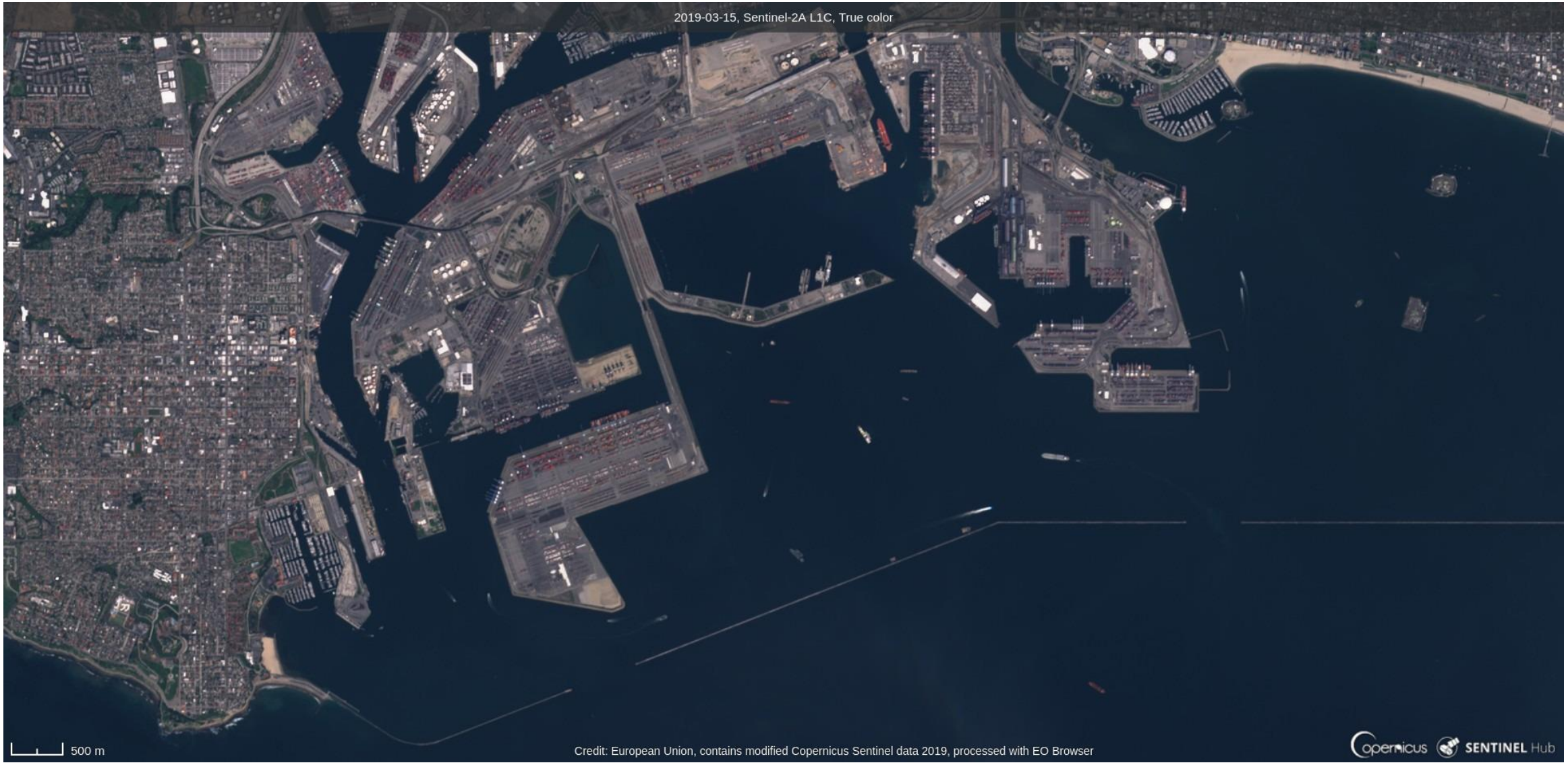


SAR vs. optical



SAR vs. optical



Related work / What is on the market?

- No published SOTA research work on ship detection from Sentinel-2 / Planet Dove (i.e. medium resolution)
- Much more research interest on VHR optical imagery
  - Google Earth, Kaggle Airbus, custom small scale datasets
- Operational systems:
  - EMSA CleanSeaNet / Copernicus Maritime Surveillance
  - Only VHR optical satellites in EMSA product catalogue
  - Different commercial providers:
    - Planet Labs, CrowdAI, Orbital Insight, Digital Globe,...

Why the lack of research?

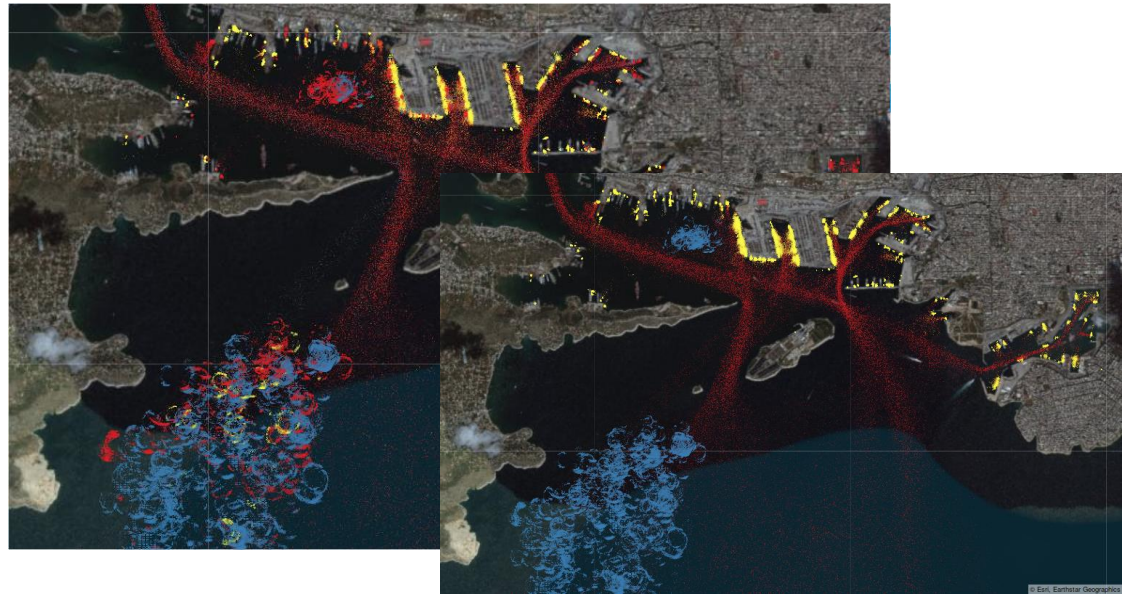
- *"...Thanks to our labeling platform and outsourcing partners we now have close to 10k labels/day capabilities in segmentation..." @ Earthcube*

- SOTA **deep-learning** based methods are data hungry!
- Large enough datasets only on VHR imagery
- Is annotating more and more data sustainable?
- Moving beyond supervised learning

Automatic Identification System (AIS)

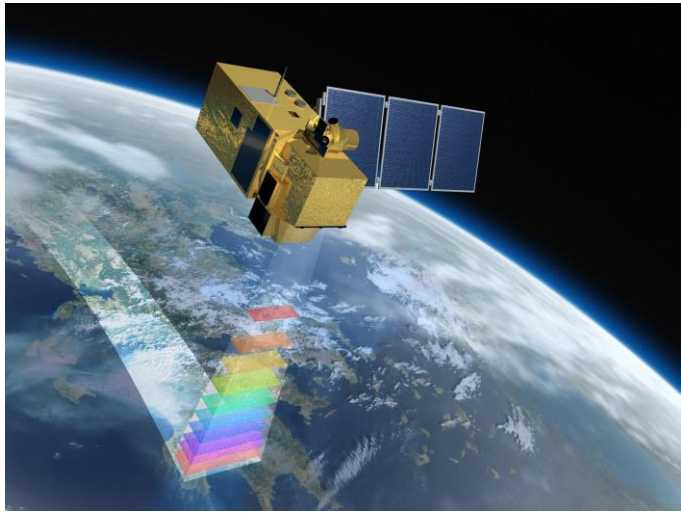
- Proposed and mandated by IMO – obligatory usage
- Navigational data, ship info, voyage data
- **Open data available**
  - http://www.aishub.net
  - ftp://ftp.ais.dk/ais_data/
  - **https://marinecadastre.gov**

BOEM
Bureau of Ocean Energy Management

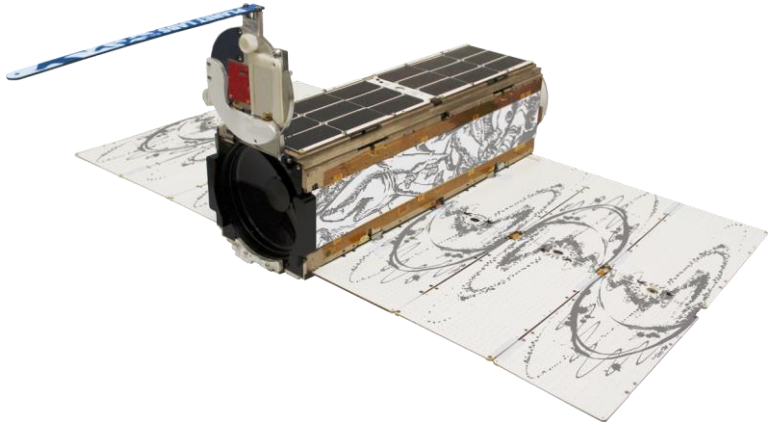


ESA Sentinel-2

- Constellation of 2 satellites with 5 days revisit time
- 10m GSD, 290km swath width
- Publicly available, including commercial use
  - ESA portal: https://scihub.copernicus.eu/
  - 3rd party providers
    - Sinergise Sentinel Hub
    - https://github.com/sentinel-hub/eo-learn

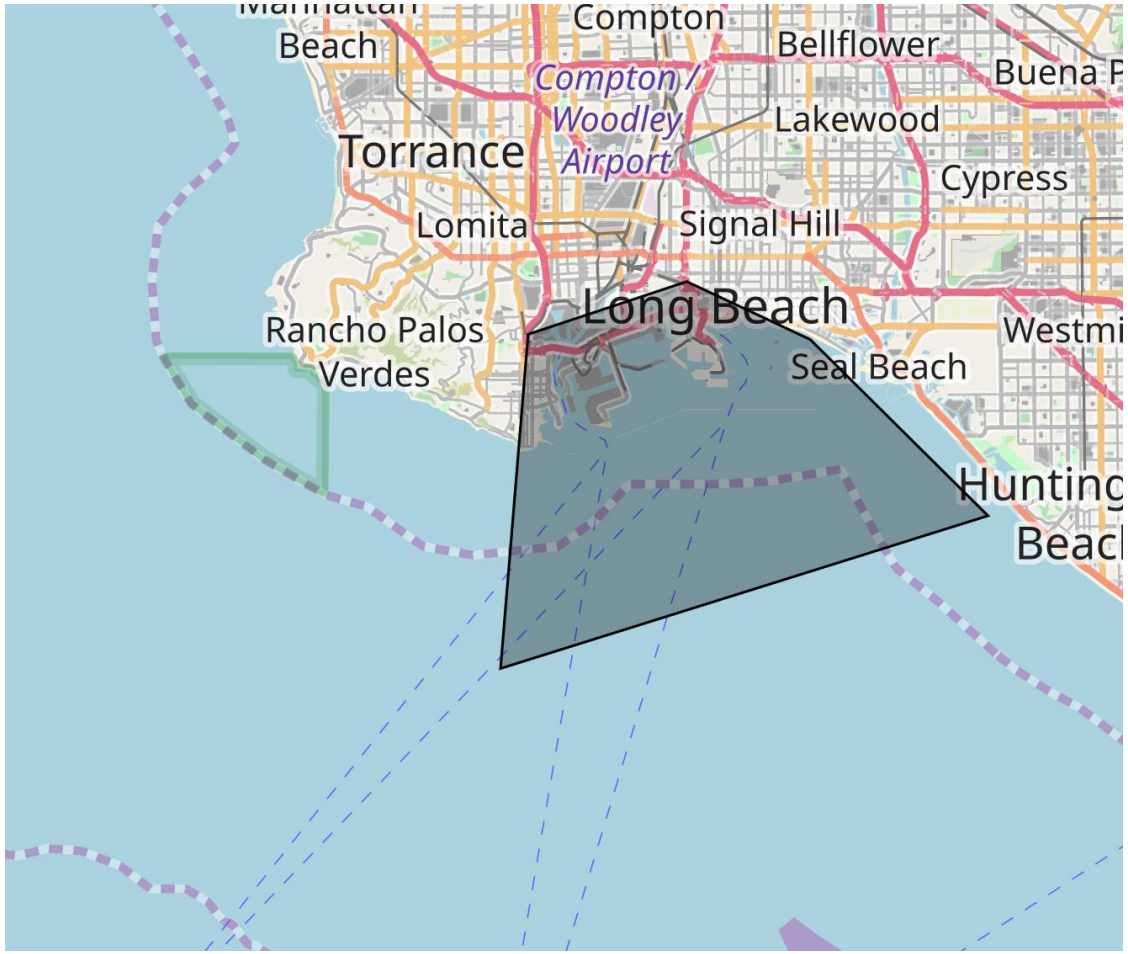


Planet Dove

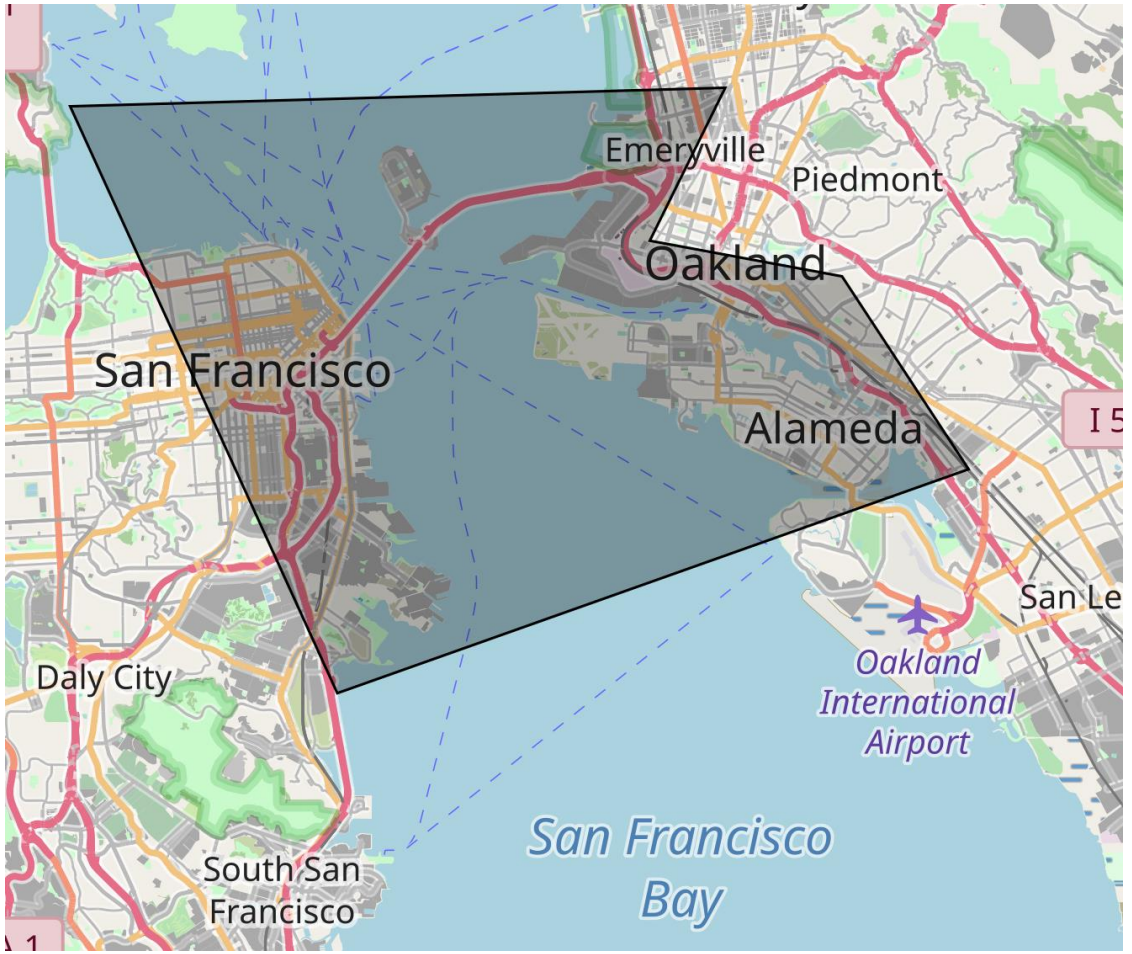


- Commercial provider with largest constellation of satellites in space (3U – 10cm x 10cm x 30cm)
- 3-5m GSD and daily revisit time, swath width ~ 20 km x 15 km
- Planet Open California
  - Satellite imagery available over California (14 day delay)
  - Licensed under CC-BY-SA, but discontinued in September

PIXSAT dataset - ROI



Port of Long Beach area



San Francisco Bay area

PIXSAT dataset – satellite images

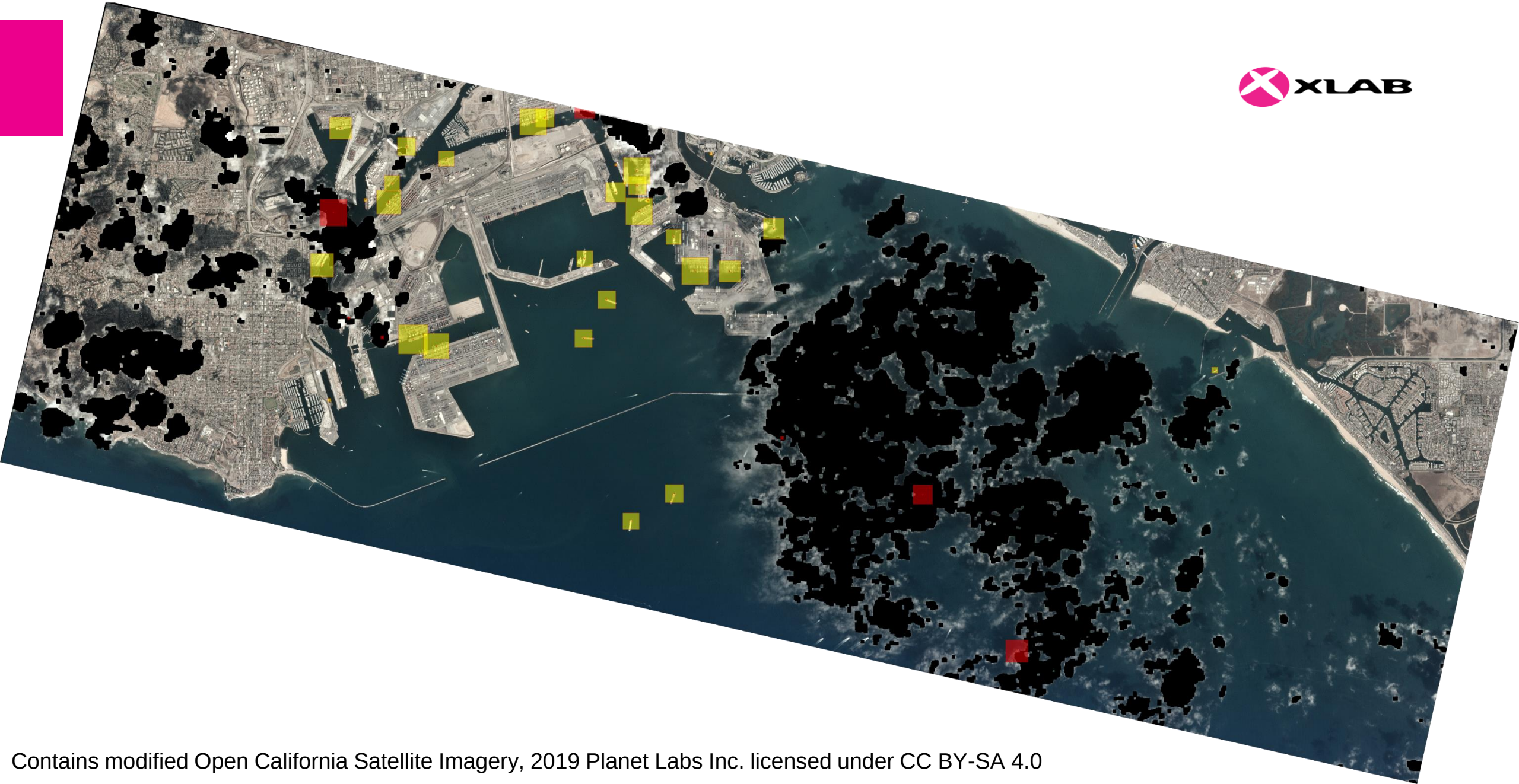
- 2 years of data – 2016 and 2017
- 2420 Planet Dove satellite images, 148 from ESA
- 2016 data used for evaluation and 2017 for development / training

	SF		LB	
	2016	**2017**	**2016**	**2017**
Planet	192	1000	212	1016
Sentinel	31	41	27	49

PIXSAT dataset - ships

- Satellite imagery combined with AIS data
- 34894 AIS matchings on Planet Dove
- 5251 AIS matchings on ESA Sentinel-2
- Only ships with length > 30m

	SF		LB	
	2016	**2017**	**2016**	**2017**
Planet	2085	10481	4076	18252
Sentinel	669	957	1229	2396



Contains modified Open California Satellite Imagery, 2019 Planet Labs Inc. licensed under CC BY-SA 4.0

Object detection method

- Facebook Mask R-CNN framework
  - Faster R-CNN with Resnet-50 backend with FPN
  - PyTorch implementation, 100 epochs for training
  - Additional non-maximum-suppression for patches
- Training data:
  - **PIXSAT**
  - **Kaggle Airbus**
    - Segmentation problem translated to object detection
    - Ships > 50m filtered out (BBOX length)
    - 26496 images with 42803 ships
    - Scale augmentations (50-70% of original size)
    - Rotation augmentations (-45° - 45°)

Results

	SF		LB	
	Planet	**Sentinel**	**Planet**	**Sentinel**
baseline	52%	54%	54%	41%
baseline (aug.)	50%	56%	52%	45%
PIXSAT	57%	86%	72%	92%
baseline + PIXSAT	61%	87%	76%	84%

Results

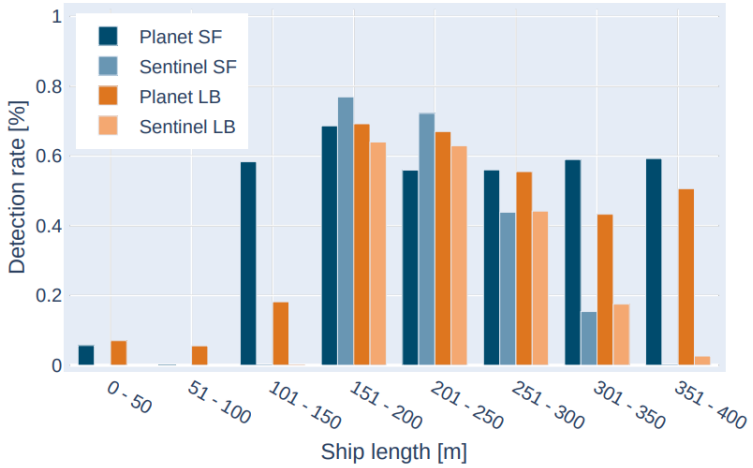


Fig. 4: Baseline - Kaggle Airbus

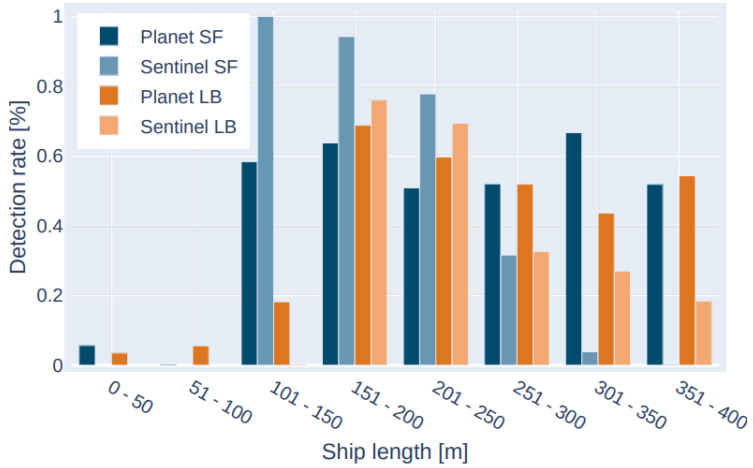


Fig. 5: Baseline - Kaggle Airbus (with augmentations)

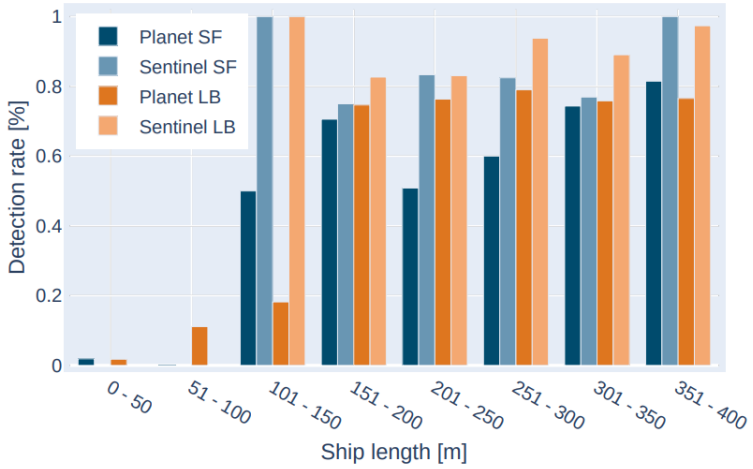


Fig. 6: PIXSAT only

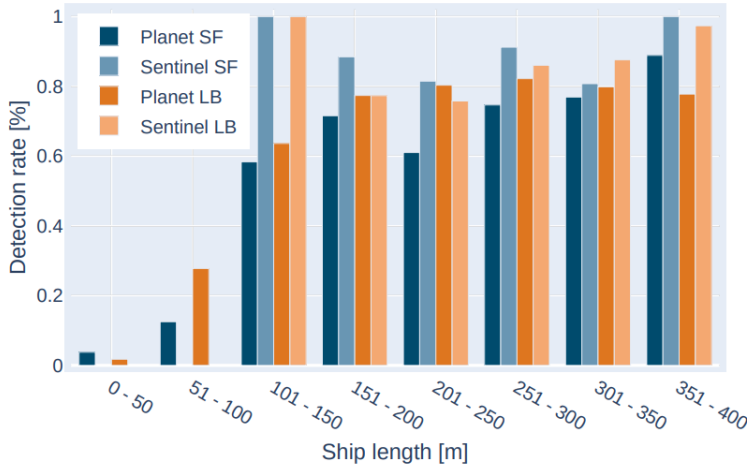


Fig. 7: PIXSAT fine-tuned on Kaggle Airbus (no aug.)

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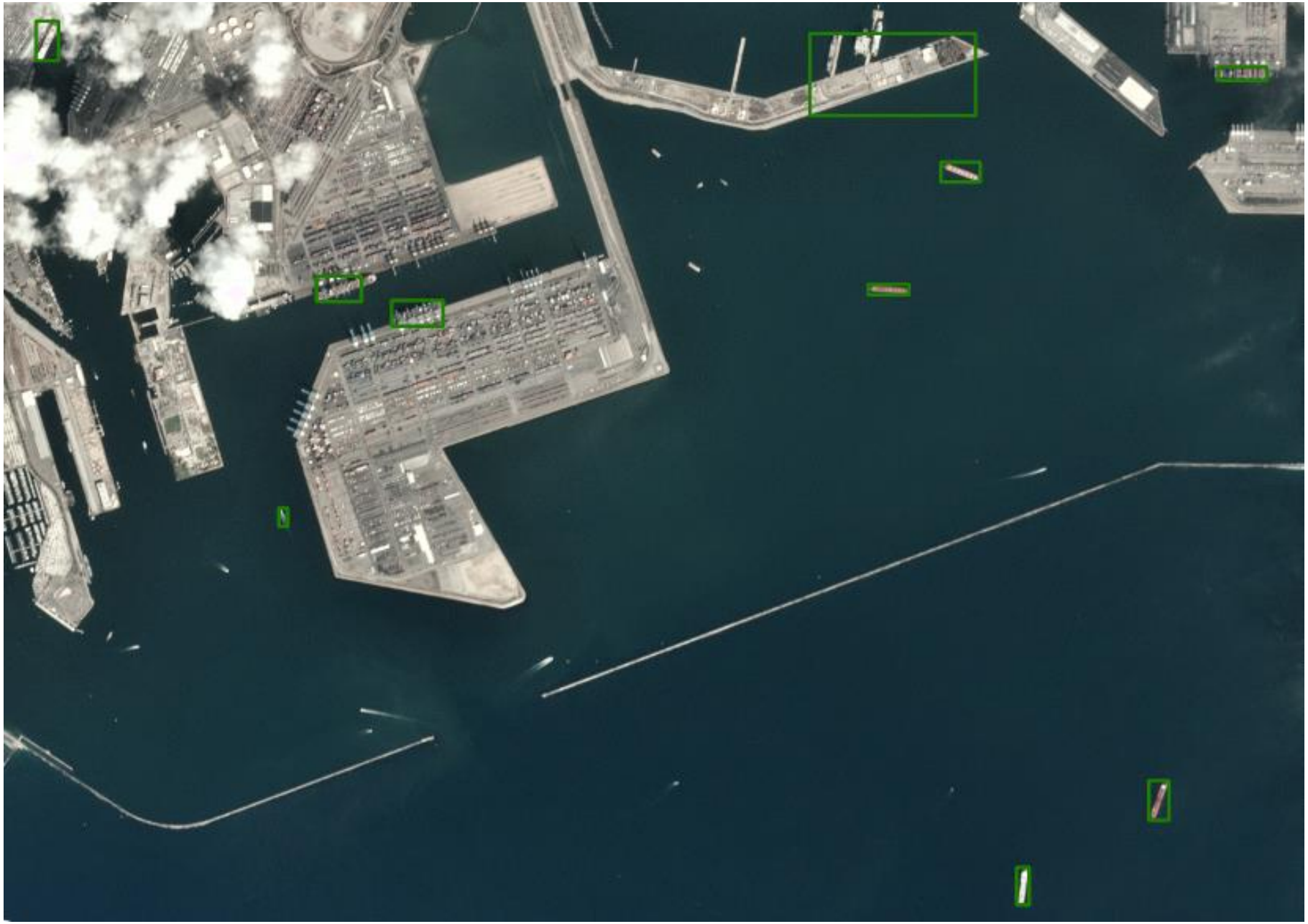

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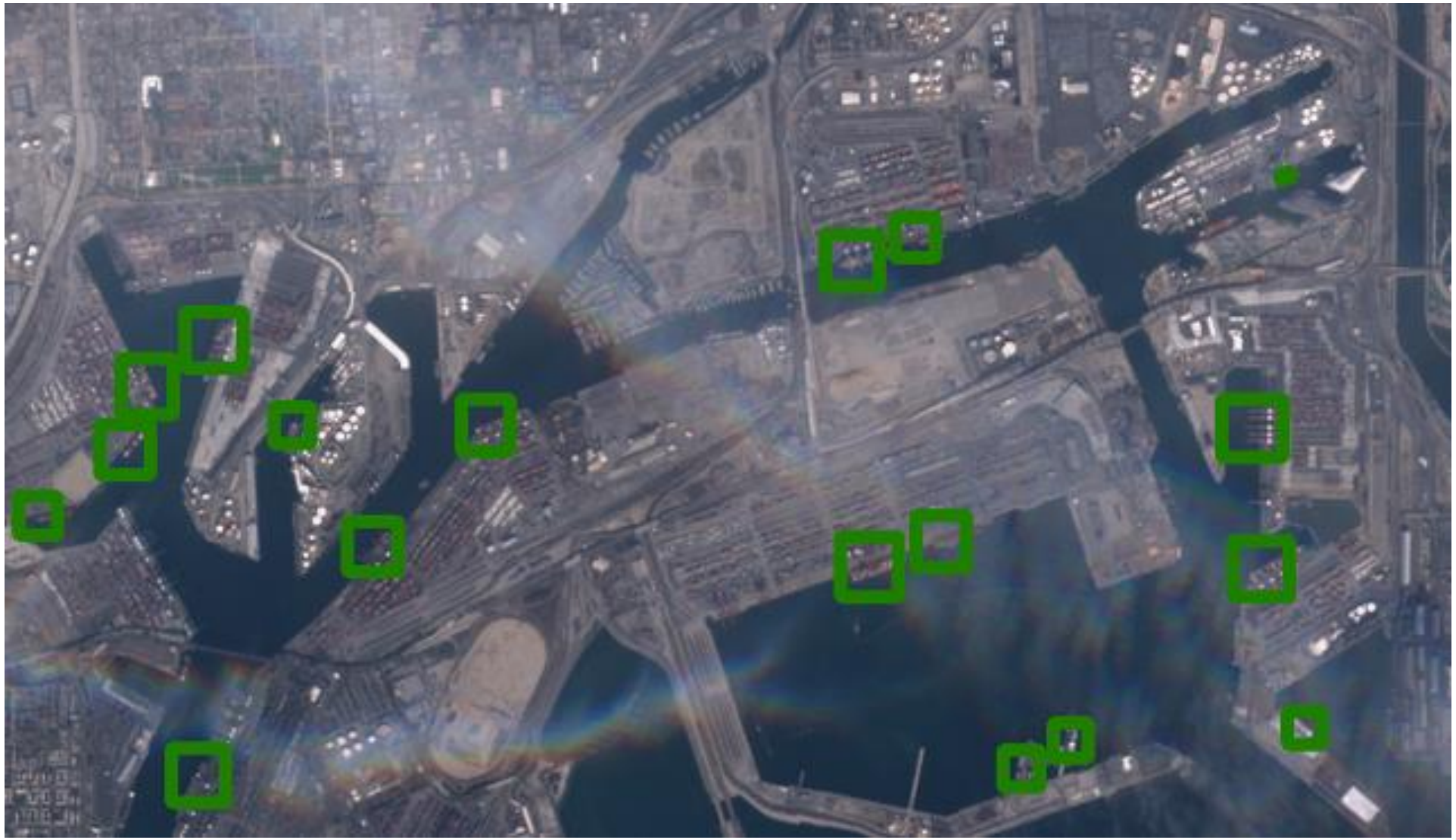

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Get IT done.

PIXSAT dataset - ships